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**COMPREHENSIVE INDUSTRY DOCUMENT
ON
PULSE, WHEAT, RICE MILLS**



**CENTRAL POLLUTION CONTROL BOARD
(Ministry of Environment & Forests, Govt. of India)
Parivesh Bhawan, East Arjun Nagar
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FOREWORD

Pulses, wheat and rice are the most important and widely used edible commodities throughout the country. The raw materials, i.e., whole pulses, wheat and paddy, grown in the farmland are transported to the processing mills and industrial units to make desired final products. Prior to industrialization, these raw grains used to be conventionally processed at household levels or in cottage type units, mostly located in rural areas in the vicinity of farm lands.

The technologies used for processing and milling are mostly indigenous and conventional in nature and are not oriented towards minimizing pollution by incorporation of in plant pollution prevention cum control measures. The environmental aspects associated with the pulse, wheat and rice mills are air pollution, water pollution and noise pollution. These units generate substantial amount of pollution, especially air pollution as a result of fugitive emissions from various operations. Though some improvements are taking place in production processes to improve the efficiency and lower the cost of production, the pollution aspects remain mostly unaddressed. The Central Pollution Control Board therefore took up a project to evolve environmental standards and guidelines for these mills with the help of the National Productivity Council, New Delhi. The Study has been completed and based on its findings, the techno-economically viable pollution control technologies, the standards for gaseous emissions, wastewater discharge and noise pollution have been worked out. The proposed standards have also been recommended by the Peer & Core Committee of the CPCB for consideration by the Ministry of Environment & Forest for notification under Environment (Protection) Act, 1986.

I am thankful to my colleagues Dr. A.B.Akolkar, Additional Director, Shri R.C.Saxena, Sr. Env. Engineer, and Ms. Alka Srivastava, Sr. Research Fellow for bringing out this Comprehensive Industrial document under the guidance of Dr. B.Sengupta, Member Secretary.

I hope that the document will be useful to the Pulse, Wheat and Rice Mills, the Regulatory Agencies, and all concerned with the Environmental Management.

(J. M. Mauskar)

17 August, 2007

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CHAPTER – 1 INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

Primary milling of rice, wheat and pulses is the most important activity in food grains. These grains are grown in almost all parts of India. Few decades ago, these food grains were processed at family level before cooking. Today, due to industrialization and global competitive market trend, it has emerged as a major industrial activity in small medium scale sector to cater to the needs of increasing population. There are large number of mills engaged in processing/milling of pulses, wheat and rice, and are spread over in almost all states across the country. Due to increasing trend especially in urban areas to buy branded products, such as wheat flour, rice, pulses, besan etc., it is estimated that the number of units under this category of industries will continue to increase throughout the country.

It is estimated that 80% of world population uses rice and wheat as major source of calories and pulses remain a major source of protein for almost half of the world's population. The technologies used for processing and milling are mostly indigenous and conventional in nature and are not oriented towards minimising pollution by incorporation of in plant pollution prevention cum control measures. These units generate substantial amount of pollution, especially air pollution as a result of fugitive emissions from various operations. Though some amount of changes are being brought in production processes to improve the efficiency and lowering the cost of production etc., as regards to pollution aspects it remains mostly unsatisfactory.

Keeping in view the large and increasing number of these industries countrywide and the gravity of environmental pollution caused by these industry sectors, Central Pollution Control Board(CPCB) initiated a project on evolving environmental standards for these industry sectors with the help of National Productivity Council (NPC), New Delhi.

1.2 METHODOLOGY

While finalizing the Environmental Standards for different categories, following methodology was adopted.

Inventorisation & Literature Survey:

For collecting information on types of technologies used, number of units, various agencies like industry association, SPCBs and other government agencies were contacted for information about units and technologies etc. The information available with the CPCB has also been reviewed. Suitable questionnaires were prepared seeking information from SPCBs as well as from other agencies. The information requested include - number of units in the state, names and addresses of contact persons, types of technologies and capacity etc. The questionnaires were sent to all State Pollution Control Boards through CPCB requesting the information. The responses to the questionnaires from SPCBs have been compiled. A literature survey was undertaken to collect available

information about the types of technologies, processes etc. Efforts were also made to collect information on types of technologies/processes used in other countries and measures adopted by them towards abatement, prevention and control of air, water, noise pollution etc. and environmental standards applicable for such industries. More information was collected through Internet browsing, visit and discussions with various national agencies.

Data Collection & Analysis:

Preliminary visits were made to the selected units for the purpose of collecting first hand information about the unit and to line up field study schedule after discussions with the unit management. Representative units were identified in consultation with CPCB and respective SPCBs. The selection of units was done on all India basis giving due weightage to location of the units, types of processes employed, types of pollution control system used etc. As per the monitoring schedule, detailed field studies were carried out in selected representative units.

The studies involved various aspects such as identification and characterisation of sources of emissions, effluents, storm water, noise pollution etc. Necessary measurements were conducted using various field instruments. The current level of efforts for abatement, prevention and control of air, water and noise pollution were studied. Detailed field monitoring studies included studies of manufacturing processes adopted in different units from raw material to finished goods, collection of information about energy requirement /consumption etc., conduction of stack monitoring studies and the efficiency & efficacy of the existing air pollution control systems as per the standard methods.

The particulate matter sampling was done as per method prescribed by USEPA. The measurement were carried out using Strohlein make stack monitoring instruments such as dry gas meter, vacuum pump assembly. Conduction of air quality monitoring at work place in major sections of the unit and ambient air quality monitoring using respirable / high volume samplers were made. The parameters measured were SPM, PM10, etc. The SO₂ and NO_x were monitored by Modified West & Gaeke method and Sodium Arsenate method respectively. Noise monitoring was done in the major sections of the unit. Wastewater monitoring was carried out in the units where applicable. Representative samples of wastewater were collected & analysed for selected parameters. Storm water monitoring was conducted in the pulse making units where storm water gets contaminated with process wastes. Representative samples of storm water were collected & analysed for selected parameters. The collected field samples were analyzed. The emission rate of different pollution parameters and efficiency of different pollution control systems were calculated/ assessed.

Technology Assessment:

Based on observations at sites, discussions with Unit Management and information from other sources regarding available technologies in the country for abatement, prevention and control of air, water and noise pollution, the technologies have been reviewed. In-depth study to assess appropriateness of existing pollution prevention cum control systems adopted at various locations in

the country and its effectiveness was carried out in representative units. Improvements were suggested and got implemented in few units to improve their systems. Information on production processes & prevention/control systems adopted in developed countries has been collected through establishing contacts with various international agencies requesting information and by reviewing various available literatures/data on the subject and through Internet surfing.

Evolution of Standards

Environmental Standards adopted in developed countries have been studied and analysed for its suitability to Indian conditions. Environmental standards for Wheat/Rice & Pulse processing industries were evolved keeping in view the information gathered and field study data. Technically and economically viable scheme of pollution control system have been recommended to enable to meet the proposed environmental standards.

CHAPTER- 2 BACKGROUND INFORMATION ON PULSE/WHEAT/RICE MILLING SECTORS

2.1 GENERAL INFORMATION

Pulses occupy important place in the world food and nutrition economy. Pulses are an important constituent in the diet, and are primary sources of protein. They also provide substantial quantity of minerals and vitamins to the diet.

Wheat is the staple food of Northern India and is commonly used all over the country in the form of its by-products. Numerous type of qualities of wheat products and by-products of wheat like wheat flour, suji, maida & dalia etc. are produced by the wheat flour and processing mills. The wheat flour is used in domestic purposes for making *chapatti*. Wheat in combination of maida is used for making bread, biscuit etc.

Rice is also a staple food in India. It is processed from paddy both at household level and industrial level. It is either used in raw or parboiled form. There are many varieties of paddy cultivated in different parts of the country.

2.2 PRODUCTION/ CULTIVATION SCENARIO

The pulse production in India increased from 8.41 Million tonnes in 1950-51 to 10.67 Million tonnes in 2000-01. Similarly, wheat production in India increased manifold from 6.46 Million Tonnes in 1950-51 to 68.76 in 2000-01 and rice production from 20.58 Million Tonnes in 1950-51 to 84.87 Million Tonnes in 2000-01. (The detail figures of all India Production and Yield of Pulses, Wheat and Rice are given in Annexure 2.1.).

The figures of average cultivation area, production and yield of Pulse, Wheat & Rice in the country over last few years are given in Table 2.1.

TABLE 2.1: Area, Production & Yield Of Pulses/Wheat/Rice In India

Year	Pulse			Wheat			Rice		
	Area (Million Hect.)	Prodn (Million Tonnes)	Yield (Kg/Hec)	Area (Million Hect.)	Prodn (Million Tonnes)	Yield (Kg/Hec.)	Area (Million Hect.)	Prodn (Million Tonnes)	Yield (Kg/Hec.)
1996-97	22.45	14.24	635	25.89	69.35	2679	43.43	81.74	1882
1997-98	22.87	12.98	567	26.70	66.35	2485	43.45	82.53	1900
1998-99	23.50	14.91	634	27.52	71.29	2590	44.80	86.08	1921
1999-'00	21.12	13.42	635	27.49	76.37	2778	45.16	89.68	1986
2000-01	20.03	10.67	533	25.07	68.76	2743	44.36	84.87	1913
2001-02*	23.12	13.79	596	25.68	73.53	2863	43.92	90.75	2066

*Advance estimates as on 05.04.2002

Source: *Agricultural Statistics at a glance 2002*, Ministry of Agriculture, Govt. of India, New Delhi.

State Wise Share In Production Of Pulse/Wheat & Rice

In the country, major share in Pulse Production is by the state of U.P. (20.3%) & M.P. (19.5%) followed by Maharashtra (15.4%), Karnataka (9.1%) & Andhra Pradesh (8.1%). The northern states of Punjab, Himachal, J & K, Uttaranchal as well as North Eastern States & Kerala do not produce pulses in significant quantities.

Maximum share in wheat production is by UP (36.3%) followed by Punjab (22.6%) and Haryana (14%) and the rest 1/4th share is by all other states.

As regards to rice production, the major share is by four states, namely West Bengal (14.7%), UP (13.6%), AP (13.5%) & Punjab (10.8%).

The state wise production of pulse/wheat/rice in different states of India is given in Table 2.2 below.

TABLE 2.2: State Wise Production Of Pulse/Wheat & Rice

State	Pulse		Wheat		Rice	
	Production (Million Tonnes)	% of total production	Production (Million Tonnes)	% of total Prod n.	Production (Million Tonnes)	% of total Prod n.
Uttar Pradesh	2.17	20.34	24.94	36.27	11.54	13.60
Madhya Pradesh	2.08	19.49	3.89	5.66	0.96	1.13
Maharashtra	1.64	15.37	0.95	1.38	1.95	2.30
Karnataka	0.97	9.09	0.24	0.35	3.73	4.39
Andhra Pradesh	0.86	8.06	-	-	11.45	13.49
Rajasthan	0.73	6.84	5.55	8.07	-	-
Bihar	0.63	5.90	4.50	6.54	5.42	6.39
Tamil Nadu	0.33	3.09	-	-	7.22	8.51
West Bengal	0.24	2.25	1.06	1.54	12.43	14.65
Chhattisgarh	0.22	2.06	-	-	3.24	3.82
Orissa	0.21	1.97	-	-	4.61	5.43
Gujarat	0.19	1.78	0.65	0.95	1.01	1.19
Jharkhand	0.10	0.94	0.10	0.15	1.64	1.93
Haryana	0.07	0.66	9.65	14.03	2.68	3.16
Punjab	-	-	15.55	22.61	9.15	10.78
Uttaranchal	-	-	0.71	1.03	-	-
Himachal Pradesh	-	-	0.59	0.86	-	-
Jammu & Kashmir	-	-	0.15	0.22	-	-
Assam	-	-	0.09	0.13	4.00	4.71
Kerala	-	-	-	-	0.75	0.88
Others	0.23	2.16	0.14	0.20	3.09	3.64

2.3 INVENTORIZATION OF PULSE/WHEAT/RICE MILLS IN INDIA

For the purpose of collecting information on the number of mills in the country various agencies were contacted like the State Pollution Boards, Industry Associations, Agricultural Department of few Universities, etc. (Refer Annexure 2.2 for the list of Agencies contacted). A Questionnaire was prepared along with a format for providing information on the number of mills on various categories, which were sent to all State Pollution Control Boards. Out of the many names received from various State Pollution Control Boards, a few units were selected where visits were made for the purpose of carrying out field studies.

Literature survey was also carried out of published document such as Annual Report of Ministry of Food Processing and internet browsing was also undertaken of various web-sites such as that of Ministry of Agriculture, Department of Food Processing, and also various international organizations etc.

The information has been received from a few State Pollution Control Boards, some of it only for part of the state. In the case of some states, the number of mills as indicated by the pollution control board varies with respect to the number published in other reliable publications such as the annual report of the Ministry of Food Processing. Wherever variations in number were found, the maximum number of mills has been considered for the purpose of compilation.

The state-wise inventorisation of the pulse/wheat/rice mills in the country has been given in Table 2.3 enclosed herewith. In all the information is available for 27 states; for some states only partial information covering part of the state is available. Regarding pulse mills, based on the information available from 15 states, the number of pulse mills are 1220. As regards to the rice mills, based on information available from 16 states, the number of rice mills is 5780. For the Wheat flour/processing mills the information (though partial) has been received from 27 states, as per which there are 867 mills. *(The above mentioned numbers are based on the partial information received from various states and subject to change.)*

TABLE 2.3: Inventerization Of Pulse/Wheat/Rice Mills In India

State	Number of Mills		
	PULSE	WHEAT	RICE
Andhra Pradesh	51	58	257
Assam	NA	40	NA
Bihar	0	58	16
Chhattisgarh	125	0	373
Punjab	1	48	8
Delhi	76	18	0
Goa	NA	2	NA
Gujarat	24	13	20
Haryana	NA	47	3,065
Himachal Pradesh	NA	15	NA
Jammu & Kashmir	NA	19	NA
Jharkhand	12	9	17

State	Number of Mills		
	PULSE	WHEAT	RICE
Karnataka	104	60	668
Kerala	1	32	103
Madhya Pradesh	549	44	360
Maharastra	NA	65	NA
Manipur	NA	1	NA
Meghalaya	6	81	96
Nagaland	NA	4	NA
Orissa	1	22	214
Pondicherry	14	99	61
Rajasthan	NA	10	NA
Sikkim	NA	3	NA
Tamilnadu	247	62	516
Tripura	NA	2	NA
Uttar Pradesh	9	6	6
West Bengal	NA	49	NA

Variation In Number of Rice Mills – Discussions:

In the case of rice mills, the number of mills as reported in the CPCB document “Comprehensive Industry Document on Rice Mills”, 1997, are quite large. This large number may include from tiny rice mills (which may not be registered with State Pollution Control Boards). Comprehensive/up to date list of rice mills working in different states is not readily available with any organization. The number of rice mills operating in 14 states of the country are given in the table below. The table also indicate the major form of rice (i.e. white rice or parboiled rice) produced in the respective states.

**TABLE 2.4 Rice Mills in The Country
(Tiny +SME Scale)**

State	Total number of Rice Mills	Major Form of Rice
Andhra Pradesh	16,410	White
Assam	5,560	Parboiled
Bihar	11,675	Parboiled
Gujarat	1,440	White
Haryana	3,065	White
Karnataka	4,500	White
Kerala	2,500	Parboiled
Madhya Pradesh	10,000	White
Maharastra	4,625	White
Orissa	10,240	Parboiled
Punjab	10,500	White
Tamil nadu	10,950	Parboiled
Uttar Pradesh	16,610	White
West Bengal	16,925	Parboiled
Total	1,25,000	

Source: CPCB Document “COINDS on Rice Mills”

2.4 COMPARISON OF INDIAN & WORLD PRODUCTION FIGURES

Information regarding worldwide production figure, area of cultivation, yield etc of pulse / rice / wheat commodities is given below at Table 2.5. The figures indicate that India is the largest producer of pulses and second largest in wheat and rice crops, China being the largest producer.

Out of the total land area of the country, more than half (54.5 %) area is agricultural land which is 162 million hectares. India's agricultural land area is the second largest, only to USA and in terms of percentage share of world agricultural land, India has a share of 11.7%. In terms of irrigated area, 59 million hectares of agricultural land in India is irrigated which is the largest irrigated land in a country, with a share 21.8 % of world's irrigated agricultural land.

In terms of production of wheat, rice and pulses, India's share in World production is 12.2, 22 and 27.1 % respectively which is rank wise 2nd , 2nd and 1st respectively.

TABLE 2.5 Comparison Of Indian & World Agricultural Production

India's Position in World Agriculture during 1999					
<i>Item</i>	<i>India</i>	<i>World</i>	<i>India's Position</i>		
			<i>% Share</i>	<i>Rank</i>	<i>Next to</i>
1. Area (Million Hectares)					
Total Area	329	13387	2.5	Seventh	Russian Federation, Canada, China, USA, Brazil, Australia
Land Area	297	13048	2.3	Seventh	Russian Federation, China, Canada, USA
Agricultural Land	162	1381	11.7	Second	USA
Irrigated Area	59	271	21.8	First	USA
2. Population (Million)					
Total	998	5978	16.7	Second	China
Agriculture	553	2575	21.5	Second	China
3. Economically Active Population (Million)					
Total	437	2911	15.0	Second	China
Agriculture	263	1317	20.0	Second	China
4. Crop Production (Million Tonnes)					
Wheat	71	584	12.2	Second	China
Rice (Paddy)	131	596	22.0	Second	China
Total Pulses	16	59	27.1	First	

Source: Web site of Ministry of Agriculture, Govt. of India

CHAPTER – 3 DESCRIPTION OF PRODUCTION PROCESSES

The predominant production processes for various types of Pulses, Wheat & Rice Mills are briefly discussed below:

3.1 PRODUCTION PROCESS IN PULSE MAKING MILLS

In India, variety of pulses are used as major food habit in our daily life. The major pulses are chana, moong, arhar, urad & masoor. A typical pulse milling process primarily involves three operations to produce “dal” namely: Cleaning, Conditioning & Milling, as described below:

3.1.1 Cleaning Process

The cleaning process starts from unloading of raw material (whole pulses) from gunny bags to the plant site unloading area. The pulses are elevated continuously with the help of bucket elevator (B/E) and fed to a cleaning screen. The cleaning screen comprises of perforated cylindrical metal sheet with holes of various sizes. The impurities such as dirt, dust, *mitti*, plant waste remains, shells of pulses etc. are cleaned either by screening through the screen or by blowing away the impurities with the help of axial fans. Some units also use destoners to remove stones from the pulses. The pulses are then passed through a set of rubber rollers (called reel machine) to scour adhered dust etc. and to break the tips of pulses (called Nakku) which is again passed through a 2nd or 3rd set of rotary screens for screening the impurities. The clean pulses are then sent for conditioning.

3.1.2 Conditioning Process

The conditioning process involves application of either water or oil to the cleaned pulses followed by soaking for desired hours and either sun-drying or hot air drying. For the pulses like channa, water is used for conditioning, whereas for other pulses such as Arhar, Moong, Urad, Masoor etc., vegetable oils are used as conditioning agent. The chana pulses are sun-dried whereas other pulses are generally dried using hot air dryer. The soaking time differs from pulses to pulses which is about 6 hrs or more and depends upon the process moisture requirement, type of raw material, its quality, size etc. The amount of water/oil used and soaking and drying durations vary from unit to unit. After proper conditioning, the pulses are sent for milling.

3.1.3 Milling Process

The milling process mainly involves application of abrasive force in various types of rollers to remove (separate) the outer shell of pulses, which is followed by shearing of pulses in two halves in grinders/chakkis. The type and material of the rolls and grinders varies for different type of pulses and depends upon various process parameters such as inherent moisture in the pulses, size of pulses and other factors.

The process flow diagram of a typical Pulse Mill is given in Figure 3.1. A typical setup of a pulse making mill is shown with the help of a few photographs at Photopage –3.1.

Certain pulses like red gram (arhar), black gram (urad), green gram (moong) and horse gram pose great difficulty in dehusking, while pulses like Bengal gram (chana), peas, lentil and khesari are relatively easy to dehusk. This difference in dehusking behaviour is due to the reason that in former category the husk is more tightly adhered to the cotyledon than in case of the latter one. The processes commonly followed among both the category of pulses are described below:

- ❖ **Red Gram (Arhar) Milling:** This is most difficult pulse to mill since the husk in case of Red gram is very tightly attached to the cotyledons compared to other pulses in this category. The cleaned and graded grains are pitted, oilsmearred (0.2-0.5%), tempered (1/2-1 day), treated with water, stored overnight, sun dried for 1-3 days and then passed through the rollers for dehusking. Such type of husk loosening and dehusking operations are repeated 2-4 times till more than 90% grains are dehusked. Dal obtained during these dehusking operations is termed as Grade II Dal since its edges are rounded off due to scouring. The mixture of dehusked and full grains (called gota) is later treated with water, tempered for few hours, sundried and split in horizontal or vertical chakki or by using a patka machine. The Dal thus obtained is considered as Grade I Dal since it has no chipped edges and has a better consumer appeal. The recovery of red gram varies from 68 to 75 percent of whole grain depending upon variety milled and method followed, the losses range from 11 to 18 percent. Of late, it is reported that in case of large scale mills sundrying is gradually being replaced with batch type bin dryers. The adoption of driers enable the units to work round the year. Red gram is mainly processed in the states of Madhya Pradesh, Uttar Pradesh, Maharashtra, Gujarat, Karnataka, Tamilnadu and Bihar.
- ❖ **Bengal Gram (Chana) Milling:** This pulse is easy to dehusk. Dehusking after cleaning and grading is done in roller machines. Splitting is carried out by treating the pulses with water. tempering for 12 hours and splitting in sheller. This pulse does not require any oil for husk loosening. The process is again repeated till all the grains are dehulled. Recovery of Dal varies between 78-82 percent, with a loss of 5-9 percent. Milling of Bengal gram is confined mainly to Uttar Pradesh, Rajasthan, Maharastra, Delhi, Haryana and Madhya Pradesh.
- ❖ **Pea Milling:** This pulse is easy to dehusk. The peas sold as such in the market are generally polished to enhance the customer appeal. The process involves cleaning and grading, moisture application, tempering and sun drying. The dehusking and splitting is carrier out in roller machines. After separation, the unhusked grains are again passed till complete dehulling is achieved. The recovery of Dal varies in the range of 80-82 percent with an average loss of 8-10 percent.

- ❖ **Black gram (Urd) milling:** The process involves cleaning, grading and pitting by emery rollers. Two or three passes are required to complete the pitting operation; it is essential to remove husk and powder after every pass. About 0.5% oil is applied to the pitted grains, which are then stored for 12 hours. The grains are then sundried for about 2 days and then re-sprayed with water and tempered. These grains are then passed through rollers for dehusking. The split Dal obtained is called grade II Dal. The grains are passed through Burr mill to obtain Dal of grade I. The polishing of split Dal is done with soapstone powder. This gives lusture to Dal and enhances its market value. Andhra Pradesh, Orissa, Tamilnadu, Karnataka and Bihar are the states where this pulse is primarily processed.

- ❖ **Green Gram (Moong) Milling:** It is a difficult to dehusk type of pulse, because the husk is tightly attached to the cotyledon and is thin, soft and slippery in texture. The bond between the two cotyledons is loose due to which the splitting occurs even before the dehusking can take place. The process involves pitting, smearing with oil, Sundrying followed by dehulling and splitting in roller machines. The losses in the form of broken and powder are large in case of Moong due to rubbing during dehusking operation. West Bengal, Uttar Pradesh, Andhra Pradesh, Orissa, Maharashtra and Rajasthan are the states where the milling of green gram is done.

- ❖ **Lentil and Khesari:** These pulses are relatively easy to dehusk. The practice generally followed is cleaning, grading, application of moisture, tempering and sundrying. This is followed by dehusking and splitting in roller machines. The dehusking process is repeated after separating Dal, till all grains are dehusked and split. Lentil is generally milled in the states of West Bengal, Madhya Pradesh, Uttar Pradesh and Bihar where as Khesari Dal is processed primarily in Bihar and Madhya Pradesh.

3.2 PRODUCTION PROCESS IN PULSE GRINDING (*BESAN*) MILLS

In the Pulse Grinding Mills, the raw material is primarily chana dal produced in the Pulse Making Mill (Chana dal mill) and the final product is Besan. Since the raw material is already cleaned, there is no cleaning section in these mills. Many chana dal mills have grinding units attached.

Typically the process involve procurement and storage of chana dal, grinding / pulverizing, centrifuging to separate coarse and fine besan portions followed by dispatch. The movement of the raw material is primarily through bucket elevator. The besan is transported pneumatically. The besan is separated in Cyclone type centrifugal equipment and the finer portion escaping from the centrifuge is collected in cloth bags, fitted on the cyclone outlet.

The typical process is explained with the help of Process Flow Diagram as shown in Figure-3.2.

Figure 3.1: Process Flow Diagram Of A Typical Pulse Mill

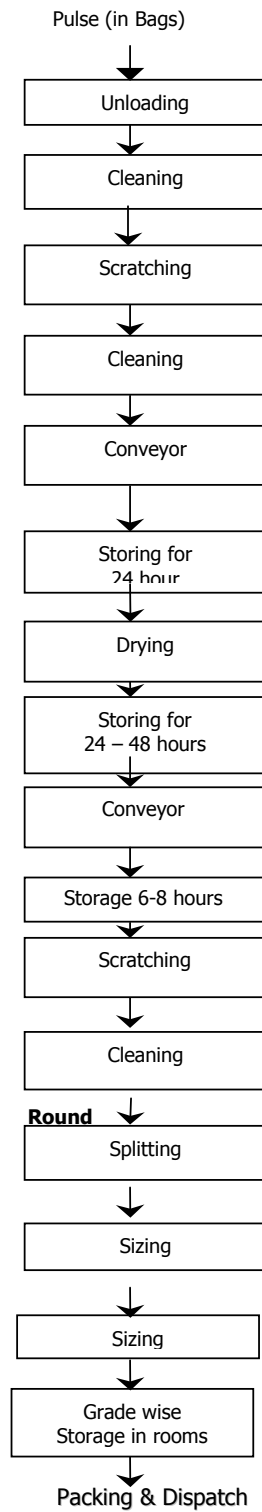
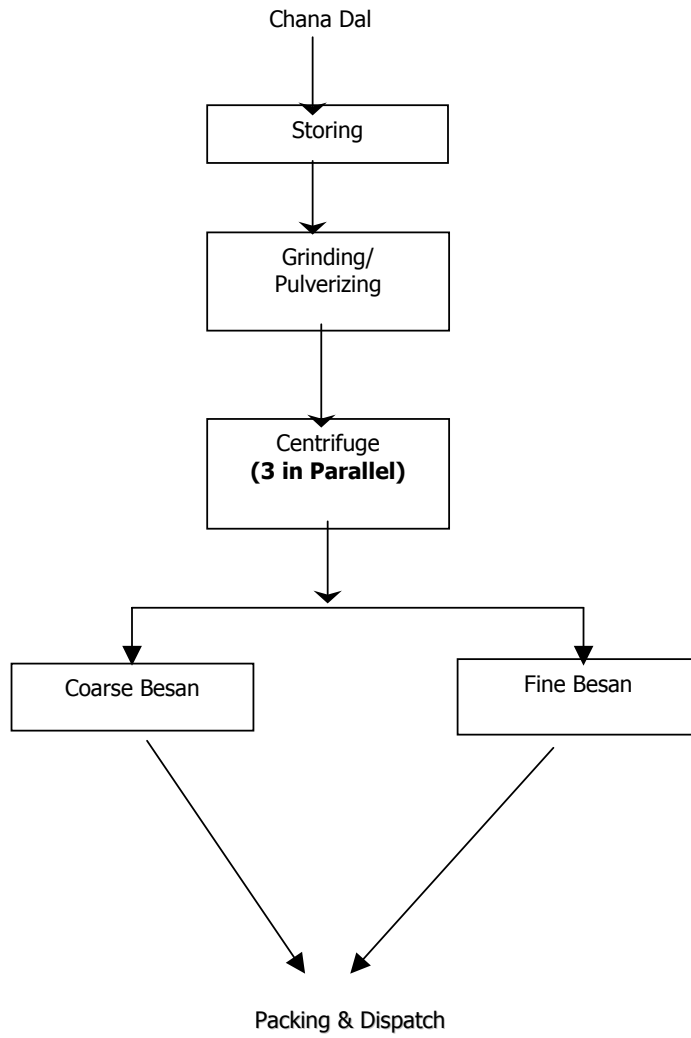


Figure-3.2: Process Flow Diagram of a typical Pulse Grinding Mill.



3.3 PRODUCTION PROCESS IN WHEAT FLOUR MILLS

There are two types of wheat flour milling process, (i) Dry type and (ii) Wet type. Both type of processes are discussed below:

3.3.1 Wheat Flour Mills – Dry type

The wheat flour making process comprises of two sections, cleaning section and milling section.

A) Cleaning Section:

Wheat is thoroughly cleaned to remove all impurities including the dust adhered to the surface of the wheat grains. To remove the impurities a few set of cleaning stages are employed, such as pre-cleaning, cleaning first stage, second stage etc. Small pieces of sticks, stones, sand, straw etc., are removed by scouring. The scourer removes outer husks, crease dirt and any smaller impurities with an intense scouring action. It is also passed through magnetic separator for the separation of iron particles. Aspiration system is used as a cleaning means as air currents act as a vacuum to remove dust and lighter impurities. Destoner is used to remove heavier particles like stone. After completion of cleaning, wheat is conditioned by dampening. The conditioned wheat is stored in a silo for 24 hours and then is sent to milling section.

B) Milling Section:

Milling of wheat is carried out predominantly by roller flour mills. The roller milling system comprises of break rolls and reduction rolls. The break rolls and reduction rolls are differentiated through the variation in their surface conditions. The surface of the reduction roll is smooth where as surface of the break roll is corrugated. In the break rolls, the bran is cracked and the kernel is opened. After each break, the mixture of free bran, free endosperm, free germ and endosperm still adhering to the bran is passed through the next break roll while the middle sized endosperm called middling are sent to the reduction rolls and are used for grinding of free millings into proper flour size. After each reduction of endosperm (middlings) the flour is sifted away from the bigger size middlings and the remaining middlings are passed again through reduction rolls.

The broken particles of wheat are introduced into box-like sifter machines, where they are shaken through a series of bolting cloths or screens to separate the larger from the smaller particles. Inside the sifter, there are a number of frames, each covered with either a nylon or stainless steel screen, with square shape openings, reducing in size in subsequent stages of screening. Up to six different sizes of particles may come from a single sifter, including some flour with each sifting. Larger particles are shaken off from the top, or “scalped”, leaving the finer flour to sift to the bottom. The “scaled” fractions are sent to other roll mills and particles of endosperm are graded by size and carried to separate purifiers.

In a purifier, a controlled flow of air lifts off bran particles while at the same time a bolting cloth separates and grades coarser fractions by size and quality. Four or five

additional “break” rolls, each with successively finer corrugations and each followed by a sifter, are usually used to rework the coarse stocks from the sifters and reduce the wheat particles to granular “middlings” that are as free from bran as possible. Germ particles are flattened by later passage through the smooth reduction rolls and can be easily separated. The reduction rolls reduce the purified, granular middlings (called farina) to flour.

The process is repeated over and over again, from sifters to purifiers to reducing rolls, until the maximum amount of flour is separated, close to 75 percent of the initial wheat weight.

The process flow diagram of a typical Wheat Mill is given in Figure 3.3 (A). A typical set-up of wheat flour mill is shown with the help of few photographs at Photopage - 3.2

3.3.2 Wheat Flour Mills – Wet type

Typically, the Wet Type flour Mills comprise of a cleaning section, washing section and milling section. The process in the cleaning and milling sections are similar to that of Dry type Flour Mills as discussed above. In the washing section, the cleaned wheat is washed with water and subsequently dampened prior to milling.

The typical process flow of a Wet Flour Mill is given in Figure 3.3(B). (A pictorial representation of a wheat flour mill is shown at Annexure-3.1 which explain the physical arrangement & working principles of various process equipments)

3.3.3 Wheat Roasting (Processing)

The raw wheat bags are cut open & fed to bucket elevator (B/E). The B/E lifts the material & delivers to a rotary type-cleaning screen. The cleaned wheat is stored in a separate room. This cleaned wheat is retrieved as per requirement and fed to the roaster through a bucket elevator chute arrangement. The roaster is a cylindrical steel vessel with tapering ends on both sides and it is enclosed inside a refractory brick lined enclosure. The roaster is indirectly heated by an oil-fired burner. The wheat along with some quantity of sand is kept rotating inside the roaster and wheat gets roasted by the time it reaches the other end. The roasted wheat is discharged from the roaster and is lifted by a bucket elevator and sent to separate storage room. The combustion gas from the roaster enclosure is separately collected and discharged to atmosphere through a stack.

The typical process flow of a Wheat processing (Roasting) Mill is given in Figure 3.3(C).

Figure 3.3(A): Process Flow Diagram Of A Typical Dry Type Wheat

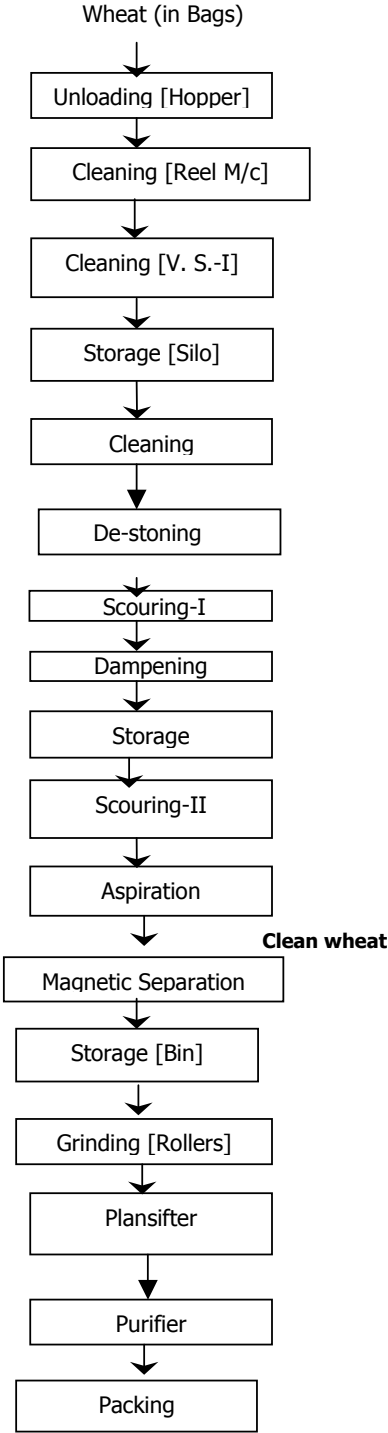


FIGURE 3.3(B): PROCESS FLOW DIAGRAM OF A TYPICAL WET TYPE WHEAT FLOUR MILL

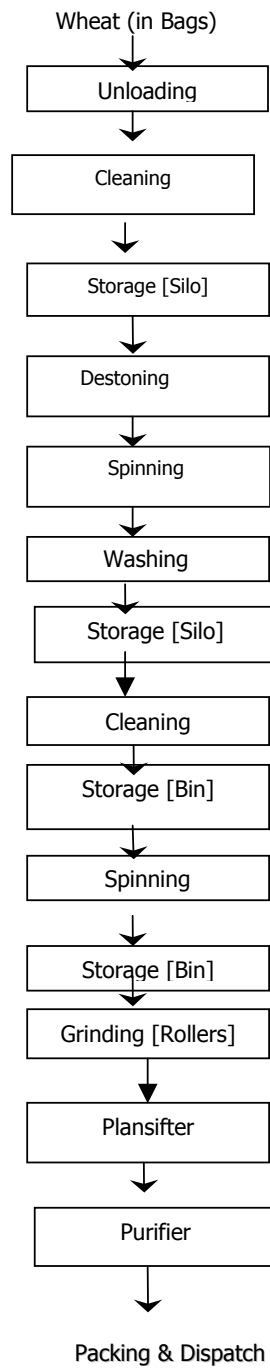
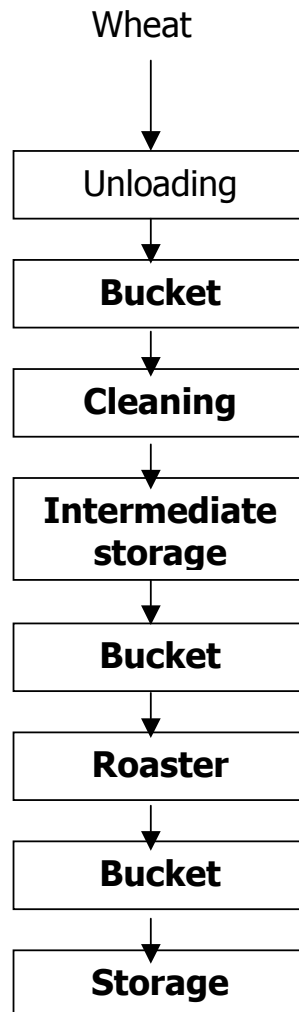


FIGURE 3.3(C): PROCESS FLOW DIAGRAM OF A TYPICAL WHEAT PROCESSING (ROASTING) MILL



3.4 PRODUCTION PROCESS IN RICE MILLS

The objective of rice milling is to get whole grain rice and preserve most of the rice kernels in their approximate original shape. In order to improve nutritional and cooking qualities of rice, a pre-treatment is given to paddy and the rice so obtained by milling the pretreated paddy is known as parboiled rice. The rice obtained from milling untreated paddy is known as raw rice or white rice.

Rice processing methods adopted in India are a blend of conventional methods and modern technology. At household level and small rice mills level, normally conventional rice processing is prevalent. In large-scale rice mills, modern and state-of-art technology and equipments are used. Rice milling consists of various unit operations, such as cleaning, parboiling, drying, hulling, dehusking, polishing and sorting. A typical set up of a rice mill showing some important process equipment is shown with the help of a few photographs enclosed at Photopage 3.3. The typical flow diagram of par-boiled rice mill and raw rice mill are given at Figure-3.4(a) and Figure-3.4(b).

A brief overview of various stages/sections involved in rice processing are discussed below:

3.4.1 Cleaning

Prior to the actual milling operation, the paddy received from the farmer is cleaned. Foreign matter or impurities are removed to protect the processing equipment and improve the final product. The impurities can be classified into large size impurities, small impurities and impurities of about the same size as the paddy grains. Large impurities normally consist of rice straw, panicles, bag strings, soil stones, and sometimes iron parts. Small impurities consist of dust, sand, soil, particles, weed seeds, insects and small stones. Impurities of about the same size as the paddy grains can be empty grains, stones and iron particles.

In the pre-cleaning process steps, different types of equipments are used depending upon size and weight of impurities. Small & large sized impurities are removed using sieving principle whereas; lighter/heavier impurities of similar size are removed using gravity separation or vibratory type screening machines. Foreign material about the same weight and size as the paddy grain is difficult to remove and it is presumed to disintegrate into smaller sizes during the sub-sequent stages.

The cleaned paddy is stored in bins & sent to subsequent processing

3.4.2 Parboiling

Parboiling is one of the latest well-developed pre-milling conditioning treatment given to paddy to improve its nutritional & cooking quality. In parboiling the paddy is soaked in water and subsequently steamed and dried, before milling. This helps in minimizing the breakage of rice and reducing the loss of nutrients during milling.

Normally, parboiling is done to:

- ◆ **prevent the loss of nutrients during milling; and**
- ◆ **increase the total and head rice yield of paddy;**

There are various methods of parboiling practiced in India, some are conventional methods while some are modern technology based methods.

The conventional method of parboiling includes single boiling, double boiling and CFTRI hot soaking method.

The modern technology of parboiling includes chromate-soaking method, pressure parboiling method, the modified pressure parboiling method and dry heat parboiling. The benefits of the most of modern technologies are (i) No smell problem, (ii) Reduction in time of processing and (iii) Reduction in paddy drying time due to less moisture content in the paddy.

3.4.3 Drying of Parboiled Paddy

Paddy, after parboiling, contains high moisture. After soaking and steaming methods, it may contain 35 to 40% moisture. After pressure parboiling, it may contain 20 to 30% moisture. In either case, it needs to be dried quickly to about 14% moisture for safe storage or for milling. Drying can be done either in the sun or in the hot air dryer. But whatever method of drying is employed, caution is to be exercised so that milling quality of paddy is not damaged. If drying is not proper, parboiled paddy can give very high breakage during milling. Generally, most mills employ a hot air type of drying. Hot air is passed through the paddy till it is dried to desired extent.

3.4.4 Milling Process

The milling process broadly consist of de-husking/hulling, husk separation and whitening/polishing

- ***Hulling/ Dehusking***

The objective of a hulling/dehusking operation is to remove the husk from the paddy grain with a minimum of damage to the bran layer and, if possible, without breaking the brown rice grain. Since, the structure of the paddy grain makes it necessary to apply friction to the grain surface to remove the husk, it leads to breaking of some of the rice.

The most common machines used in hulling paddy are the under-runner disc huller, and the rubber roll huller, which was introduced after world war II and is most popular. Hulling machines are known by different names, such as shellers, hullers, dehuskers, huskers and hulling mills. Most commonly these machines are called "hullers". The paddy is fed into the center of the machine through a small hopper. A vertically adjustable cylindrical sleeve regulates the capacity and equal distribution of the paddy over the entire surface of the rotating disc. By centrifugal force the

paddy is forced between the two discs and as a result of pressure and friction most of the paddy is dehusked (hulled).

- **Husk Separation**

The discharge from a rice huller is a mixture of de-husked rice, husk and paddy. The mixture is transferred to screen for the separation of husk. A separator is used to screen the remaining paddy from the de-husked rice.

- **Whitening and polishing**

In the process of whitening, the silver skin and the bran layer of the brown rice are removed. During polishing of the whitened rice, the bran particles still sticking to the surface of the rice are removed and the surface of the rice is slightly polished to give it a glazed appearance.

Three kinds of whitening machines are widely used in the rice processing industry. They are- (i) the vertical abrasive whitening cone; (ii) the horizontal abrasive whitening machine; and (iii) the horizontal jet pearler

Two types of polishing machines are used in the rice mill industry. They are-(i) the vertical cone type polisher; and (ii) the horizontal polisher.

3.5 PRODUCTION PROCESS IN DRY RICE GRINDING MILLS

Typically the dry rice grinding mills are tiny scale units operated by an individual or a family. Such mills are predominantly found in southern states of India. The typical set up these mills have been shown through a set of photographs placed at *Photopage 3.4*. The typical process is explained with the help of process flow diagram given at Figure 3.5

In India, the Dry Rice Grinding is mostly carried out on job order basis. Normally in one batch of operation, about 10 kg rice is ground. Some units process from paddy to rice powder, while some process only rice to rice powder

Initially, the raw material (Paddy) is weighed in a weighing machine. Then, the paddy is fed in to dehusker for the separation of husk from the rice. Then the rice is passed through vibratory screen & destoner for the removal of foreign matter i.e. dust, mitti, stones etc . The cleaned rice is stored for a day.

The cleaned rice (raw material) is fed in to grinding machine. The grinder, which consists of a pair of jaw shapes steel plates, attached to the shaft of induction motor. The machine is a cone shaped structure; the rice is grind between two jaw plates. After grinding the product is collected in a container. The quality (fineness) of dry rice powder is controlled with the help of a rotary vane, which is operated manually. The process may be repeated for 3-4 times depending upon the fineness of dry rice powder required. After grinding, the product is collected in a container or packed in a polythene bag for commercial purpose.

FIGURE 3.4(a) :PROCESS FLOW DIAGRAM OF PARBOILING RICE PRODUCTION

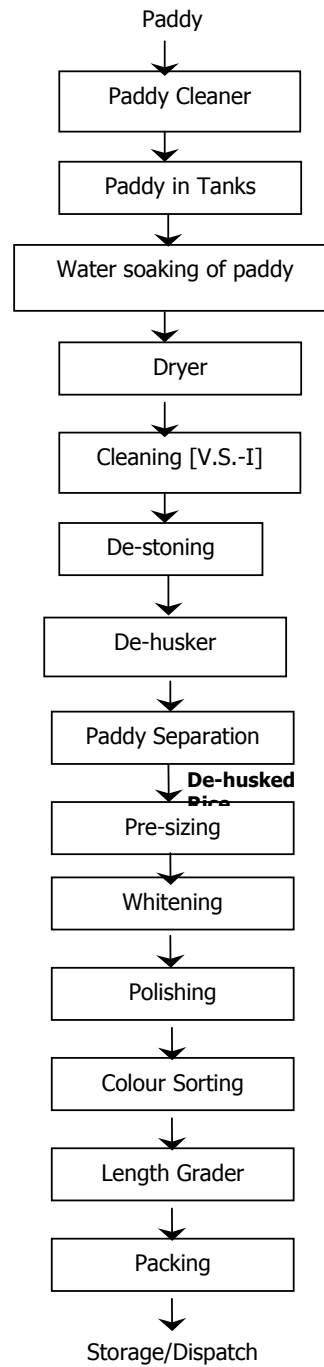


FIGURE 3.4(b): PROCESS FLOW DIAGRAM OF WHITE (RAW) RICE PRODUCTION

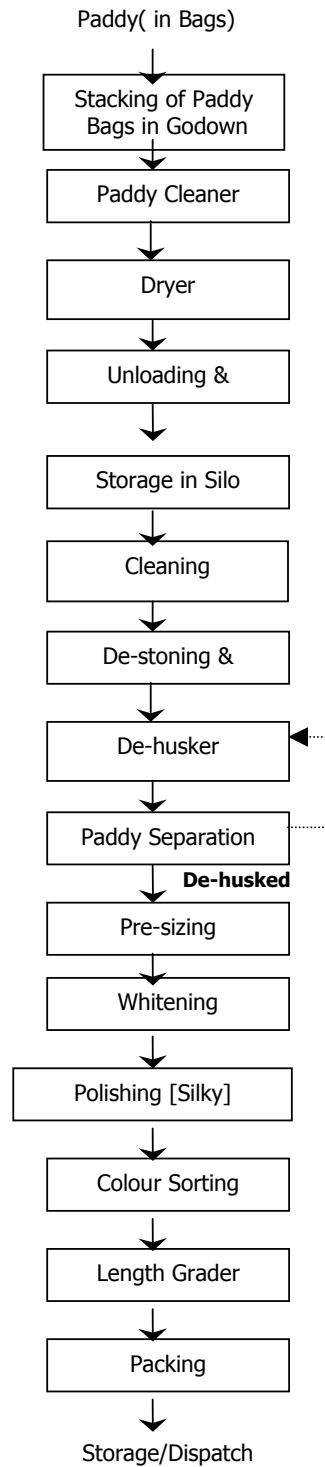
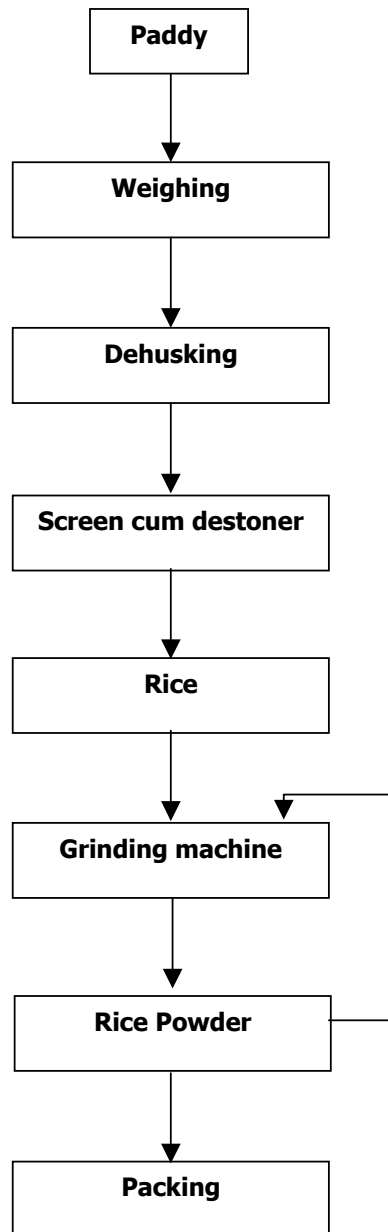


FIGURE 3.5: PROCESS FLOW DIAGRAM OF DRY RICE GRINDING MILL



3.6 Review of latest technologies

A literature review and extensive internet browsing was carried out to get information on latest technologies/developments in pulse/wheat/rice milling process equipments, especially from an angle of better environmental management practices. Highlights of some of the noticeable technologies are described below.

▪ Pulse Conditioning Unit to Eliminate Powdering

A complete automatic type process technology suitable for processing all type of pulses have been developed by M/s. S. K. Engineering and Allied Works, Baharaich, UP which could be operated only by one workman. Plants are available in capacities ranging from 1 to 8 TPH.

The technology has been specially developed to eliminate processing losses by breaking of pulses or rubbing of splits, thereby powdering losses are eliminated. It is achieved by appropriately conditioning of pulses which firstly enable losses the binding of the husk with cotylydens (Dalls) and secondly it makes ineffective the attachment of two dalls with each other (email: skengg21@hotmail.com). The yield is higher by 5 to 10 % of better quality.

The technology provides clean and hygienic working conditions and hence environmentally appropriate.

• Improved double huller rice milling

There are certain inherent defects found in the rice huller mills constraining to produce higher yield and pure bran with higher oil content. In order to overcome these defects of the conventional commercial huller, a low-capital more efficient, small capacity rice milling system has been developed by CFTRI. By this system, one can have a higher yield of good rice and bran with higher oil content.

In this system, two hullers are mounted one above the other, with gravity flow arrangement for products to move from the first to the second huller. Further, aspiration and sieving systems are also provided in order to separate the husk and to get oil-rich bran, containing 13-14 % oil. It has additional advantage of reducing the grain breakage because of its gentle, step-wise milling action. The rice output is thus increased. The double huller rice milling system has a capacity to mill about 300/500 kg of paddy per hour. The unit can be established in rice growing rural parts, as a custom service unit.

CHAPTER - 4

ENVIRONMENTAL POLLUTION ASPECTS IN PULSE/WHEAT/RICE MILLS

A medical research (by Mc Louth and Paules, 1961, reference Page 356 of Air Pollution Engineering manual, US Department of Health, Education and Welfare, 1967) shows deleterious or toxic effects of feed grain dusts, many individuals experience bronchial or allergic disturbances after exposure to feed and grain process dusts. Persons affected may be inside the grain processing plant or even some miles downhill.

The raw material received by the mills commonly contain much fine dust in addition to long fiber shaped dust particles. Fine dust may include the actual soil in which the grain was grown, owing to wind or rain action in the field. Other fine particles may originate from weeds or insects or be produced from the grain itself by abrasion in handling and storing. For these reasons, no reliable prediction of the kind and amount of dust in one lot of raw-material may be expected. The amount of dust found in many other miscellaneous feed materials varies far more widely than in grains.

In the conveying equipments, the rubbing friction of the raw-material creates fine dust particles. Dust is generated at the transfer points of the enclosed conveying equipment, carried through bucket elevators and emitted at the discharge of the conveyed materials. In size reduction of the whole grains or other feed materials, the amount of dust discharged from the pneumatic conveyor cyclone may increase as the materials are more finely ground, the character of the material however is the chief determinant of the dust generated.

The main pollutant of concern in pulse, wheat & rice milling facilities is particulate matter emission generated from material handling, cleaning, milling or packing operations. These operations are typically located in side the mill buildings. Dust released from these operations spread inside the shop floor environment of the factory. Dust extraction systems are generally used to collect the dust and to improve the shop floor environment. Dust emitted inside the mill may settle on the floor and wall surfaces, or may be emitted to the environment through doors and windows.

The environmental aspects associated with the pulse, wheat and rice mills from the view point of air pollution, water pollution and noise etc. are discussed below separately for each type of mills.

4.1 AIR POLLUTION

4.1.1 Pulse Making Mills

During the process of the Pulse making, dust is generated/emitted from various points, which spreads into the surrounding areas and pollute the shop floor environment. A schematic presentation of the process flow diagram showing the points of dust generation is shown at Figure 4.1.

Sources of Dust Emissions

A) Cleaning Section

In the cleaning section, fine dust is generated at various points as detailed below:

- While Unloading the pulses
- At different stages of lifting and discharging of pulses through bucket elevator and pipes.
- During rotary screening
- During Scratching of pulses for breaking of tips (nakku) in Roller type m/c
- At Discharge points of the rotary screens
- De-stoner machines
- Blown away dust/ bhussi

B) Milling Section

In this section, the dust generated is lesser compared to the cleaning section, as most of the dust has already been cleaned in the cleaning section. The dust emanating from this section is mainly due to breaking of chana and its movement.

The points of generation are:

- The bucket elevator discharge points
- Chakki discharge (Milling/Grinding).
- Chillka collection/ storage room.
- The reel machines
- The grinding chakki/ machines
- The rotary screen classifiers

The dust and powder emitted from the cleaning and milling sections need to be separately extracted and captured in separate air pollution control systems. The dust collected from the cleaning section primarily contains impurities like soil, silica, stones etc. which needs to be disposed, whereas, the powder collected from the milling section is a byproduct which can be sold as animal feed.

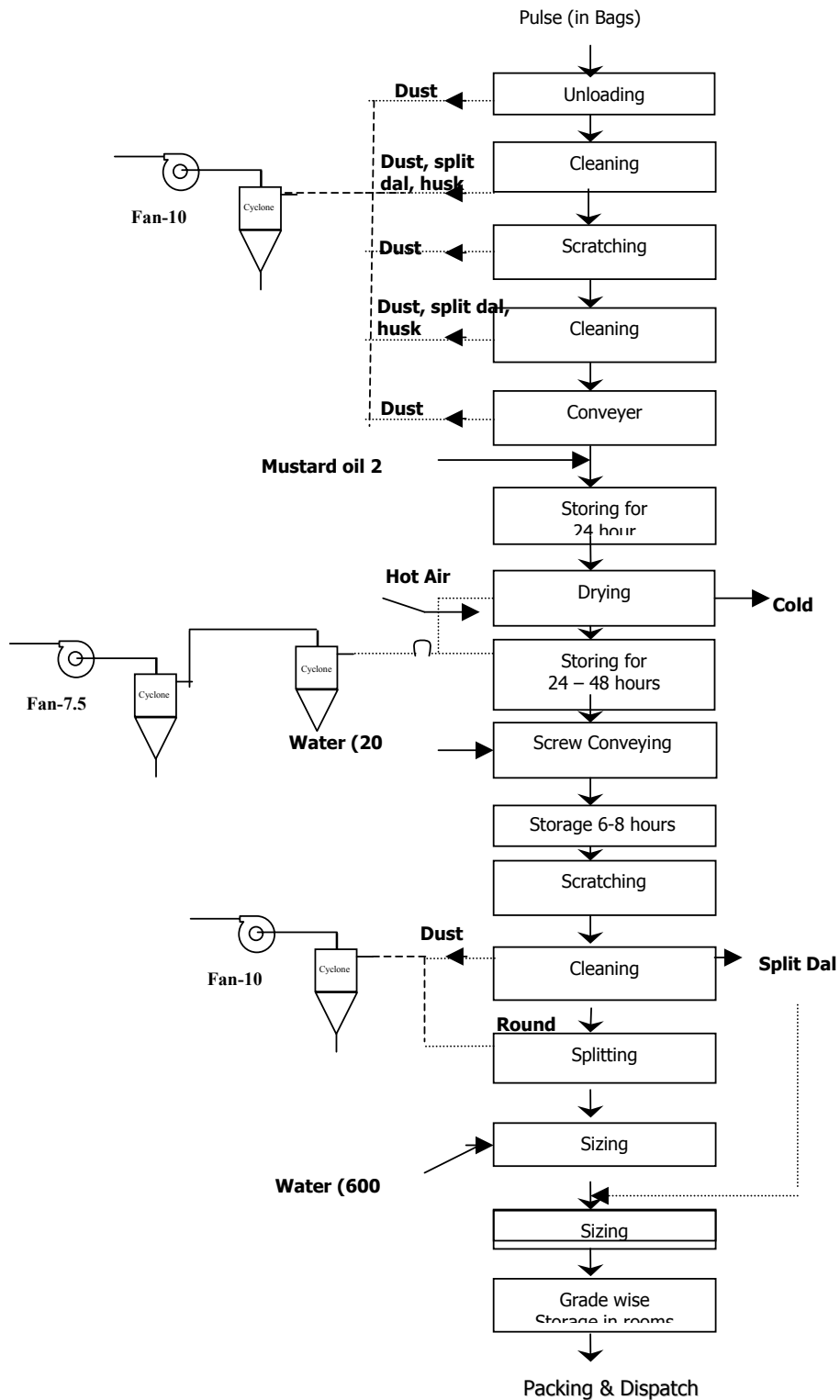
4.1.2 Pulse Grinding Mills

In the Pulse Grinding Mills, since the raw material is clean dal, there is hardly any dust emission at the sections like bucket elevator discharge point or classifying screen. After grinding, the besan is pneumatically transported and separated in the centrifugal /cyclone type equipment and the fine besan escaping the centrifuge is collected in filter bags. No fine besan is allowed to escape from leakages etc. as it would be loss of product. There are no fugitive emission sources observed in these mills.

Sources of Dust Emissions

In the Pulse grinding mills, the source of emissions could be leakages in the system if any. No stack is provided discharging emissions to environment.

FIGURE 4.1: PFD OF A TYPICAL PULSE MILL SHOWING POLLUTION SOURCES & CONTROL SYSTEMS



4.1.3 Wheat Flour Mill

In the wheat flour mills, the cleaning process is somewhat similar to that followed in the pulse mills. However, the number of stages of cleaning are generally two or three stages (more compared to that of pulse mills) to ensure thorough cleaning of the wheat. Sources of emission are similar as discussed in the pulse mills section. In general, single cyclone or a series of two or three cyclones are commonly installed as dust collection devices for the cleaning section in the wheat mills. A schematic presentation of the process flow diagram showing the points of dust generation in is shown at Figure 4.2, 4.3 & 4.4 for dry type wheat flour mill, wet type wheat flour mill & wheat processing (roasting) mills respectively.

In the milling section, the outer shell is separately collected through a combination of cyclones. The fine powder emissions from subsequent milling stages is primarily the product in terms of wheat, flour or maida which is carefully collected using high efficiency multiple cyclones and bag filter house.

In wheat flour mill, dust is generated at various points in the cleaning and milling sections and are detailed below.

Sources of Dust Emissions:

Cleaning section:

- While Unloading the wheat
- At different stages of lifting and discharging of wheat through bucket elevator and screw conveyor
- At Reel machine
- During vibrating screening
- At De-stoner machines
- At Scourer machine
- At Aspirator machine
- At Magnetic separator
- At Toggle Cylinder

Milling Section

- At bucket elevator discharge points
- At Grinding mill discharge.
- At Purifier machine
- At Plansifter machine

FIGURE 4.2: PFD OF A TYPICAL DRY TYPE WHEAT FLOUR MILL SHOWING POLLUTION SOURCES & CONTROL SYSTEMS

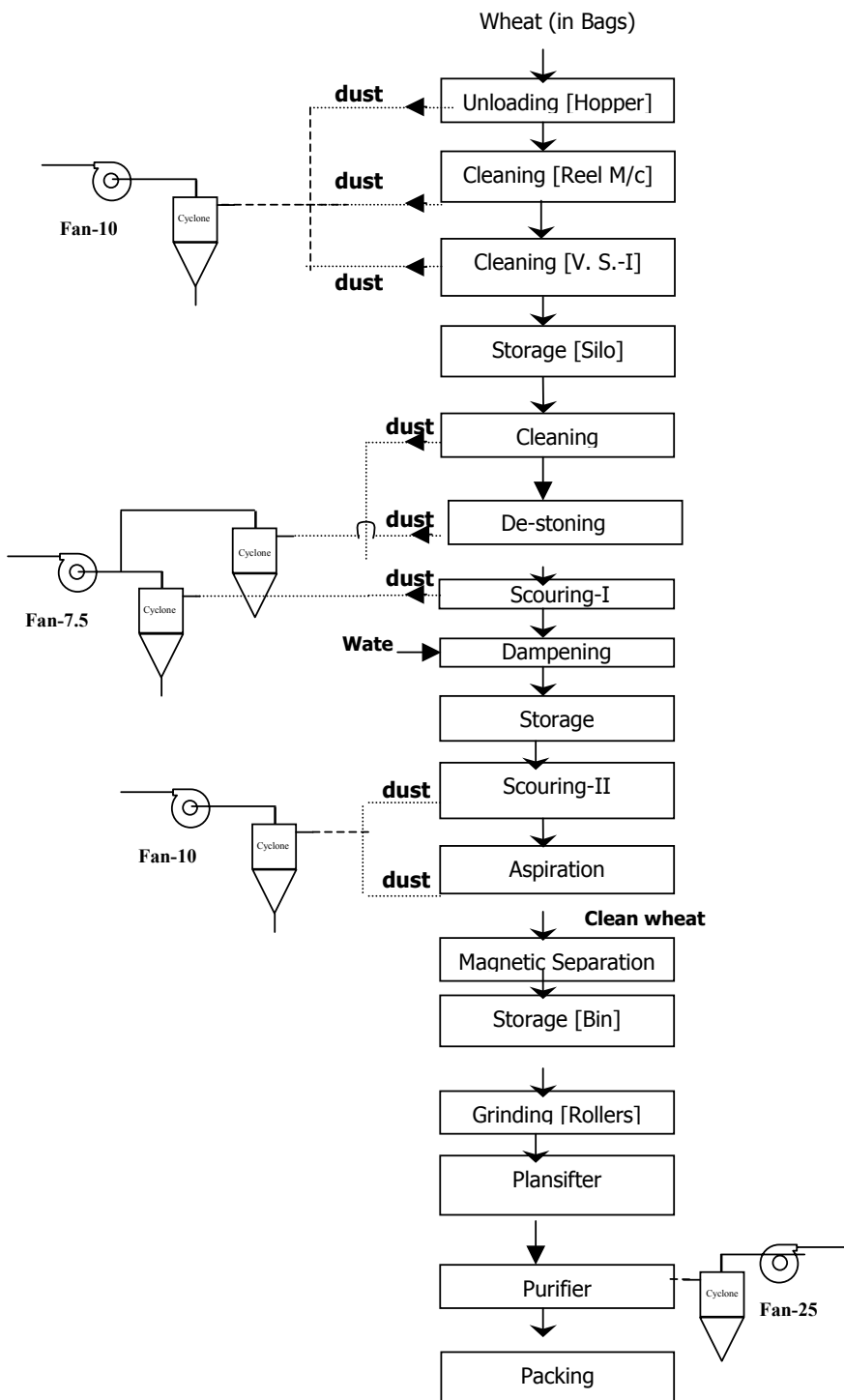
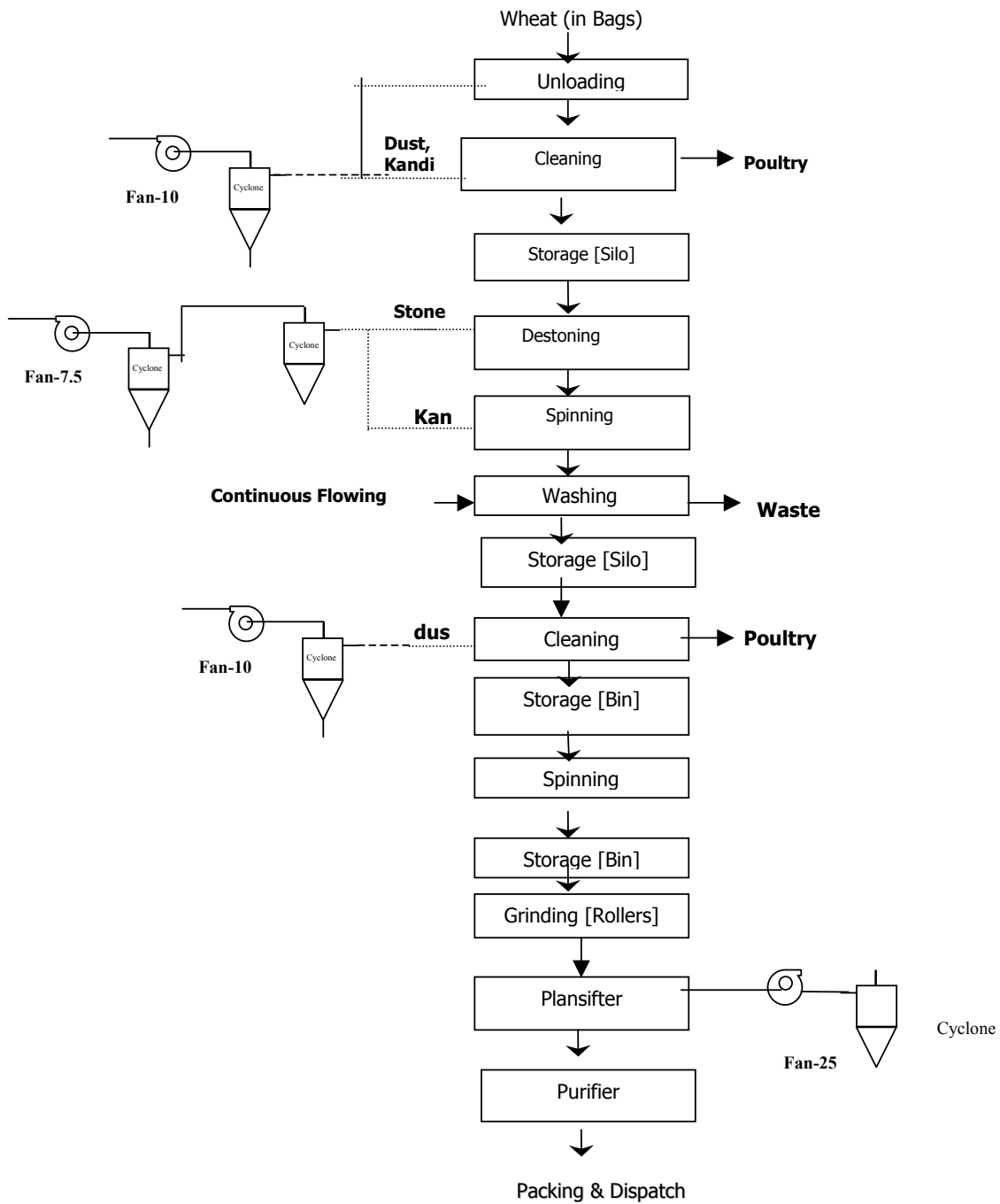


FIGURE 4.3: PFD OF A TYPICAL WET TYPE WHEAT FLOUR MILL SHOWING POLLUTION SOURCES & CONTROL SYSTEMS



4.1.4 Wheat Processing (Roasting) Mill

In the wheat roasting mill, the dust emission occur primarily from the cleaning section & fumes/combustion gases are emitted from the roaster. The points of dust/fume emissions are as given below:

Sources of dust emissions:

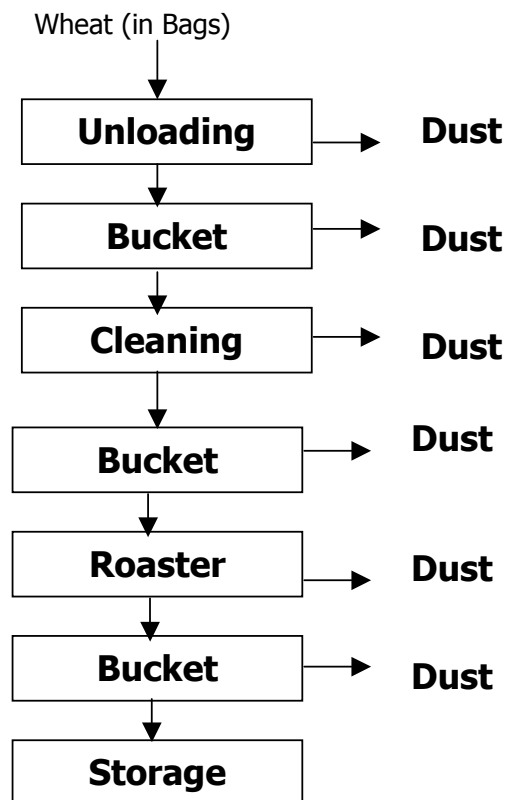
- Raw wheat unloading point
- Wheat conveying Bucket Elevator discharge points
- Rotary Screen
- Roaster feeding end & discharge end
- Points of free fall of wheat through pipes

Sources of fumes/gas emissions

- Oily fumes from the material discharge end of the roaster
- Combustion gas emission through leakages in the roaster walls & roofs

The dust/fume generated from above mentioned sources need to be extracted/sucked from various point as close to the source of generation as possible and it should be directed through efficient control equipment.

FIGURE 4.4: PFD OF A TYPICAL WHEAT PROCESSING (ROASTING) MILL SHOWING POLLUTION SOURCES & CONTROL SYSTEMS



4.1.5 Rice Mill

In a rice mill, the primary air pollutant is particulate matter emissions from the cleaning & milling sections. In the par-boiled type rice mills, the particulate matter is also emitted from the Boiler Stack. A schematic presentation of the process flow diagram showing the points of dust generation in is shown at Figure 4.5, 4.6 & 4.7 for par-boiled rice producing mills, raw rice producing mills and dry rice grinding mills respectively. Various dust generating sources in a rice mill are mentioned below:

Sources of Dust emissions

Cleaning Section:

- While Unloading the paddy
- At different stages of lifting and discharging of paddy rice through bucket elevator
- During pre-cleaning (Chalni)
- During paddy cleaning in paddy cleaner/ vibrating screen
- At Destoner machine
- At Magnetic separator

Milling Section

- At different stages of lifting and discharging of paddy /rice through bucket elevator
- During dehusking in rubber roll
- At Aspirator used for husk removal
- During polishing of rice
- During grading of rice in rice grader

Boiler House

- Flue gas through boiler stack

**FIGURE 4.5 PFD OF A TYPICAL PARBOILING RICE PRODUCING MILL & HOUSING
SHOWING POLLUTION SOURCES & CONTROL SYSTEMS**

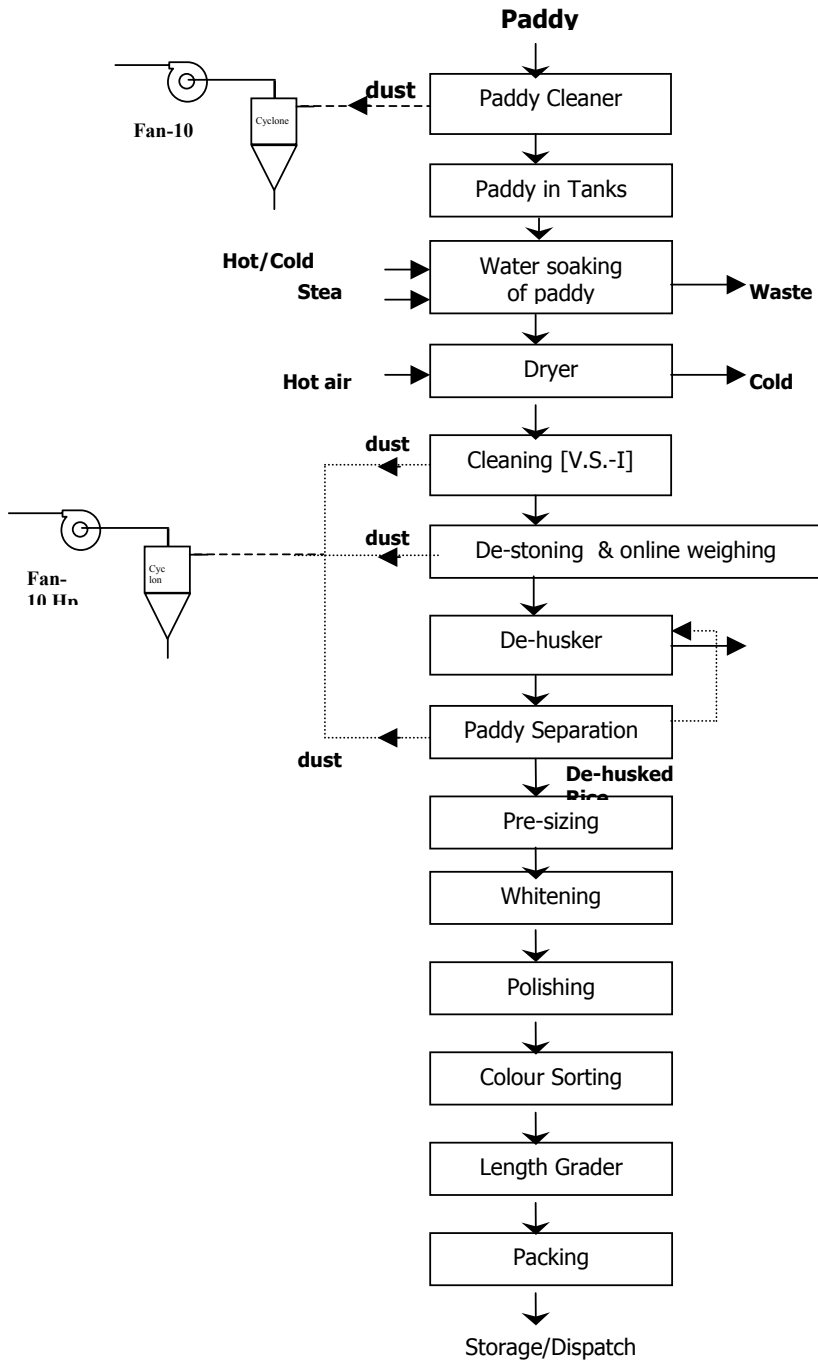
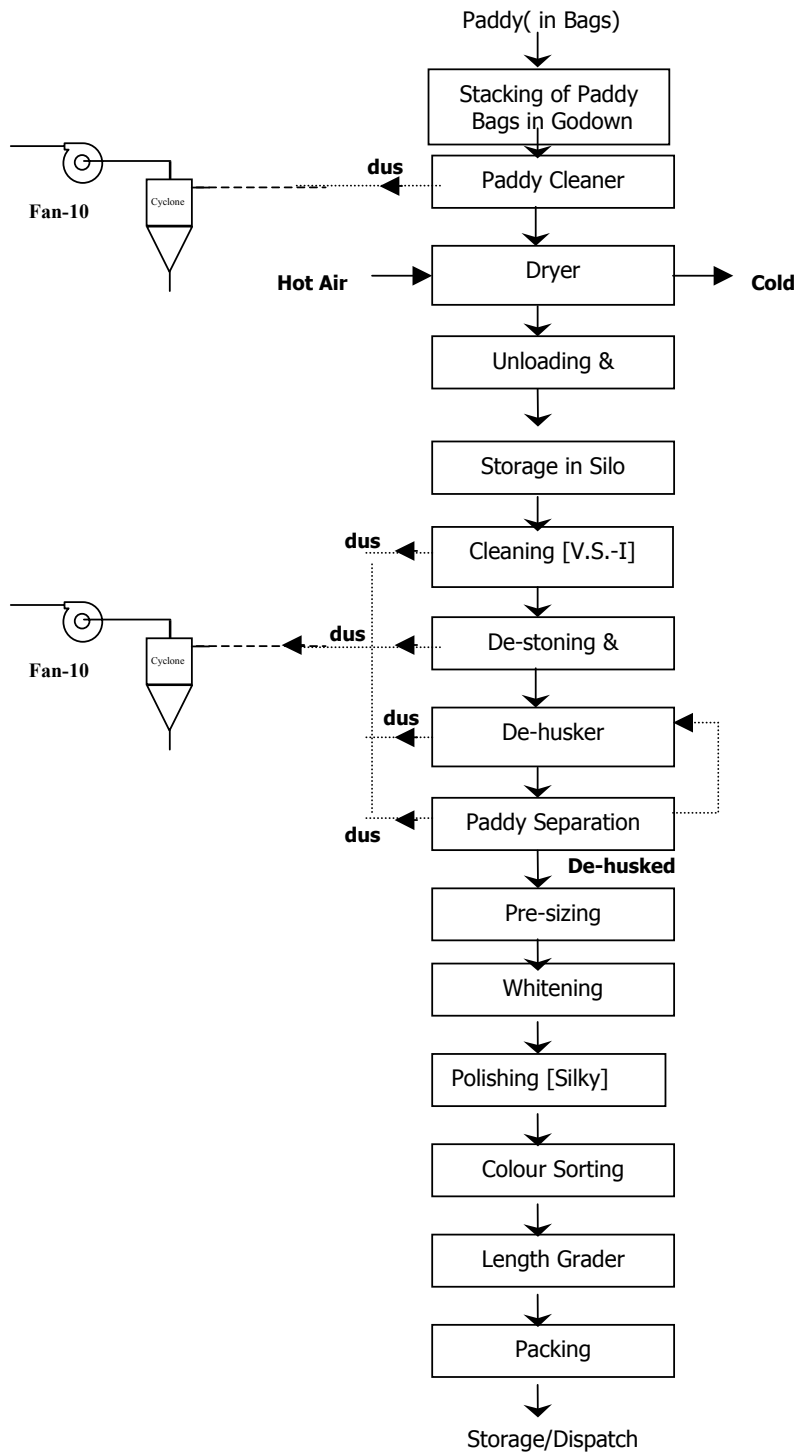


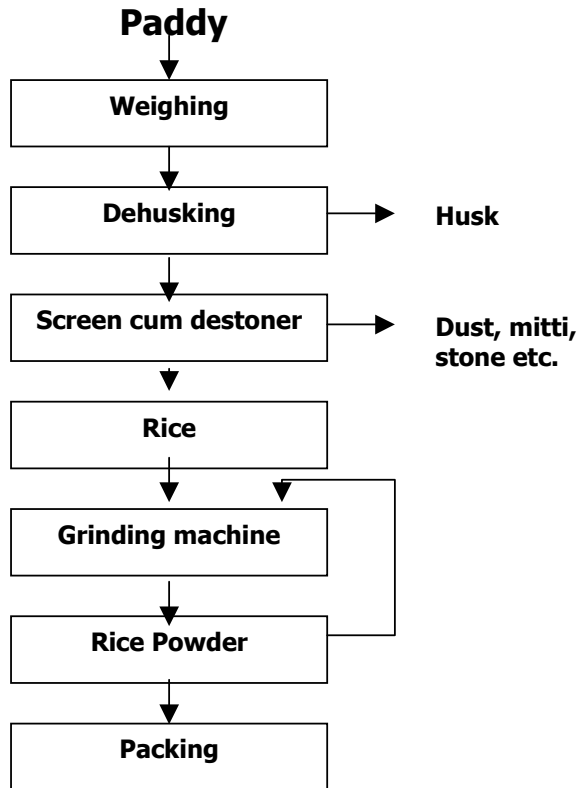
FIGURE 4.6 PFD OF TYPICAL WHITE (RAW) RICE PRODUCING MILL SHOWING POLLUTION SOURCES & CONTROL SYSTEMS



4.1.6 Dry Rice Grinding Mills

In Dry Rice Grinding Mills, some mills process from raw paddy to rice powder, while some mills process rice grains to make rice powder. In the mills processing paddy, the particulate matter emission occur while cleaning & dehusking the paddy. During rice grinding, as the fine rice powder is the product, it is not allowed to escape, as it is loss of product. There is no stack attached to any grinding equipment.

FIGURE 4.7 PFD OF DRY RICE GRINDING MILL SHOWING POLLUTION SOURCES & CONTROL SYSTEMS



4.2 WATER POLLUTION

4.2.1 Pulse Making Mills:

In the pulse making mills, there is no wastewater generation from process, since whatever little quantity of water if used for conditioning the pulses gets consumed /evaporated completely. However, the storm (rain) water from the rooftops may carry the organic residual material comprising of pulses/ shells etc lying on the roof terrace during sun-drying. This storm water is generally let out to the public sewer directly.

4.2.2 Pulse Grinding Mills:

In the Pulse Grinding Mills, there is neither any wastewater generated nor the storm water is contaminated, as there is no sun-drying operation in these mills.

4.2.3 Wheat Flour/Processing Mills -Dry Type:

In dry type wheat flour mills, there is no wastewater generation from process.

4.2.4 Wheat Flour Mills -Wet Type:

In wet type flour mills, where water is used for washing of wheat, wastewater is generated from these mills. These types of wet flour mills are only old mills and the most modern mills operate on dry basis and do not use any water during the process and, therefore, no effluents are generated.

4.2.5 Wheat Processing (Roasting) Mills:

In wheat processing (Roasting), there is no wastewater generation from process.

4.2.6 Rice Mills

In rice mill, the wastewater is usually generated in the parboiled rice mills from the soaking operation. In addition, in few older mills where mechanical cleaning facilities are not available, the cleaning is done by washing of paddy prior to further processing and this leads to generation of wastewater.

In the parboiled type of Rice mills, wastewater is also generated from the Boiler section in the form of Boiler Blow down, Backwash of DM Plant/Softener and from discharge of Wet scrubber type air pollution control equipments installed for the controlling of Boiler Stack emission.

In the Dry Rice Grinding Mills, there is no use of water in the process and therefore there is no generation of wastewater.

A table showing various wastewater generation sources in all the above type of mills is given below:

Wastewater/Storm Water Generation From Different Types Of Mills

Type of Mill	Section	Point of wastewater/ storm water generation
Wheat	Wet type Flour Mill	Washing of cleaned wheat
Rice	Par-Boiling (Handi)	Soaked wastewater discharged from Handi.
	Boiler House	Softener/ DM Plant backwashing
Pulse	Pulse Making Mills	Rainwater from roof terrace (storm water)

4.3 NOISE POLLUTION

Noise is generated from various material handling and process equipments, which are highlighted below:

Typical Noise Pollution Sources In Pulse/Wheat/Rice Mills

Types of Mill	Section	Points of Noise emission
Pulse	Cleaning	Vibrating screen
		Reel machine
		Destoner
		Bucket Elevator
	Milling	Bucket elevator Chakki
Wheat	Cleaning	Separator
		Scourer
		Vibratory screen
		Reel machine
		Destoner
	Milling	Packing machine
		Roller Mill
		Purifier
		Planshifter
		Blower
		Bran Finisher
		Milling Fan
		ID Fan
Rice	Cleaning	Destoner
		Vibratory Screen
		Bucker Elevator
		Dryer
	Milling	De-stoner
		Polisher
		Colour Sorter
		Length Grader
		Blower
		Dehusker
		Paddy separator
		Thickness Grader
		Whitener
		Packing Section
	Paddy cleaner	
Boiler House	ID Fans, soot blowing	

Apart from the above sections, noise is also generated from the diesel generating sets.

CHAPTER-5 CHARACTERISATION & QUANTIFICATION OF POLLUTANTS

5.1 HIGHLIGHTS OF FIELD STUDY UNITS

For the purpose of characterization and quantification of various pollutants in various types of mills, visits were made to several industries and detailed field studies were conducted in number of industries in each category. Based on the measured values, the average values (from each section) have been taken as basis to characterize the typical pollutant streams.

Broadly the characterization and quantification has been done for air (emissions), water (wastewater/storm water) and noise pollutants. For all the category of mills, broadly there are two sections, one the cleaning section and other the milling section. The characterization of pollutants from both cleaning and milling section has been done separately.

The detailed field studies were carried out in various units mentioned in the Table-5.1 below. (For further details about these units, refer Annexure-5.1). A few photographs during conduction of the field studies are given at Photo-page –5.1.

TABLE-5.1: List of Industries Where Detailed Studies were carried out

Unit Code	Type of mills	Location of unit	Capacity	Product (s)
PMK-1	Pulse Making	Indore (Madhya Pradesh)	2 TPH	Urad dal
PMK-2	Pulse Making	Indore (Madhya Pradesh)	2 TPH	Chana Dal
PMK-3	Pulse Making	Delhi	1.5 TPH	Moong
PMK-4	Pulse Making	Delhi	3 TPH	Chana
PMK-5	Pulse Making	Delhi	2 TPH	Moong
PMK-6	Pulse Making	Nagpur (Maharashtra)	1.5 TPH	Arhar Dal
PGN-1	Pulse Grinding	Delhi	0.75 TPH	Chana Besan
WFR-1	Wheat Flour	Panchkula (Haryana)	5.5 TPH	Atta, Maida, Suji, Bran
WFR-2	Wheat Flour	Panchkula (Haryana)	5.5 TPH	Atta, Maida, Suji, Bran
WFR-3	Wheat Flour	Indore (Madhya Pradesh)	3.75 TPH	Wheat Flour
WFR-4	Wheat Flour	Indore (Madhya Pradesh)	9 TPH	Atta, Maida, Suji, Bran
WPR-1	Wheat Processing	Delhi	0.75 TPH	Roasted Wheat
RIM-1	Rice Mill	Durg (Chhattisgarh)	2 TPH	Parboiled Rice
RIM-2	Rice Mill	Durg (Chhattisgarh)	2 TPH	Parboiled Rice
RIM-3	Rice Mill	Bhandara Road (Maharashtra)	2.5 TPH	Raw Rice

Unit Code	Type of mills	Location of unit	Capacity	Product (s)
RIM-4	Rice Mill	Bhandara Road (Maharastra)	2 TPH	Raw Rice
RIM-5	Rice Mill	Bhandara Road (Maharastra)	1.5 TPH	Raw Rice
RIM-6	Rice Mill	Sonepat (Haryana)	1.5 TPH	Raw Rice
RIM-7	Rice Mill	Sonepat (Haryana)	1.8 TPH	Raw & Parboiled Rice
RGM-1	Dry Rice Grinding	Tirunelveli District, Tamilnadu	1.0 TPH	Rice Powder

Based on the detailed field studies conducted in above mentioned units, the characterization & quantification of pollutants in various types of mills/ sections is presented in following tables:

Table no.	<u>Characterisation & quantification of Pollutants in different sections</u>
5.2	Emissions from Pulse Making Mills- Cleaning Section
5.3	Emissions from Pulse Making Mills- Milling Section
5.4	Emissions from Wheat Mills- Cleaning Section
5.5	Emissions from Wheat Mills- Milling Section
5.6	Emissions from Rice Mills- Cleaning Section
5.7	Emissions from Rice Mills- Milling Section
5.8	Storm water from Pulse Making Mills
5.9	Effluent from Wet Flour Mills
5.10	Effluent from Par-Boiled Mills
5.11	Typical Noise level range at shop floor
5.12	Typical Noise Level range of various equipments commonly used in Pulse/ Wheat/ Rice Processing Mill
5.13	Typical Noise level range outside the unit premises

In addition, visits were also made to more units in different states for the purpose of general assessment of the mills, the names of these additional units visited is given at Annexure-5.2.

The tables giving characterization & quantification are given through following pages along with discussions on the important aspects of the data.

5.2 CHARACTERISATION OF AIR POLLUTION (EMISSIONS)

5.2.1 Pulse Mills

5.2.1(a) Pulse Making Mill - Cleaning Section

Based on the field measurements conducted in the cleaning section of several dal mills, characterization and quantification of emissions based on the average values are given in the table below

TABLE-5.2: CHARACTERISATION OF EMISSIONS FROM PULSE MAKING MILLS - CLEANING SECTION

Unit code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load Before APCD (kg/hr)	Specific Dust Load Before APCD (Kg/T)
		Before APCD (mg/NM ³)	After APCD (mg/NM ³)				
PMK-1	2	28820	(a)	Cy+OBF	2571	74.1	37.0
PMK-2	2	35200	805	cy	3193	112.4	56.2
PMK-4	3	1211	(a)	Cy+ OBF	3210	3.9	1.3
PMK-3	3	NM	15.4	CBF-3	1740	NM	NM
PMK-4	3	12575	31.5	Cy+ Bagfilter	3220	40.5	13.5
PMK-5	2	8225	48.2	Cy +Bagfilter	6120	50.3	25.2

Note: (a): For the cyclone cum open bag filter type APCD, since there is no final stack, no stack monitoring was possible after APCD.

Particle Size Distribution Of Emissions In Cleaning Section

Particle size distribution was also conducted in the cleaning section of Pulse making mill before APCD for the purpose of generating data on the percentage of particles of various sizes and specially the finer particles below 10 micron. The results of the measurement are given in the table below:

PARTICLE SIZE	% OF PARTICLES
> 1 micron	93.1
> 2 micron	86.2
> 5 micron	67.8
> 10 micron	44.8
> 15 micron	29.3
> 20 micron	19.1
> 30 micron	7.9
Fine Particle content	
<10 micron	45.2
< 5 micron	32.2

The above particle size distribution analysis shows that more than 45% particles are of small size (<10 micron).

The particulate matter concentration measured at the inlet of the APCD varies drastically from 1,211 to 35,200 mg/NM³. This variation could be due to different reasons such as variation in the raw material quality and dust content, efficiency of extraction systems, type of APCD, fugitive emission etc.

In the unit employing only cyclone type dust collector has final emission level of 805 mg/NM³ (with inlet loading of 35,200 mg/NM³). For other units employing cyclone plus open bag filter type APCD, since there is no final discharge stack, the measurement regarding efficiency cannot be carried out. In other units employing an appropriate bag-filter (close bag-house with cleaning mechanism discharging treated emission through a stack), the final emission levels of 31.5 to 48.2 mg/NM³ are achieved and such APCDs have efficiency of 99.4 to 99.7%.

Typically the emissions from the cleaning section comprise of dirt, dust, etc. carried from agriculture field along with the raw material. Out of the units studied, some units had Cyclone cum Open Bag-filter type arrangement without final outlet stack and without any bag cleaning mechanism. Such system could only partially suck the emission from the dust generating sources and there was high level of fugitive emissions observed at the sources. However, some units had a proper closed type bag-filter house along with stack and cleaning arrangement which were able to suck/extract the dust emissions from all the dust generating points satisfactorily and the fugitive emission in the shop floor were eliminated/ minimal.

The specific dust load (kg of dust emission per ton of raw material processed) measured based on the dust concentration before the control system multiplied by the gas flow rate varies widely. This depends on the source of the raw material, its quality, dust/dirt carry over from the agricultural field which varies drastically from industry to industry and the actual amount of dust sucked by the APCD which also varies widely as per the type of system designed. A badly designed extraction system may only suck a little amount of dust and the major portion of the dust either escapes from the sources as fugitive emission or gets carried away to subsequent later stage of processing which affects the quality of product adversely. Based on the data of the units who have proper extraction cum control arrangement with negligible fugitive emission, the specific dust load varies in the range of 13.5 to 25.2 kg/T (1.3 to 2.5%).

5.2.1(b) Pulse Making - Milling Section

Based on the field measurements conducted in the milling section of several Pulse Making Mills, characterization and quantification of emissions based on the average values are given in the table below

Table-5.3: Characterization of Emissions From Pulse Making Mills - Milling Section

Unit code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load Before APCD (kg/hr)	Specific Dust Load Before APCD (Kg/T)
		Before APCD (mg/NM ³)	After APCD (mg/NM ³)				
PMK-1	2	4209	(a)	Cy+OB F	2590	10.9	5.5
PMK-2	2	NM	(a)	Cy+OB F	3238	NM	NM
PMK-4	3	3449	(a)	Cy+OB F	3870	13.3	4.4

PMK-3	3	NM	11.8	CBF	2480	NM	NM
PMK-4	3	17685	31.5	Cy+CB F	5210	92.1	30.7
PMK-5	2	11930	48.2	Cy+CB F	3710	44.3	22.1

Note: Cy – Cyclone, OBF – Open Bag filter, CBF – Closed Bag filter.

(a): For the cyclone cum open type bag filter type APCD, since there is no final stack arrangement at the outlet of bag filter, no stack monitoring after APCD can be conducted

The average dust concentration measured before the APCD varies widely from 3449 to 17685 mg/NM³. The specific dust load (kg emission per ton of cleaned raw material processed) varies from 4.4 to 30.7 Kg/T. In the units where the extraction system is not satisfactory and there are high fugitive emissions in the shop-floor, the emission actually extracted by the system are lesser and therefore the specific dust load is also lower in the range of 4.4 to 5.5 Kg/T. However, in other units where better extraction system exists along with a proper bag filter arrangement, the specific dust load is higher in the range of 22.1 to 30.7 Kg/T (2 to 3 %).

Particle Size Distribution Of Emissions In Milling Section

PARTICLE SIZE	% OF PARTICLES
> 1 micron	97.6
> 2 micron	93.4
> 5 micron	76.4
> 10 micron	46.8
> 15 micron	24.8
> 20 micron	11.8
> 30 micron	2.0
<i>Fine Particle Content</i>	
<10 micron	53.2
< 5 micron	33.6

The above particle size distribution analysis of the emission from the milling section before control system indicates 53.2% particles are of small size (less than 10 micron).

Ambient SPM concentration range

Ambient SPM concentration measurements were carried out outside the mill premises and the average range of values are given below:

Parameters	<u>SPM Range</u> ($\mu\text{g}/\text{m}^3$)
SPM	12,106 to 49,755

Sox	0.4 to 22.77
Nox	1.0 to 17.7

The above ambient SPM concentration is substantially high which is due to un-extracted emission from the process equipment which give rise to fugitive emission which spread in the surrounding environment through the opening / doors and results into high ambient SPM level.

The units where measurements were carried out were primarily small-scale units with hardly any open space outside the building housing the mill. Due to inadequate dust extraction and control arrangement substantial fugitive emissions were observed from various process equipment and these emissions find way out through the opening like gates and windows and spread into ambient environment. The samplers were located close to the unit boundary that is also close to the factory building gates.

Part of the SPM could be due to other activities outside the unit premises and due to road transportation etc.

Fugitive Dust Emission Measurement

There were fugitive emissions observed in various mills, which may be due to inadequate provision of dust extraction system. The SPM measurements were conducted at the shop floor of the Pulse making units primarily to estimate the fugitive emissions arising out of ineffectiveness of dust extraction systems. It was assumed that an inefficient dust extraction arrangement would lead to higher SPM concentration at shop floor and efficient dust extraction would have lesser SPM concentration at shop floor.

The average values measured are given in the table below:

Section	<u>SPM Range</u> ($\mu\text{g}/\text{m}^3$)
Cleaning	13,825 to 45,097
Milling	6,910 to 50,636

5.2.1(c) Pulse Grinding (Besan) Mill

As there is no stack attached to any process equipment in Besan Mills, no stack monitoring could be carried out. However, in order to assess in appropriateness of the pneumatic conveying system of Besan, shop floor SPM concentration measurement was carried out to measure the impact of fugitive emissions on shop floor air quality. The High Volume Sampler were operated in the vicinity of process equipments .The result are given below:

Pulse Grinding- Shop Floor SPM Concentration

Parameters	Range ($\mu\text{g}/\text{m}^3$)
SPM	2,267 to 13, 277

The SPM concentration in the shop floor could be due to some amount of fugitive emission through leakages etc. in the system.

5.2.2 Wheat Mills

5.2.2(a) Wheat Flour Mill- Cleaning Section

Based on the field measurements conducted in the cleaning section of several Wheat Flour Mills, characterization and quantification of emissions based on the average values are given in the table below.

TABLE-5.4: Characteristics Of Emissions From Wheat Flour Mills- Cleaning Section

Unit code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load Before APCD (kg/hr)	Specific Dust Load Before APCD (Kg/T)
		Before APCD (mg/NM ³)	After APCD (mg/NM ³)				
1st STAGE CLEANING							
WFR-4	9	4496	NM	Cy	3030	13.6	1.5
WFR-3	4	1712	27	Cy	2980	5.1	1.3
WFR-1	5.5	2564	218	Cy	6128	15.7	2.9
WFR-2	5.5	NM	250	Cy	8695	NM	NM
2nd STAGE CLEANING							
WFR-4	9	5941	189	Cy	9490	56.4	6.3
WFR-3	4	1457	193	Cy	2960	4.3	1.1
WFR-1	5.5	2840	121	Cy	4913	14.0	2.5
WFR-2	5.5	NM	127	Cy	7657	NM	NM
3rd STAGE CLEANING							
WFR-4	9	2279	298	Cy	3030	6.9	0.8
WFR-3	4	690	17	Cy	2980	2.1	0.5
WFR-1	5.5	2205	105	Cy	6128	13.5	2.5

Typically the cleaning section of flour mills has three stages of cleaning namely, 1st, 2nd & 3rd stage cleaning. The cleaning is done rigorously so as to remove all dust /dirt and foreign matter from the wheat else the carried over dust would get mixed with wheat flour and would hamper its quality adversely. Each stage of cleaning has a separate dust extraction cum cyclone system with separate ID Fans.

The above data indicates dust concentration (Before APCD) in the 1st stage cleaning in the range of 1717 to 4496 mg/NM³, in the 2nd stage cleaning in the range of 1457 to 5941 mg/NM³, in the 3rd stage cleaning in the range of 690 to 2279 mg/NM³.

The specific dust load in the 1st stage cleaning varies in the range of 1.3 to 2.9 Kg/T, 2nd stage from 1.1 to 6.2 and in the 3rd stage from 0.5 to 2.5 This large variation in the specific dust load could be due to variation in the dust and foreign matter content in the raw wheat procured by the different mills from different sources.

The average of 1st stage cleaning dust concentration is 2924 mg/NM³, for 2nd stage cleaning it is 3413 mg/NM³ and for 3rd stage cleaning the average is 1725 mg/NM³ The overall average for the cleaning section as a whole works out to 2687 mg/NM³ (Before APCD).

Particle Size Distribution -Cleaning Section Of Flour Mill:

PARTICLE SIZE	% OF PARTICLES
> 1 micron	98.1
> 2 micron	91.3
> 5 micron	70.2
> 10 micron	50.5
> 15 micron	41.0
<u>Fine Particles range</u>	
<10 micron	49.5
< 5 micron	29.8

The above particle size distribution analysis shows that more than 49.5% particles are of small size (<10 micron) and 29.8% are in even smaller size range of less than 5 micron.

5.2.2(b) Wheat Flour Mill – Milling Section

Based on the field measurements conducted in the milling section of several Wheat Flour Mills, characterization and quantification of emissions based on the average values are given in the table below:

TABLE: 5.5: Characteristics of Emission From Wheat Flour Mill- Milling Section

Unit Code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load Before APCD (kg/hr)	Specific Dust Load Before APCD (Kg/T)
		Before APCD	After APCD				
		(mg/NM ³)	(mg/NM ³)				
WFR-4	9	1036	242	2 Cyclone in series	10700	11.1	1.2
WFR-3	4	NM	112.67	Cyclone	10500	NM	NM
WFR-1	5.5	NM	88.5	Cyclone	9662.3	NM	NM
WFR-2	5.5	NM	14.5	Cyclone	6285	NM	NM

Note: (a): For the cyclone cum open bag filter type APCD, since there is no final stack arrangement at the outlet of bag filter, no stack monitoring after APCD can be conducted. NM: Not measured due to non-availability of port-hole arrangement

The average dust concentration at the outlet of the control equipment is in the range of 14.5 to 242 mg/Nm³. In the milling section of the flour mills mostly single or multiple cyclones are employed.

Particle Size Distribution -Milling Section Of Flour Mill:

PARTICLE SIZE	% OF PARTICLES
> 1 micron	99.3
> 2 micron	96.8
> 5 micron	78.5
> 10 micron	32.9
> 15 micron	6.6
> 20 micron	0.6
> 30 micron	0.0
<u>Fine Particles range</u>	
<10 micron	67.1
< 5 micron	21.5

The above particle size distribution analysis shows that more than 67% particles are of small size (<10 micron).

Ambient SPM concentration range

Parameters	<u>SPM Range</u> ($\mu\text{g}/\text{m}^3$)
SPM	380 to 886

The ambient SPM range of 380 to 886 shows that in some areas the fugitive emissions lead to higher SPM concentration in the ambient air.

Fugitive Dust Emission Measurement

Section	RSPM ($\mu\text{g}/\text{m}^3$) <PM10	<u>SPM Range</u> ($\mu\text{g}/\text{m}^3$)
Unloading Hall	593 to 1314	7,050 to 9,836
Packing Hall	941	13,876 to 20,820
Pulveriser Hall	3,644	32,132 to 76,975

The high SPM levels in the shop floor in the pulveriser hall and packing hall are primarily due to fugitive emissions. The SPM in the unloading hall could be due to insufficient extraction of dust emissions.

5.2.2 c) Wheat Processing (Roasting) Mill

TABLE: 5.6: Characteristics of Emission From Wheat Processing (Roasting) Section

Unit Code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load Before APCD (kg/hr)	Specific Dust Load Before APCD (Kg/T)
		Before APCD	After APCD				
		(mg/NM ³)	(mg/NM ³)				
WPR - 1	1.5	3841	5	Closed Bag Filter	2880	11.06	7.37

The dust concentration at the inlet of control equipment is 3841 mg/Nm³ and at the outlet of the control equipment is 5 mg/Nm³.

5.2.3 Rice Mill

5.2.3(a) Rice Mill – Cleaning Section

Based on the field measurements conducted in the cleaning section of several Rice Mills, characterization and quantification of emissions based on the average values are given in the table below

TABLE-5.7: Characteristics of Emissions From Rice Mills- Cleaning Section

Unit Code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load Before APCD (kg/hr)	Specific Dust Load Before APCD (Kg/T)
		Before APCD	After APCD				
		(mg/NM ³)	(mg/NM ³)				
RIM-1	2	5327	NM	Cyclone	1032	5.5	2.7
RIM-1	2	NM	478	Settling chamber	10207	NM	NM
RIM-2	2	232	NM	No APCD	493	0.1	0.1
RIM-4	2	NM	1938	Cy	4913	NM	NM
RIM-7	5	2525	89	Cy	5624	14.2	2.8

Note: (a): For the cyclone cum open bag filter type APCD, since there is no final stack arrangement at the outlet of bag filter, no stack monitoring after APCD can be conducted

NM: Not measured due to non-availability of port-hole arrangement

The outlet emissions are in the range of 89 to 1938 mg/Nm³. For settling chamber type APCD, the air volume extracted is much higher than other control equipment like cyclone, bag filter, primarily due to low pressure drop, but the particulate matter concentration at the outlet is high.

5.2.3(b) Rice Mill – Milling Section

Based on the field measurements conducted in the milling section of several Rice Mills, characterization and quantification of emissions based on the average values are given in the table below:

TABLE-5.8: Characteristics Of Emissions From Rice Mills - Milling Section

Unit Code number	Capacity (TPH)	Average Dust Concentration		Type of APCD	Gas Flow NM ³ /hr	Average Dust load (kg/hr)	Specific Dust Load (Kg/T)
		Before APCD (mg/NM ³)	After APCD (mg/NM ³)				
RIM-7	5	671	92.5	Cyclone	4401	3.0	0.6
RIM-7	5	1543.5	NM	Cyclone	2852	4.4	0.9
RIM-6	1.5	NM	13.5	Cyclone	4467	NM	NM
RIM-6	1.5	NM	62	Cyclone	4775	NM	NM

Note: NM: Not measured due to non-availability of port-hole arrangement.

5.2.3 (c) Rice Mill – Boiler House Section

The rice husk fired boiler emissions are passed through a settling chamber and the emissions are discharged through stack. The measured data in the stack is given below:

Unit Code Number	Capacity (TPH)	Dust Concentration After APCD (mg/NM ³)	Type of APCD	Gas Flow NM ³ /hr
RIM-1	2	5050	Settling chamber	5864

The particulate matter emission measured in the stack is quite high in the range of 5050 mg/Nm³. This indicates the settling chamber type control system is not adequate for controlling the particulates efficiently.

Ambient SPM concentration range

Parameter	Range (µg/m ³)
SPM	255 to 810
PM<10	180 to 626

The ambient SPM range of 255 to 810 shows that in some areas the fugitive emissions lead to higher SPM concentration in the ambient air.

Fugitive Dust Emission Measurement

Section	Range ($\mu\text{g}/\text{m}^3$)
Paddy cleaning	12,340 to 55,683
Paddy milling	573 to 5,648

The high SPM levels in the shop floor in the paddy cleaning section are primarily due to fugitive emissions occurring due to inadequate dust extraction arrangement.

5.2.3(d) Dry Rice Grinding Mills

The dry rice grinding equipments do not have any chimney attached to any of the equipment neither there is any dust extraction cum control system. It is therefore, there is no possibility of carrying out a stack monitoring study to characterize and quantify the emissions. As generally the raw material is pre-cleaned rice, the ground material is totally the product and there are no impurities.

5.3 CHARACTERISATION AND QUANTIFICATION OF STORM/WASTEWATER POLLUTION

5.3.1 PULSE MILLS

Pulse Making Mills have very limited or no use of water during processing of the pulses. The water is generally used only for the purpose of wetting the pulses like channa with an objective of soaking to make the shell removal possible without breaking the pulse. This small quantity of water is totally consumed and no wastewater is discharged from any process steps from the pulse making mills. Pulse Grinding Mills also do not generate any effluent.

However, when the pulses are required to be sun dried after soaking, generally the roof terraces are used where the pulses are spread and kept under the sun for natural evaporation of water/moisture. After drying, these pulses are collected and dropped into storage bins through pipes by gravity. During rains, the remains or wastes of pulses lying on the roof terraces may get carried away along with rainwater in the storm water drains, which may pollute water due to organic matter content. A few storm water samples from dal mills and have been characterized and quantified in the table below:

TABLE-5.9 Characterization Of Storm Water From Pulse Making Mills

Timing of sample collection	Unit Code	Sample number	pH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	Oil & Grease (mg/l)
Initial stage of rain water	PMK-4	1	4.8	820	852	467	34
	PMK-5	2	5.3	184	1238	830	50
		3	6.5	316	528	360	20
Subsequent stage of	PMK-4	1	6.7	37	64	10	8.8

nt stage of rain water	PMK-3	2	5.1	21	327	93	9.8
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The above results show that during the initial rain period, the storm water contains higher levels of TSS, BOD and also Oil & Grease. The TSS varies in the range of 184 to 820, the COD from 528 to 1238 and BOD from 360 to 830 mg/l and Oil & Grease from 20 to 50 mg/l. The Oil & Grease in the storm water may also be due to the carry over of Oil & Grease from the machinery parts stored on the terraces such as bearing, housings, tractor engines etc. which cannot be separately estimated. After some times of rain, the above parameters have lower concentration in the subsequent storm water as mentioned in the table above. This is evident from the fact that most of the organic contents from the roof terraces is washed away in the initial stage of rain.

As regard to quantification of storm water the same may depend on the gravity and duration of rainfall, which may vary from region to region. The quantity can be estimated based on average rain fall in the region multiplied by the roof terrace area used for sun drying of pulses. For example, for an average roof area of 100 sq. metre, in Delhi, with an average rain fall of 62 cm of rain every monsoon (Source: News article "Reaping the Rain" published in Hindustan Times, Page No. 3, Delhi Edition, July 16, 2003), the total quantity of storm water would be in the range of 50 cu. m. spread over the monsoon season

5.3.2 Wheat Flour Mills

In the wheat flour mills category, the wet type flour mills give rise to generation of effluent. The characterization & quantification of effluent from a wet flour mill was carried out through field studies and the results are given in the table below:

TABLE-5.10: Characterisation Of Effluent From Wet Flour Mill

Unit Code	Location	Quantity	RANGE OF CHARACTERISTICS OF WASTEWATER				
			pH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	O/G (mg/l)
WFR -3	Washing (Pre-cleaning)	35 - 40 m3/day	6.4 - 7.5	215 - 325	1200 - 1380	450 - 600	5 - 10

The wastewater is generated primarily from wheat washing operation in the pre-cleaning section of the mill. The above sampling results show that the value of BOD, COD & TSS are higher than the discharge standards for surface as well as municipal sewer discharge.

The dry type flour mills and wheat processing (roasting) mills do not use water in their production process and therefore there is no effluent generation from these mills.

5.3.3 Rice Mills

In rice mills, the wastewater is generated in par-boiling section. The mills producing only the raw rice do not use any water in the process and therefore no effluent are generated. The typical characteristics of effluent from the par-boiling section of the rice mill, based on the field measurement and lab analysis results are presented in the table below:

TABLE-5.11: Characterization Of Effluent From Par-Boiled Rice Mills

	Location	CHARACTERISTICS OF WASTEWATER				
		PH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	O & G (mg/l)
RIM - 1	Parboiling Section (Inlet to ETP)	5.5	1258	1980	820	74
RIM - 2	Parboiling Section (Inlet to ETP)	5.5	128	3754	2223	6.8
RIM - 7	Parboiling Section (Inlet to ETP)	6.88	62	437	211	4.8 (<10.0)
RIM - 7	Parboiling Section (Treated waste from ETP)	7.44	48	154	22	2.8 (<10.0)

The quantity of wastewater would depend on the actual production. The characteristics of the above parameters may also vary widely depending on the type of raw material (paddy) and quality of parboiled rice produced.

Wastewater is also generated from the Boiler House in terms of periodical blow down water, softener/DM Plant backwash water that primarily contain higher TDS and variable pH. A typical characteristics of wastewater is given Table below:

Characterization Of Effluent From DM Plants

Source	CHARACTERISTICS OF WASTEWATER			
	PH	TSS (mg/l)	COD (mg/l)	BOD (mg/l)
DM Plant backwashing	12.8	36	88	2

In Dry Rice Grinding Mill, there is no water used in the process and therefore no effluents are generated.

5.4 CHARACTERISATION AND QUANTIFICATION OF NOISE POLLUTION

The characterization and quantification of noise level have been done in terms of general shop floor noise level, individual equipment noise level and Noise level

outside the unit premises. The measured data is given through the tables below along with relevant discussion.

TABLE-5.12: Typical Noise Level Range measured at Shop Floor

Section/ Equipment	Noise generating sources	Noise Level Range (dBA)
Pulse Making Mill shop floor	Rotary Screen, Bucket Elevators, Destoner, Grinding wheels/rollers	70.4 to 93.8
Wheat Flour Mill shop floor	Reel machine, de-stoner, screen, grinder etc.	62.6 to 79.7
Rice mill shop floor	Vibrating screen, de-stoner, de-husker, polisher, grader etc.	62.9 to 90.7

Typically most of the Pulse Making Mills are located in smaller plots within a two or three storied building premise and most of the equipment are so arranged in various floors such that the flow of raw material takes place through bucket elevators or through pipes by gravity. It is therefore; most of the equipment are located closely and as a result the shop floor noise level are higher. In the wheat flour mills and rice mills, these mills are located in the larger area and are spread out in various sheds and therefore the shop floor noise level varies widely in various sheds.

TABLE-5.13 Typical Noise Level Range Of Various Equipments Commonly Used In Pulse/Wheat/Rice Processing Mills

Section/ Equipment	Noise Level Range (dBA)
Destoner	80.3 to 82.5
Separator screen	85.4 to 86
Vibratory screen	92.7 to 93.7
Purifiers	89.5 to 95.3
Roller Mills	95.8 to 98.2
Scourer	92.4 to 94.0
Plansifter	89.5 to 98.6
Blowers	78.9 to 106.9
Packing machine	70.2 to 82.3
Polisher	81.1 to 82.0
Dehusker	90.9 to 91.8
Length Graders	86.2 to 86.8
Colour sorter	83.1 to 90.7
Bran finisher	90.8 to 91.3
Reel machine	91.3 to 91.9
Dryer	50.9 to 66.6
Boiler House	71.6 to 88.4

The above measurements were made in the vicinity (within 0.5 m to 1 m distance) of the above machines to access the range of noise level by individual machine.

However, there could be interference of noise from nearby operating machine also. Typically most of the equipment produces noise in the range of 70 to 95 dBA. However, some rotating equipment operating at high rpm like blowers have higher noise level.

TABLE-5.14 TYPICAL NOISE LEVEL RANGE OUTSIDE THE UNIT PREMISES

Location	Noise Level Range (dBA)
Outside Pulse Making Mill Premises	69 to 78.2
Outside Flour Mill Premises	62.6 to 79.7
Outside Rice Mill Premises	45.2 to 74.9

Typically since the rice mill have a large area, the ambient noise level are quite low at some section like storage etc. and it could be higher in the areas like Boiler House. In the Pulse Making Mill premises, the noise level is general found to be higher as they are mostly located in the smaller land area within a compact two or three stored building with several machines operating in close vicinity.

In Dry rice grinding mill, during grinding, noise is generated and the level is in the range of 75 to 85 dB(A).

5.5 Categorisation of Mills by Capacity

The mills are categorized as small or medium units, as below.

Type of Mill	Capacity Category	
	Small	Medium & Large
Dal Mills	< 2 TPH	> 2 TPH
Besan Grinding	< 1 TPH	> 1 TPH
Rice Mills	< 1 TPH	> 1 TPH
Wheat Flour Mills	< 4 TPH	> 4 TPH
Wheat Processing Mills	< 1 TPH	> 1 TPH
Dry Rice Grinding	< 1 TPH	> 1 TPH

Most of the dall mills generally have a capacity range between 1 to 2 TPH and fall under small scale category (Investment less than Rs. One crore).

The investment in terms of plant and machinery are not substantial in the case of dall mills, besan mills, conventional flour mills, rice grinding mills, as most of the machinery like bucket elevations, screens, rollers, grinders etc are manufactured/supplied locally and are comparatively inexpensive.

Some of the modern roller flour mills and rice mills, employ high tech machines like colour sortex machines have higher investments and may fall under “Medium” size category. There are hardly any large scale category industries in these sectors.

CHAPTER 6: EMISSION EXTRACTION AND TREATMENT REQUIREMENTS

6.1. HOODING & VENTILATION REQUIREMENTS

In grain processing mills, the dust adhered to the raw material grains & other impurities get loose due to operations like material handling, size reduction, screening, free falling etc and the dust gets air borne. This dust needs to be extracted out of the system from the generating points/place at the earliest possible. The volume of air exhausted is simply the volume of the bulk material displacing air.

The recommended dust extraction points for various mills are described below:

6.1.1 Recommended Dust Extraction Points:

Dust should be extracted from various points as mentioned below.

Table 6.1: Recommended Dust extraction points

Type of Mill	Section	Recommended dust extraction points
PULSE MAKING	Cleaning	<ul style="list-style-type: none">• Raw material Unloading area• Bucket elevators• Rotary screens• Roll type scoring machines• Free fall discharge points of raw material• De-stoner machines
	Milling	<ul style="list-style-type: none">• The bucket elevator discharge points• Chakki discharge (Milling/Grinding).• Chillka collection/ storage room.• The reel machines• The grinding chakki/ machines• The rotary screen classifiers
WHEAT FLOUR	Cleaning	<ul style="list-style-type: none">• Unloading of Raw Material• Bucket Elevator & Screw Conveyor Areas• Reel machines• Vibrating Screen• De-stoner machines• Scourer

		<ul style="list-style-type: none"> • Aspirator • Magnetic separator • Toggle Cylinder
	Milling	<ul style="list-style-type: none"> • Bucket Elevator discharge points • Grinding rollers discharge areas • Purifier • Plan shifter
RICE MILL	Cleaning	<ul style="list-style-type: none"> • Raw Material Unloading area • Bucket Elevator and Screw Conveyor • During pre-cleaning (Chalni) • Vibratory Screen • Destoner machine • Magnetic separator
	Milling	<ul style="list-style-type: none"> • Bucket Elevator and screw conveyor • Rubber roll • Aspirator • Polishing Machine • Grading Machine
WHEAT PROCESSING (ROASTING)		<ul style="list-style-type: none"> • Raw wheat unloading point • Bucket Elevator discharge points • Rotary Screen • Roaster feeder end & discharge end • Points of free fall of wheat through pipes • Roaster • Leakages in the roaster walls & roofs

Containment Enclosures

The process equipments like bucket elevators, screening equipments (rotary / vibratory), milling equipments etc. should be enclosed. But since they do have openings at inlet and outlet as well as some leakages etc., the finer emissions do escape to shop floor as fugitive emissions through openings and leakages, however good the enclosures may be, unless extracted.

6.1.2 Effect of Inadequate Extraction of Emissions

Inadequate dust extraction cum control systems lead to fugitive emissions from the dust generating sources and as a result the SPM concentration in the shop floor increases substantially. During field studies it has been observed that values

were in the range of less than 1,000 to 77,000 $\mu\text{g}/\text{m}^3$ have been measured in some mills with excessive fugitive emissions.

As per OSHA standards, the occupational exposure limit (Long term) for grain dust is $10 \text{ mg}/\text{m}^3$ (Refer Annexure 6.3 for OSHA Standard), which indicates that fugitive emissions leading to shop floor SPM exceeding $10 \text{ mg}/\text{m}^3$ is not acceptable.

6.1.3 Recommended Extraction volume for various equipments

The amount of air quantity to be extracted from the material handling equipment like bucket elevator, belt conveyors and processing equipment like vibratory screen, cylindrical screen has been specified below:

Table 6.2: Recommended Extraction volume for various equipment

Type of equipment to be extracted	Air quantity to be extracted	Remarks	Reference
Vibratory / Flat deck screen	340 $\text{m}^3/\text{sq. feet}$ through hood opening,	But not less than 85 $\text{m}^3/\text{sq. feet}$ screen area	Figure 6.1
Belt Conveyor	600 m^3/feet of belt width	For belt speed 1.0 m/s or less	Figure 6.2
	850 m^3/feet of belt width	For belt speed more than 1.0 m/s	
Bucket Elevator	170 $\text{m}^3/\text{sq. ft}$ casing cross section	Suction at top & bottom end required	Figure 6.3
Cylindrical screen	170 $\text{m}^3/\text{sq. feet}$ circular cross section of screen	At least 680 $\text{m}^3/\text{sq. feet}$ of enclosure opening	-

Source: Handbook "Industrial Ventilation" by American Conference on Governmental Industrial Hygienists.

The typical extraction arrangements for various process equipments are shown in the figures below:

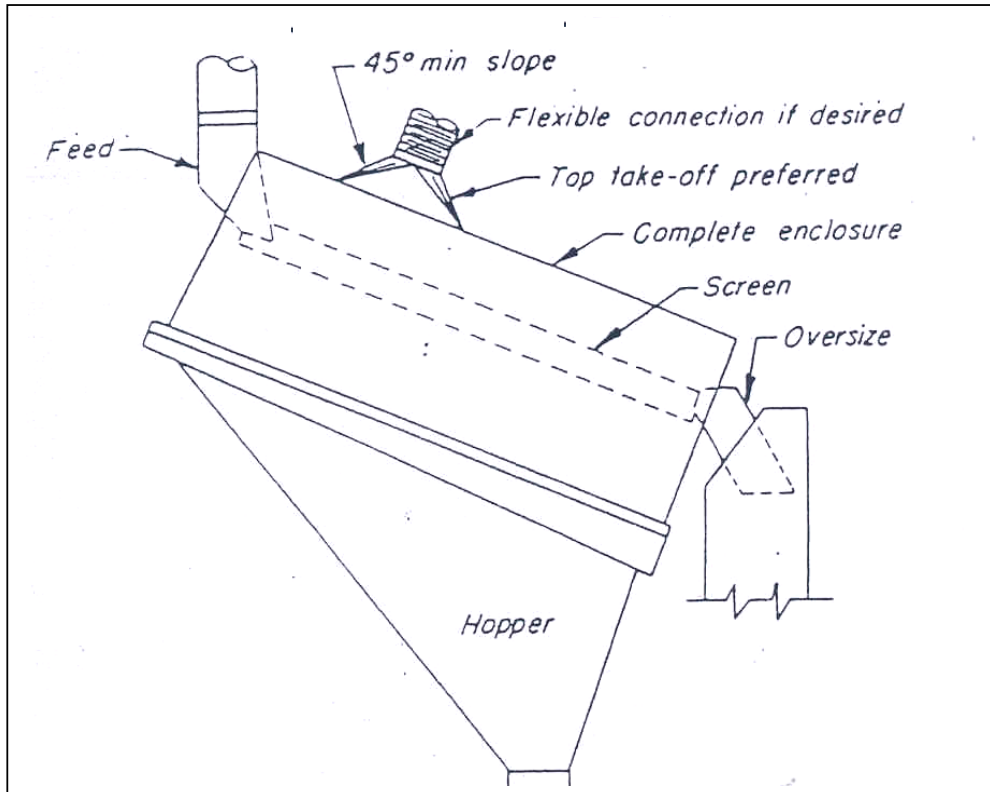


Figure 6.1 Typical Extraction Arrangement for Vibratory

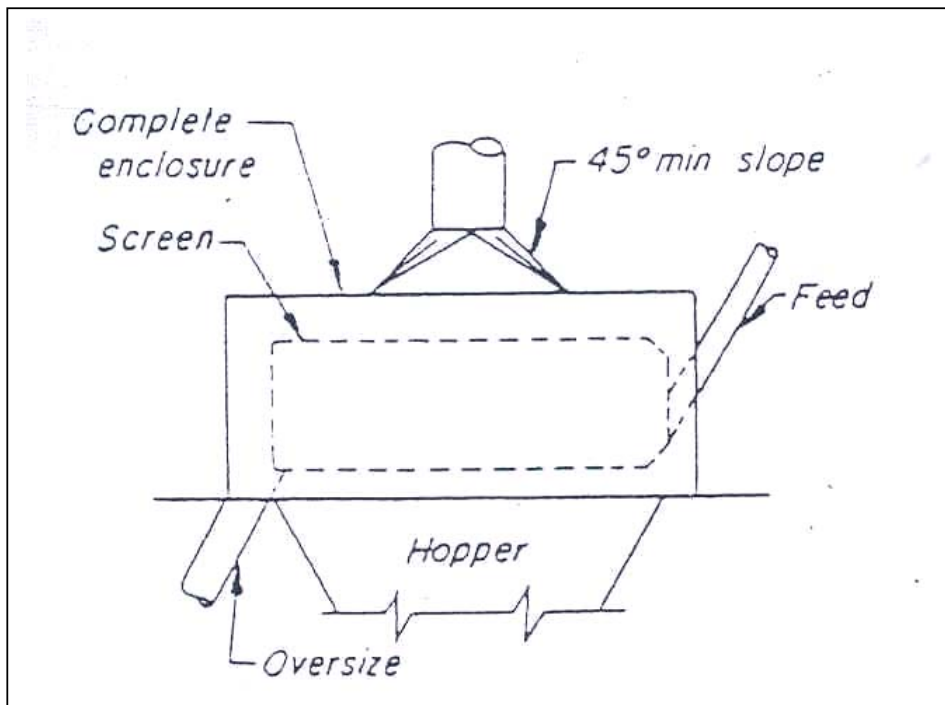


Figure 6.2 Typical Extraction Arrangement for Belt conveyor Discharge

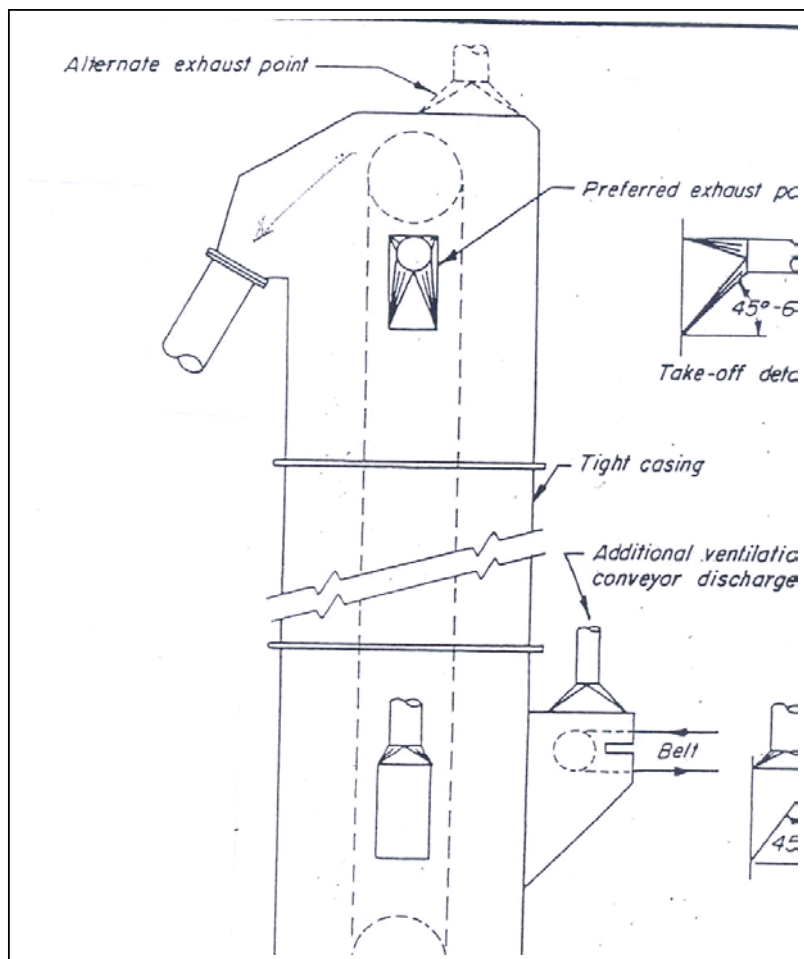


Figure 6.3 Typical Extraction Points for Bucket

6.2 TYPICAL CHARACTERISTICS OF EMISSIONS

a) Particle Size Distribution of Grain Dust Emissions

The emissions from grain mills are primarily from the handling and processing operations. The handling operations involve areas like transfer of material (by bucket elevator, through pipes etc.) and miscellaneous handling activities such as loading, unloading etc. The grain processing involves activities such as screening (through rotary or vibratory screens and grinding operations (in roll mills, chakkis etc.). Both the handling and processing operations are carried out in the cleaning as well as milling sections of the grain mills.

Typical particle size distribution for Indian Grain Mills based on the field studies conducted are compiled in the table below:

Table 6.3: Typical measured PSD for grain mill emissions

PARTICLE SIZE	Pulse Mill Cleaning Section (%)	Pulse Milling Section (%)	Wheat Flour Mill Cleaning Section (%)
> 1 micron	93.1	97.6	99.3
> 2 micron	86.2	93.4	96.8
> 5 micron	67.8	76.4	78.5
> 10 micron	44.8	46.8	32.9
> 15 micron	29.3	24.8	6.6
> 20 micron	19.1	11.8	0.6
> 30 micron	7.9	2.0	0.0

Typical particle size distribution for grain handling and processing operations in USA is given below.

Table 6.4: Typical PSD for Grain Handling/ Processing Operations in USA

Operation	Sub-section	Emissions generated due to	Typical equipments	Percentage of Particle Size Range (microns)			Overall % < 10 micron
				0 – 2.5	2.5 – 6	6 - 10	
Handling	Material Transfer, Misc. handling	Mechanical agitation of materials	Bucket elevators, unloading etc.	1%	6%	8%	15 %
Processing	Screening, Grinding	Separation size reduction	Rotary / Vibratory screens, Grinding machines	23%	20%	18%	61 %
Average percentage for mixed dust (handling + Processing)				12 %	13 %	13 %	38 %

(Source.: Information from USEPA through internet, document No.AP-42;)

The PSD measurements carried out in pulse/wheat/rice mills indicate that the percentage of fine dust < 10 micron size is in the range of 53 -67 % , which has close similarity to the US-EPA PSD figure of 61 % . For grain processing mills. However, the content of fine particles depend upon the quality of raw material, pre-cleaning practices in farms, type of material handling and processing equipment used, etc.

b) Average Representative Particulate Matter Concentration

The uncontrolled dust concentrations measured before the control systems vary widely from unit to unit depending upon the type of extraction cum control system provided and its capacity etc. Badly designed ineffective extraction systems extract only a little portions of the emissions the rest un-extracted emissions either

come out as fugitive emissions or it is carried with the raw material to subsequent stages. Better designed extraction systems with adequate capacity extract more dust and it eliminates fugitive emissions or carry over of dust to subsequent stages.

It is therefore the dust concentrations of best performing units out of the units studied has been taken as the basis for fixing uncontrolled dust concentrations. The representative values are given below:

Table 6.5: Average Representative uncontrolled dust concentration

Type of Mill	Section	Average Representative uncontrolled dust conc. mg/Nm ³	*Reference
Pulse Making	Cleaning	10,400	Table 5.2 (PMK-4 & PMK-5)
	Milling	15,307	Table 5.3 (PMK-4, PMK-5)
Wheat	Cleaning	2924	Table 5.4 (WFR-4,3 &1))
	Milling	1036	Table 5.5 (WFR-4)
Rice	Cleaning	3926	Table 5.6 (RIM 1,2 & 4)
	Milling	1107	Table 5.7 (RIM 7)

6.3 EFFICIENCY OF VARIOUS APCDS FOR CONTROLLING FINER SIZE PARTICLES

The various types of commonly practiced air pollution control systems like enclosures, settling chambers, cyclones, scrubbers, bag filters etc. have varying degree of control efficiency for various particle sizes, especially for finer particles less than 10 micron size.

The typical efficiency levels of various control equipments for controlling fine particles less than 10 microns are given in the table below.

Table 6.6: Typical Collection Efficiencies (%) of Various APCDs

Type of APCD	% Efficiency for fine particle size range in μ			% Efficiency for coarse particle size range in μ		
	0 to 2.5 μ	2.5 to 6 μ	6 to10 μ	10 to20 μ	20 to 30 μ	>30 μ
Gravity Collector (Settling Chamber)	2.9 %	4.0 %	4.8 %	7.4%	15%	>40%
Single Cyclone	10.0 %	35.0 %	50.0 %	65%	90%	>98%

Dust Suppression by water sprays	40.0 %	65.0 %	90.0 %	> 90%
Spray tower type wet scrubber	20.0 %	80.0 %	90.0 %	> 90%
Ventury Scrubber	90.0 %	95.0 %	99.0 %	> 99%
Fabric Filter (Bag filter)	99.0 %	99.5 %	99.5 %	> 99.5%
Electrostatic precipitator	95.0 %	99.0%	99.5 %	> 99.5%

Source: Internet download from USEPA document AP42 Appendix B.2, generalized particle size distributions.

The above data represent an average of actual efficiencies and are representative of well-designed and well-operated control equipments. Site-specific factors such as type of particulate being collected, varying pressure drops across scrubbers and maintenance of equipment etc. will affect the collection efficiencies. The above efficiencies shown are only a guidance for estimating control equipment performance when source specific data are not available.

6.3.1 Achievable final dust concentration with various APCDs

Primarily, cyclone type or bag filter type Air Pollution Control equipment are widely used in these type of mills as the final control equipment. The efficiency of bag filters for almost all type and size of dust is 99.5 % or more. The efficiency of cyclones varies with the dimensions of cyclones, particle size distribution, etc. For the PSD measured in some units, the overall maximum cyclone efficiency works out to be about 85 %, which may be lower for improperly designed cyclones. The estimated achievable dust concentrations using cyclones or bag filters are given in the table below:

Table 6.7: Achievable final dust conc. with various APCDs (Estimated)

Type of Mill	Section	Average Representative uncontrolled dust conc. mg/Nm ³	*Reference	Achievable final dust conc. with various APCDs mg/Nm ³ (% η)	
				Cyclone# (85 % η)	Bag filter (99.5 % η)
Pulse Making	Cleaning	10,400	Table 5.2 (PMK-4 & PMK-5)	1560	52
	Milling	15,307	Table 5.3 (PMK-4, PMK-5)	2296	77
Wheat	Cleaning	2924	Table 5.4 (WFR-4,3 &1))	439	15
	Milling	1036	Table 5.5 (WFR-4)	155	5

Rice	Cleaning	3926	Table 5.6 (RIM 1,2 & 4)	589	20
	Milling	1107	Table 5.7 (RIM 7)	166	6

Note:

* Some dust uncontrolled dust concentration measurements were not representative due to reasons like excessive extraction of raw material along with dust from some locations whereas fugitive emissions from other under-sucked locations; therefore not considered for calculating representative average values.

The typical efficiency of cyclone for dust from Pulse/Wheat/Rice mills, based on the particle size distribution, works out to be in the range of 80-85 %, maximum value is considered to calculate final dust emission level at cyclone outlet.

The above table shows that using bag filter type treatment technology, which is widely practised in pulse/wheat/rice mills, an outlet emission level of below 150 mg/Nm³, is achievable and hence recommended.

CHAPTER 7: ENVIRONMENTAL MANAGEMENT PRACTICES IN DEVELOPED COUNTRIES

This section of the report describes about characteristics of the industry in developed countries like USA, Germany etc. The chapter gives a general overview flour and rice mills. It also describes the pollutant emissions, the emission control technologies and environmental standards in developed countries.

7.1 Wheat Milling

Wheat is often differentiated into one of its three most common species. Common wheat includes winter and spring wheat, and its principal use is for production of bread. Club wheat, similar to common wheat but not bearded, is also a source for flour and food products. Durum wheat has harder kernels and, when ground, holds together well for use in pastas. The wheat germ may also be used for human consumption and in livestock feeds. Wheat is processed through a sequence of dry milling operations to produce flour. Wheat flour milling is by far the predominant dry milling process described.

The wheat flour milling process consists of five main steps:

1. Wheat reception, preliminary cleaning, and storage.
2. 2. Wheat cleaning.
3. Tempering or conditioning.
4. 4. Milling the wheat into flour and its byproducts&
5. Storage and/or shipment of finished product.

Operations performed in typical wheat mills are discussed in the following paragraphs.

Wheat arrives at mill elevators by truck, rail, barge, or ship, and is transferred by conveyors to the elevator head house. Often, preliminary cleaning occurs prior to wheat storage. After cleaning, the wheat is conveyed to storage bins. These receiving, handling, and storage operations are comparable to those found in grain elevators. As grain is needed for milling, it is withdrawn from the storage elevator and conveyed to the mill area.

In the mill area, wheat is first sent through a cleaning operation. This section of a mill is called the cleaning house. In the cleaning house, dust and smaller pieces of foreign material are removed from the grain. Impurities are removed from wheat based on size, specific gravity, shape, air resistance, and inherent differences in material (e.g., metal, stone). Equipment used to clean the wheat targets one or more of these differences to accomplish the cleaning. While placement and sequence of equipment varies from mill to mill and each mill may contain various material handling and storage operations between primary processing operations.

The wheat first enters a separator, where it passes through a vibrating screen that removes bits of straw and other oversized foreign material and then through a

second screen that removes undersized foreign material, such as seeds. Next, an aspirator uses air to lift off lighter impurities in the wheat. The stream of grain is directed across screens while air removes the dust and lighter particles.

The stream of wheat then passes over a magnetic separator that removes iron and steel particles. The magnetic separator acts as a safeguard against nuts, bolts, rivets, or other pieces of metal, which may break loose from harvesting, transportation, or handling machinery. Magnetic separators are used at many different points in a mill, especially prior to wheat entering any machine applying friction, where the risk of damage or fire is greatest.

From the magnetic separator, the wheat enters a disc separator, which consists of discs revolving on a horizontal axis. The surface of the discs is indented to catch individual grains of wheat but rejects larger or smaller material. The blades also act to push the wheat from one end of the machine to the other. The revolving discs discharge the wheat into a hopper, or into the continuing stream.

The wheat is then directed to a stoner for removal of stones, sand, flints, and balls of caked earth or mud, which may be so close in size to the wheat grains that they cannot be adequately sifted out. Both wet and dry stoners are used for this purpose.

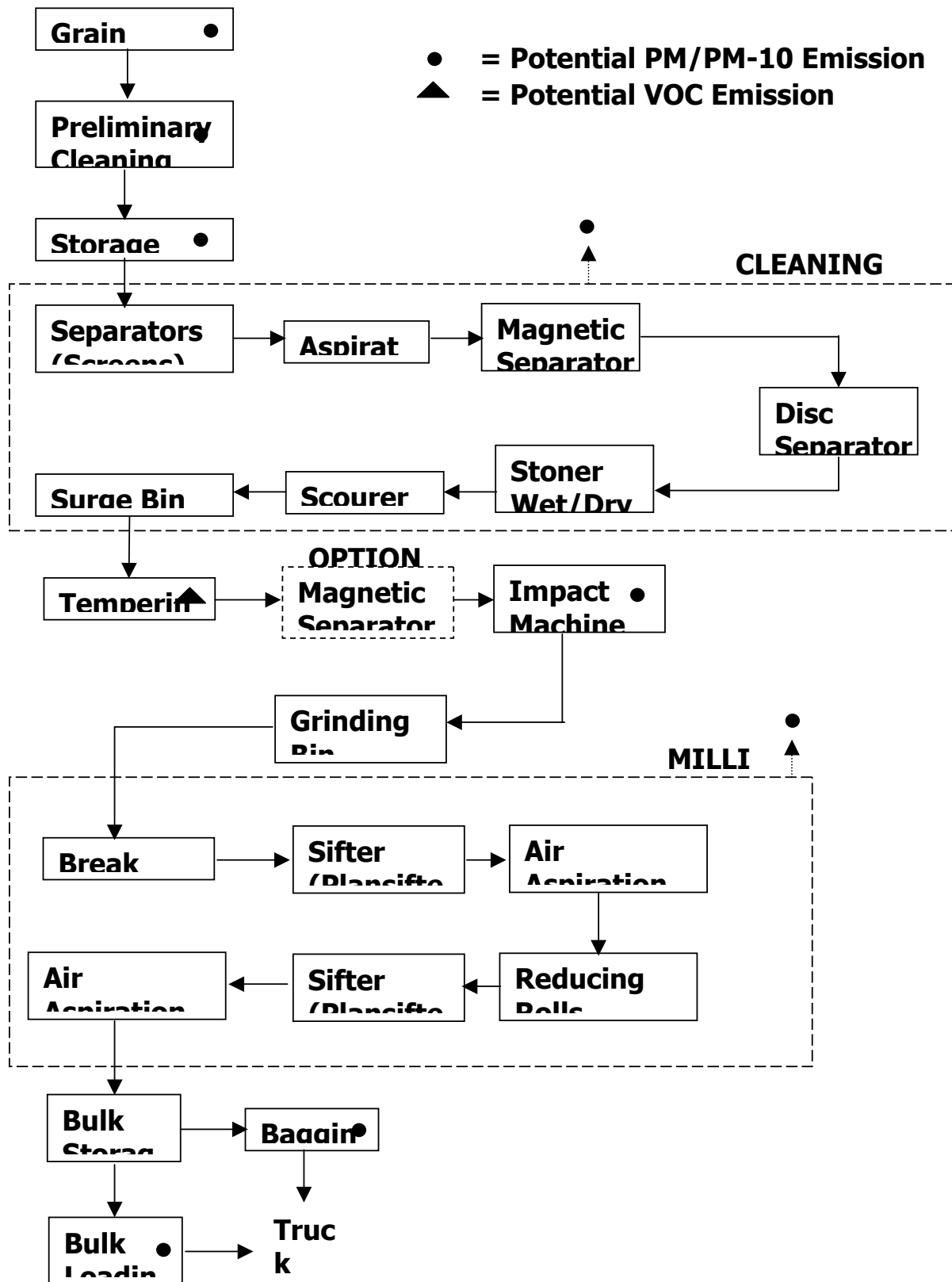


Figure: 7.2 Simplified Flow Process of a Typical Flour

The wheat then moves into a scourer—a machine in which beaters attached to a central shaft throw the wheat violently against a surrounding drum—buffing each kernel and breaking off the beard. The machines also remove a large amount of dust and loose bran—skin adhering to the wheat grains. Scourers may either be horizontal or upright, with or without brushes, and adjusted for mild, medium, or hard scouring. Air currents carry off the dust and loosened particles of bran coating.

Following the scouring step, the grain is typically sent through a surge bin, which acts as a storage/supply point between the cleaning house and the tempering bins or tanks. Modern milling practices utilize conditioning or tempering before the wheat is ground. Tempering, as it is practiced in the United States, involves adding water to grain to raise the moisture of hard wheat to 15 percent to 19 percent and of soft wheat to 14.5 percent to 17 percent. After moisture is added, the wheat lies in tempering bins (with little or no temperature control) for periods of 8 to 72 hours (hr). During this time, the water enters the bran and diffuses inward causing the bran to lose its friable characteristic and to toughen. Tempering also softens or mellows the endosperm, making it easier to grind. The percentage of moisture, length of soaking time, and temperature are the three important factors in tempering, with different requirements for soft and hard wheat. Usually, tempering is done in successive steps because more than a few percent of water cannot practically be added to wheat at one time.

When the moisture is properly dispersed in the wheat for efficient milling, the grain is passed through an impact machine as a final step in cleaning, possibly after passing through an additional magnetic separation step. Discs revolving at high speed in the impact machine hurl the wheat against fingerlike pins. The impact cracks any unsound kernels, which are subsequently rejected. From the impact machines, the wheat flows to a grinding bin or hopper from which it is fed in a continuous metered stream into the mill itself.

The milling of bread wheat to flour is done with a series of roller mills, pairs of rolls which rotate in opposite directions at different rates of speed and exert relatively gentle shearing rather than crunching forces. The roller milling area is divided into two sections, the break system and the reduction system.

In the break system, the kernel is broken open and the endosperm is separated from the bran and germ. The break system quite often involves four or more sets of corrugated rolls, each taking feedstock from the preceding one. After each break, the mixture of free bran, free endosperm, free germ, and bran containing adhering endosperm is sifted. The bran having endosperm still attached goes to the next break roll, and the process is repeated until as much endosperm has been separated from the bran as is possible. The sifting system is a combination of sieving operation (plansifters) and air aspiration (purifiers).

The plansifter has flat sieves piled in tiers, one above the other. The action of the sifter is rotary in a plane parallel with the floor. As the sifter moves in about a 89-mm (3.5-in) diameter circle, the small-sized particles spill through the sieve below while the oversized particles travel across the sieve to a collecting trough and are removed. As many as 12 sieves can be stacked one on top of the other, and there

are four separate compartments in one plansifter. The flour and endosperm chunks (middlings) from the plansifter still contain minute bran particles, which are removed by sending the product through a purifier where air currents carry the bran away. A purifier is essentially a long oscillating sieve, inclined downwards becoming coarser from head to tail. The currents pass upward through the sieve causing the flour to stratify into endosperm chunks of different size. Aspirated materials are used for mill feed, which consists of brans and shorts.

The reduction system comprises two parts, roll mills and sifting machines. In roll mills, surfaces of the rolls are smooth, rather than grooved, and are set to reduce endosperm middling to flour-size particles and facilitate the removal of the last remaining particles of bran and germ. Plansifters are also used behind the reduction rolls, and their purpose is to divide the stock into coarse middlings, fine middlings, and flour. The coarse middlings are returned to the coarse (or sizing) rolls, and the fine middlings are returned to the fine roll, while the flour is removed from the milling system. Purifiers are often used behind the coarse reduction rolls for size grading rather than purification. Purifiers are sometimes superior to plansifters for these separation requirements.

Flour stock is transported from machine to machine by gravity or air conveying. Older mills depend upon gravity, with the wheat and flour being moved to the top of the mill by bucket elevators from which the flour flows by spouts to the rolls and to the sifters. Bucket elevators have two serious disadvantages: they are dusty and they can harbor insects. Consequently, newer flour mills have converted to the air conveying of flour and are abandoning bucket elevators and gravity spouts.

Transfer of the finished product to storage, bagging, or bulk loading is generally done by pneumatic conveying systems. Bulk storage capacity varies widely, but most mills have bulk flour storage from 2 to 4 days of production. Special railroad cars and trucks are generally used to transport bulk flour.

7.2. Rice Milling

Nearly all rice consumed as food undergoes some type of milling operation during its preparation. Rice milling differs considerably from the milling of all other grains because the preferred form of rice is the whole grain rather than a flour or meal. However, broken kernels and small pieces are sold for manufacturing purposes, as for brewing and the manufacture of breakfast cereals or snacks.

Brown rice is the product that remains after the hull or husk are removed, while white rice is what remains after the bran and some of the germ are removed. White rice includes both whole rice (called head rice) and broken kernels. The wet basis moisture content of harvested rice is 24 to 25 percent. In order to be stored safely, the rice moisture must be reduced to 13 to 14 percent MCwb. Consequently, the first step in rice processing operations after harvest is rice drying.

Essentially all of the rice is dried either on the farm or at commercial drying facilities/warehouses prior to shipping to the rice mill. The two types of mechanical dryers used are fixed-bed dryers and continuous-flow dryers. Fixed-bed dryers, with circular and rectangular, are used for complete on-farm drying of rice and for finish-drying after primary drying in continuous-flow dryers at commercial drying facilities. Fixed-bed dryers, which include large capacity integral bins, can also be used for temporary rice storage subsequent to drying. Circular, fixed-bed dryers are equipped with perforated floors. A fan at the base of the facility creates a high pressure area under the grain by pulling drying air from the outside, the air is forced up through the grain, and moist air is exhausted from the top of the bin. Circular-bin dryers are usually equipped with supplemental heaters used if the relative humidity of the ambient air is too high to provide adequate drying. Rectangular-bin dryers are typically used for finish drying and storage and are usually not designed with supplemental heating equipment. Large fans placed outside the bins distribute drying air through large tunnels on the floor of the bin. Air is exhausted from the vents along the top of the bin.

Most of the rice produced in the United States is dried commercially in continuous-flow dryers, which use forced heated air as the drying medium. Two common continuous-flow dryers are the mixing and non-mixing types. In a non-mixing columnar-type dryer, the rice flows by gravity in a straight path between two screens. This dryer is sometimes called a "cross-flow" dryer because air is forced to flow across a moving bed of rice. The non-mixing column-type dryer is probably the most common commercial rice dryer in use today. One type of mixing-type columnar dryer can use baffles to promote mixing. In another type, rice flows downward over inverted V-shaped air channels. Air flows in and out alternate rows of channels, and mixing is accomplished because the inlet and outlet air ducts are offset from one another.

After the rice is dried, it is stored and subsequently shipped to rice mills for further processing. Both conventional and parboil rice mills are used in the United States, with the former accounting for about 85 percent of the national rice crop. (Parboiled rice is obtained by partially boiling the rice using pressurized steam before it is milled.) There are three distinct stages in each of these mills: (1) rough rice receiving, cleaning, drying, and storage; (2) milling; and (3) milled rice and byproduct bagging, packaging and shipping.

The process for conventional and parboil rice mills is described in the following paragraphs.

Rice is received primarily by truck and rail at rice mills. Rough rice is delivered to the mill containing various kinds of foreign material, such as straw, loose hulls, bran, weed seeds, pebbles, and granules of dirt. Before cleaning, this rough rice is weighed in an automatic hopper scale to determine the weight of the uncleaned grain. The rough rice is then cleaned using combinations of scalpings, screens, and aspiration.

The precleaner system has aspiration for light impurities, an oscillating double sieve for heavy impurities, and a magnet to trap any iron particles. Light small

impurities, mainly dust, are blown inside a cyclone for separation and discharge. All other impurities are discharged into sacks or containers. Because this type of precleaning machine cannot generally separate the small stones of about the same size as the rice grains, the rice grain passes a stoner or gravity separator that separates the stones from the grain by using the differences in density of stones and rough rice. The grain then passes a second automatic hopper scale that weighs clean rough rice that will actually be processed in the rice mill to determine the degree of purity of the rough rice.

The milling of rough rice to produce white rice is the major milling operation conducted at U.S. rice mills. Cleaned rice is first transported to a disk huller where the rice is dehulled. Stone and rubber shellers are used for this operation. The hulls that are produced are relatively light and are readily removed from the shelled grains when the mixture is aspirated. Before the material is aspirated, it first passes through a double sieve which separates the coarse bran and small broken (brown rice) that have been generated in the disk huller. The hulls are collected by passing the aspiration air through a product recovery device, usually a cyclone.

The product stream in the shelling process contains a mixture of unshelled rice grains and brown rice, which must be separated. This operation is performed in a device known as a paddy separator, which consists of flat cars divided into three tiers of irregular compartments. The cars are tilted in such a way that when they are rapidly shuttled, the lighter, bulkier, rough rice (commonly called paddy) is concentrated at the raised side, while the heavier brown rice migrates to the lower opposite side. The process is continuous, and streams of brown and rough rice are removed simultaneously. The unshelled paddy is then fed into another pair of shellers set closer together than the first set, and the above process of shelling, aspiration, and separation is repeated.

From the paddy machines, the brown rice is conveyed to a sequence of milling machines called whitening cones, which scour off the outer bran coats and germ from the rice kernels. Milling may be accomplished in one, two, or three distinct operations, that is, by a single pass through a mill or by consecutive passages through multiple whitening cones, depending on plant practice. The discharge from each stage contains a mixture of whole kernels and rice fragments, which are separated by sieves.

After the rice is milled, it consists of almost-white whole kernels mixed with broken kernels of different sizes. It is now ready for the brush (or polishing cone), a device for removing the white inner bran layers and the proteinaceous aleuronic layer. The brush is essentially a large, vertical, stationary, cylindrical screen inside of which rotates a drum with overlapping leather flaps. The rice enters at the top of the machine and, as it progresses toward the bottom, is rubbed against the screen by the leather flaps. The white flour mixture of fine bran and aleurone layer removed by abrasive action is forced through the screen and is collected and sacked. The collected "polishings" are usually sold as a byproduct for animal feed. The whitening cones, all coated with an abrasive material, and the polishing cone, covered with leather strips, are connected to an aspiration system for grain cooling. At the same time, this aspiration system removes some bran, which is recovered through one or more cyclones. At this stage, the rice kernel consists of

the white, starchy endosperm, together with fragments of the aleurone layer. Rice may be sold in this form as polished, uncoated rice or it may be conveyed to machines known as trumbels, in which it is coated with talc and glucose. This inert, harmless coating is used to give the rice a gloss.

Even with care, some of the kernels are broken during milling. A series of classifiers known as trieurs separate the different size kernels. The whole and three-quarter kernels are screened into a fraction and designated as "head" rice, the one-third to three-quarter rice grains are known as "screenings," and the still smaller fragments are termed "brewers" since they form a useful brewing adjunct. Following the trieurs, the rice is transferred to bulk storage prior to packing and shipping. For packing, the rice is transported to a packing machine where the product is weighed and placed in 45.4 kg (100 lb) burlap sacks. While burlap sacks are the primary packaging material, some mills may ship the finished rice in bulk or packaged in paper bags or cardboard boxes.

Some mills in the United States produce only parboiled rice, while others produce both white and parboiled rice. All parboiling mills are similar in that they all involve soaking rough rice following cleaning, then steaming, drying, and milling. Pressure vessels are utilized for the steaming step and steam tube dryers are employed to dry the rice to 11 percent to 13 percent moisture. Following the drying step, the rice is milled in conventional equipment to remove hull, bran, and germ. The better head yields obtained in the milling of parboiled rice than in the milling of raw rice defrays to a considerable degree the cost of parboiling so that parboiled rice sells for a little more than white rice.

7.3 EMISSIONS FROM WHEAT & RICE MILLS IN DEVELOPED COUNTRIES

7.3.1 Emissions in Wheat Flour mills:

The sources of air pollution in a wheat flour mill complex can be grouped into three main categories: grain receiving and handling operations; grain cleaning (cleaning house); and milling operations. The following presents some of the more significant potential sources of air pollution in each category.

These unloading and cleaning steps are the main sources. Dust, dirt, seeds, and chaff are emitted from the equipment used in the cleaning house. The separator, aspirator, and scouring equipment are the principal sources of emissions in the cleaning house. In the mill house, the product recovery systems associated with the various pieces of milling equipment are potential sources of emission; bran and flour would be the principal materials emitted from these sources. Flour shipping operations may not be a significant dust source because efforts are made to minimize loss of the valuable final product. Loading of byproducts may be a significant dust source depending upon the loading procedures used at specific mills.

7.3.2 Emissions in Rice Milling

In rice mills, air pollutants result primarily from receiving, cleaning, and storage operations; and rice milling equipment and byproduct processing/loading

operations. Table below presents some of the more significant potential sources of air pollution in rice mills.

Since rice is marketed as a whole grain product, it is important that grains not be fractured or otherwise damaged before or during the drying process. Large column-type, continuous-flow dryers are widely used for rice drying. It usually requires two or more passes through the dryers to reduce the moisture content to 12.0 percent to 13.5 percent, which is usually considered satisfactory for safe storage. Rice drying is reported to generate a considerable amount of dust. Preliminary cleaning of rice is sometimes done prior to drying. This preliminary cleaning can produce a significant reduction in dust emissions during the drying step. Finished rice, marketed as U.S. No. 1 grade, must be dust-free. To achieve this grade, aspiration is used extensively in rice mills to remove dust as it is generated in the various milling steps (i.e., dust is not conveyed from one machine to another). As a result, all machinery in a rice mill is a source of some amount of dust. The most significant sources of dust are the scalpers, screens, sieves, disc separators, and shellers involved in the cleaning and handling of rough rice. The milling machines, pearlers, and brushes create bran dust. However, this dust is collected carefully because of its value as a byproduct.

7.4 ENVIRONMENTAL CONTROL TECHNOLOGIES IN DEVELOPED COUNTRIES

7.4.1 Emission Control Technologies in USA

Types of emission control mechanisms adopted in USA in various sections are tabulated below:

TABLE 7.1 Process Control And Exhaust Systems For Grain Handling And Processing

Grain handling and processing operation	Potential control mechanism(s)b
Receiving	Grain flow control Capture/collection Total/partial enclosure
Belt conveyors	Enclosure Flow control Capture/collection Oil suppression Total/partial enclosure
Elevator legs	Capture/collection Oil suppression Total/partial enclosure
Distributors	Capture/collection Total/partial enclosure
Cleaners	Enclosure/exhaust
Scales	Enclosure/exhaust
Grain dryers	Screens Total/partial enclosure
Hammermills	Capture/collection Total/partial enclosure
Roller mills	Capture/collection

Grain handling and processing operation	Potential control mechanism(s)b
	Total/partial enclosure
Mixers	Capture/collection Total/partial enclosure
Truck/rail loadout	Dust suppression Capture/collection Oil suppression Total/partial enclosure
Barge/ship loadout	Dust suppression Capture/collection Oil suppression Total/partial enclosure

a Source: USEPA document No. AP-42 page 2-41

b Capture/collection refers to a forced ventilation system consisting of a capture device (hood or enclosure) connected via ductwork to a dust collector.

Highlights of Emission Control Practices in USA

A) Techniques used to reduce emissions

- Controls are often used at unloading and loading areas.
- Control Systems include cyclones, fabric filters, baffles in unloading pits, choke unloading, dust covers, or belt wipers; oil suppression and use of dead-boxes or specially designed spouts for grain loading.
- Deepening the trough of the open-belt conveyors
- Slowing the conveyor speed,
- Increasing the size of leg belt buckets
- Slowing leg velocity.
- In addition, for modern elevators, process vents are tied to ventilation systems and exhausted to air pollution control systems;

General Types of Measures To Reduce Emissions

i) Process Modifications for Emission prevention/reduction.

- Enclosing the receiving area to the degree practicable
- Specifying dust-tight cleaning and processing equipment;
- Providing lip-type shaft seals at bearings on conveyor and other equipment housings;
- Providing flanged inlets and outlets on all spouting, transitions, and miscellaneous hoppers;
- Full enclosure and sealing of all areas in contact with products handled.
- By reducing grain free fall distances and grain velocities.

- Extraction of the entrained air and dust liberated at the point of grain free falls to a dust collector

ii) Capture /Collection Systems

- Ventilation or capture/collection, systems to reduce emissions to acceptable levels for receiving pits, cleaning operations, and elevator legs.
- Hooding systems on all handling and transfer operations.
- Elevators and processing plants located in densely populated areas normally use fabric filters for control.
- Although cyclone collectors can achieve acceptable performance in some scenarios, and fabric filters are highly efficient,
- Both devices are subject to failure if they are not properly operated and maintained.
- Malfunction of the ventilation system can lead to increased emissions at the source.

7.4.2 Highlights of Emission Control Practices in Germany

- All equipment handling materials and machinery should be enclosed and fitted with appropriate aspiration connections.
- Mass separators or Filter separators may be used.
- Dust from aspiration and cleaning systems to be collected and bagged.
- Dust waste and granular cleaning waste is treated and added to mill after products (bran)
- The live pests from cleaning waste to be destroyed immediately.

Noise control requirement in Germany

- Precautions must be taken to protect employees and local residents.
- Structural measures, such as the lining of ceilings and walls with soundproofing materials, must be taken.
- Vibration isolation materials must be used for machine foundations.

Other Safety Requirements in Germany

People, buildings and the machine stock can be at risk from dust explosions and fires. Following any such explosion, there is a chemical conversion of a dust/air mixture, which accelerates as heat is generated, causing a sudden pressure effect from existing or newly formed gases. Three components constitute the basis for a dust explosion: dust, air (oxygen) and ignition energy; the latter can be in the form of heat or electricity (electrostatic charging).

Silo installations are particularly at risk from dust explosions. Mechanical sparks, pockets of glowing materials, mechanical heating, hot surfaces, welding work,

electrostatic discharge sparks and the like are possible ignition sources. They must be eliminated as a safety measure, and the formation of explosive dust concentrations must be prevented, for example by enclosing machines. Structural precautions can also be taken, namely the creation of compression-proof rooms and pressure release and explosion suppressing systems. The following organisational precautions are also effective in terms of fire and explosion safety:

Welding and cutting works only to be carried out during factory shutdowns;

Regular cleaning with dust-explosion-proof equipment;

Training of employees in the handling of fire-fighting equipment and

Information to employees about the causes of dust fires and explosions.

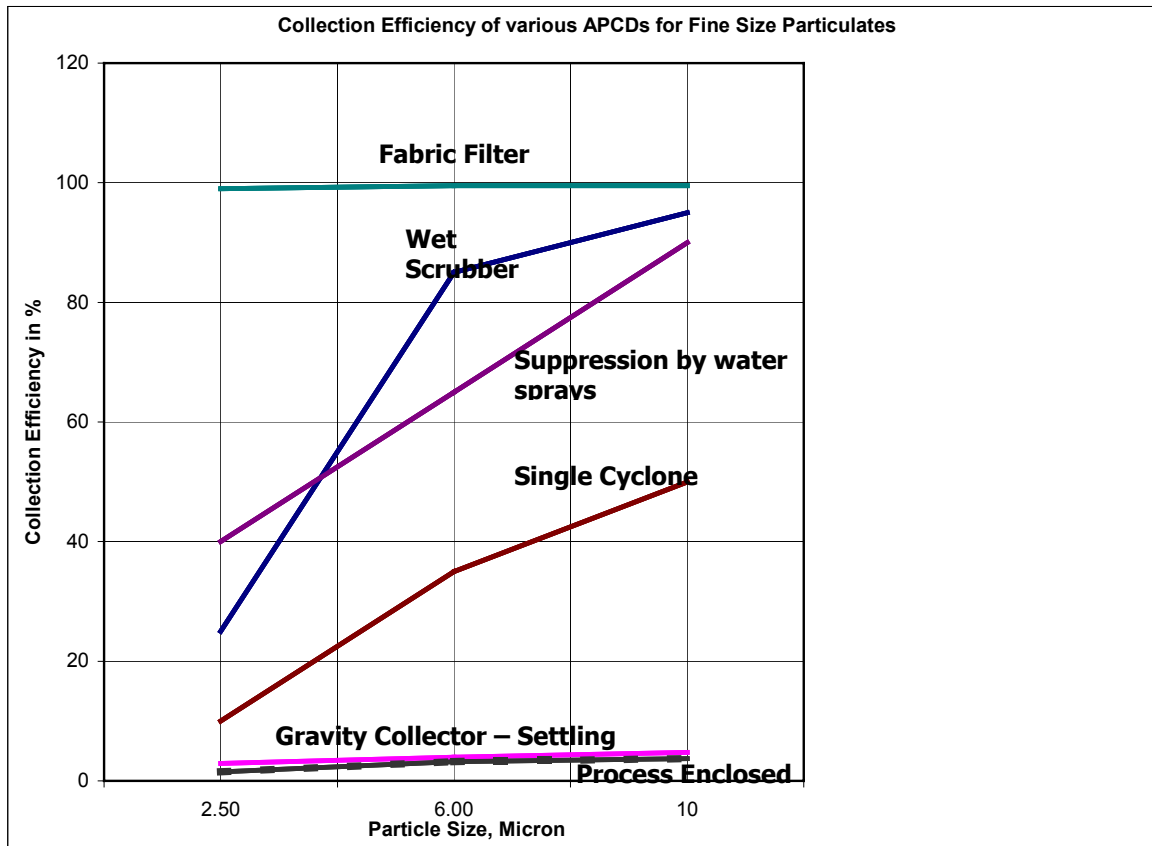
7.5 Efficiency of various APCD for controlling grain dust emission

For the typical particle size distribution of the dust emission from the grain mills in USA, the cumulative efficiency of various types of APCDs have been calculated as presented in the table below.

Type of APCD	% Efficiency for particle sizes in microns			Cumulative Efficiency for < 10 μ		
	0 - 2.5	2.5 - 6	6 -10	Grain handling < 10 μ = 15%	Grain Processing < 10 μ = 61%	Average Efficiency
Process Enclosed	1.5	3.2	3.7	3.4	2.7	3.0 %
Gravity Collector (Settling Chamber)	2.9	4.0	4.8	4.4	3.8	4.1 %
Single Cyclone	10.0	35.0	50.0	41.3	30.0	35.7 %
Dust Suppression by water sprays	40.0	65.0	90.0	76.7	63.0	69.8 %
Spray tower type wet scrubber	20.0	80.0	90.0	81.3	60.3	70.8 %
Fabric Filter (Low Temperature)	99.0	99.5	99.5	99.5	99.3	99.4 %

The graphical presentation of efficiency of various APCDs for controlling grain dust emissions is given in the graph below:

Collection Efficiency of various APCDs for Controlling Fine Dust Emissions



7.6 EMISSION STANDARDS IN DEVELOPED COUNTRIES

The following paragraphs describe the dust content of the service air from the various mill sections and admissible emission values in USA and Germany.

USA

The EPA's New Source 12 Performance Standards (NSPS) for grain elevators established visible emission limits for grain dryers by requiring 0 percent opacity for emissions from column dryers with column plate perforations not to exceed 2.4 mm diameter (0.094 in.) or rack dryers with a screen filter not to exceed 50 mesh openings.

Germany

Table 7.2 - Pollutants and admissible emission values in Germany

Type of mil industry	Dust content of service air in g/m ³	Permissible emission values in mg/m ³
Silo installations	12 to 15	50
Drying plants	15 to 18	50
Mills handling cereal crops	approx.96	50
Hulling mills	6 to 8	50
Seed cleaning	8 to 10	50

Noise Standards

USA

According to the ANSI Standards, the permissible limit of sound exposure for 8 hours of working is 90 dB (A). (Noise & vibration in the working environment, Occupational safety and health series :33, ILO, Geneva, 1976).

Germany

The noise emission values for local environmental protection in Germany are those specified in the TA-Lärm (Technical Instructions on Noise Abatement). The guideline of the German Association of Engineers no. 2058 requires noise protection at the workplace, with the issue of personal hearing protection from 85 dB(A) upwards, and the wearing of this protective gear from 90 dB(A). These workplaces should be labeled and compliance with safety measures monitored.

CHAPTER – 8 SUITABILITY OF VARIOUS POLLUTION TREATMENT TECHNOLOGIES

8.1 SUITABILITY OF VARIOUS AIR POLLUTION TREATMENT TECHNOLOGIES:

The technical viability of various types of treatment technologies for Pulse/Wheat/Rice mills has been discussed below. For those technologies, which are technically viable, the aspects of operation and maintenance feasibilities, economic feasibilities, usefulness of recovered material are further discussed.

There are several types of control devices for removing particulate matter from exhaust gases before the gases are emitted into the atmosphere. These include settling chambers, cyclones, wet scrubbers, electrostatic precipitators, and bag houses. The suitability of these emission treatment technologies for Pulse / Wheat / rice mills application is described below:

There are large variations in the type of pollution control measures adopted in various sections of Pulse/Wheat/Rice Mills across the Country. A few photographs showing various types of control systems prevalent in the pulse/wheat/rice mills are shown at Photo page – 8.1. The most common type of emission control systems employed in the grain processing plants (Pulse, Wheat & Rice) has been reviewed below with respect to its suitability.

8.1. 1. Only Enclosures (without any dust extraction arrangement)

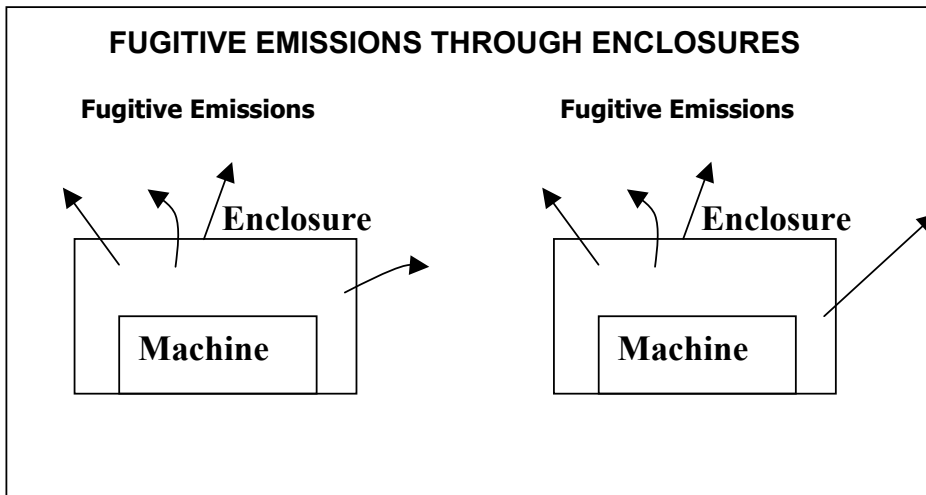
In many mills in the country, specially the older mills, only enclosures have been provided and there is hardly any dust extraction arrangement installed. The emissions escape from various points wherever there are leakage or gaps available, and as a result the emissions are everywhere inside the shop floor shed. This results in significant air pollution in the shop floor area and causes adverse environmental effects in the work environment and affects adversely health of workers. It also damages the Plant and Machinery, especially the rotating parts like bearing. The dusty environment also increases the probability of accident hazards due to poor visibility levels. The dust deposited on the machines and the other parts get air borne again and again, which results, into secondary air pollution problems. In general the shop floor condition in such mills are quite unhygienic. The product produced by such mills is also of inferior quality due to carry over of dust/dirt etc. in the product. The dust emission from the shed escape to the outside environment through windows and ventilation openings, also through the gaps in the roof and results into air pollution of surrounding areas.

The grain milling process generally has enclosure/ containment for the material handling as well as process equipments such as bucket elevators, rotary/ vibratory screens, grinding machines etc. and it is generally considered that these enclosure alone would be sufficient to control the dust emission. But the control efficiency of such enclosures is very poor for finer size dust particles as given in the table below:

Efficiency of enclosure/ containment of process equipments for various particle sizes

0 to 2.5 micron	2.5 to 6 micron	6 to 10 micron
1.5 %	3.2 %	3.7 %

Typically the percentage of fines below 10 micron is in the range of 45 to 53% in emissions from grain processing mills. Considering this substantial percentage of fines, the enclosures alone are not adequate to prevent dust emissions; the finer particles would escape through discharge openings & leakage etc. & pollute shop floor environment.



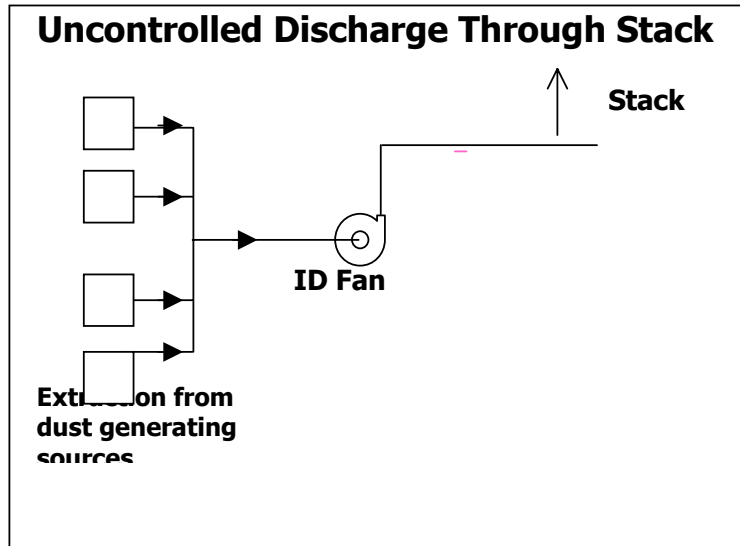
Assessment for suitability:

The “only enclosure” type of air pollution abatement, prevention cum control practice is certainly not suitable due to following reasons:

- High level of fugitive emissions polluting shop floor environment heavily
- Unhygienic working conditions
- Adverse impacts on health of workers
- No extraction and channalization of emissions
- Emission not discharged above roof level

8.1. 2. Uncontrolled discharge through Stack

In some mills, dust is extracted from a few dust generating points with the help of induced draft (ID) fan. The ID Fan sucks the dust and discharges directly into the atmosphere without any dust-control system. In such mills, though the shop floor is comparatively less polluted, the fine dust discharged to the atmosphere leads to air pollution in the surrounding areas. A schematic diagram of such arrangement is shown in the following figure.



Assessment for suitability:

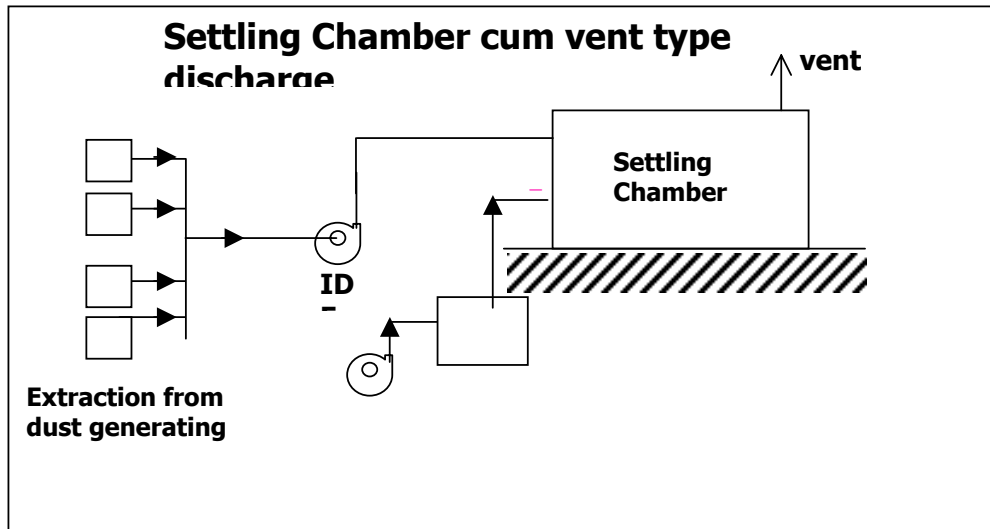
This type of air pollution abatement, prevention cum control practice is not suitable due to following reasons:

- Uncontrolled emission directly discharged above roof level polluting surrounding environment
- Inadequate extraction and channalization of emissions.
- Fugitive emissions from some points, polluting shop floor environment
- Unhygienic working conditions
- Adverse impacts on health of workers

8.1. 3. Settling Chamber

Settling chambers remove dust particles through expansion, thereby slowing the speed of gas streams and allowing gravitational force to pull dust particles from the gas stream. Settling chambers can capture only coarse particles efficiently, but its efficiency for collecting fine particles ($<10\mu$) in the range of 4-5 % only.

In this system, dust is extracted through various dust generating points or blown away by a fan into a settling chamber. An ID fan sucks the dust and discharges into a room type-settling chamber. The heavy particulate matter settles in the settling chamber and lighter particulate matter escape through the vent/stack. There is a provision of a door to take out the settled dust at periodic interval. The settled dust may get air borne if not removed periodically. In such system with a short vent pipe type discharge, there is hardly any dust sampling provision. A schematic presentation of the system is given below.



Efficiency of settling chamber for fine particles

0 to 2.5 micron	2.5 to 6 micron	6 to 10 micron
2.9 %	4.0 %	4.8 %

The above table indicates that the settling chamber type dust control system / arrangement is very inefficient for controlling less than 10 micron particles. Typically the percentage of fines below 10 micron is in the range of 45 to 53% in grain processing mills. Considering this substantial percentage of fines, the settling chamber type equipment is not suitable and adequate.

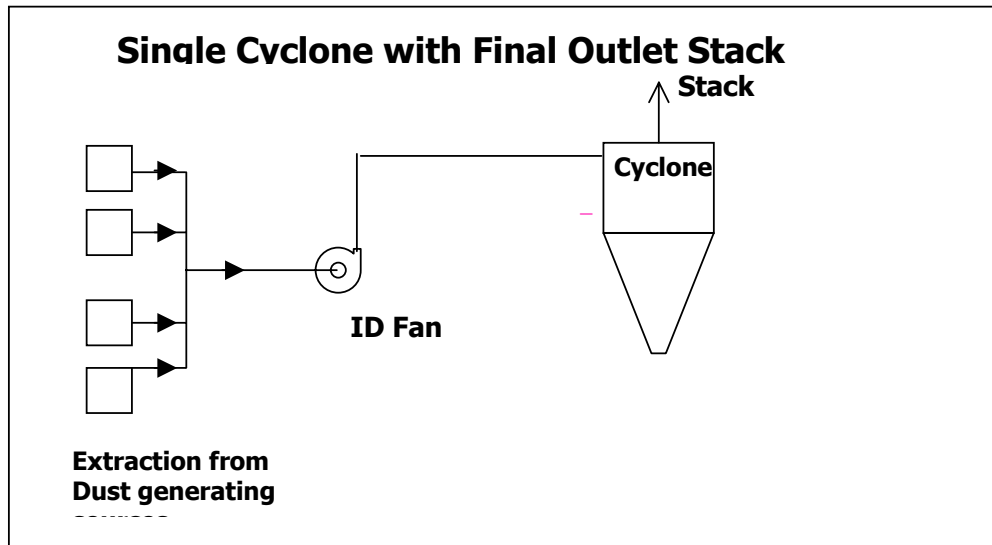
Technical Viability:

- As settling chambers can capture only heavy & large size particles, typically > 30 microns and the finer particle below 10 microns escape through vent, this type of treatment technology is suitable only for applications where coarse materials are to be captured. Typically, if the fine air borne dust emissions are extracted out of the process by appropriate dust extraction arrangement, subsequently settling chambers can be used for settling of coarser materials like shells of pulses (chilka) in pulse making mills, rice husk in rice mills, etc.
- In applications like cleaning and milling operations, the settling chamber could be used as pre-collector with vent gases directed through filter cloth bags for arresting finer particles.

8.1. 4. Cyclones

Cyclone removes particles by causing the entire gas stream to spin in a vortex at high velocity inside a cylindrical chamber. The centrifugal force acts more strongly on the larger, denser particles and flings them preferentially toward the inside wall of the cyclone where they impact and then fall to the bottom of the cyclone. The gas flows out through the top of the cyclone (still carrying some of the smaller, lighter particles), while the collected dust is removed from the bottom.

The ID fan sucks the dust, which is passed through a Cyclone. Some particulate matter is collected in the Cyclone but lighter particulate matter (less than 10 micron size) escape. As the quantity of such fine particle is substantial in these types of mills, substantial quantity of fine dust is emitted into the environment resulting in air pollution



Technical viability for various mills:

Cyclones are typically suitable for treatment of particles greater than 10 microns efficiently. For emissions where the percentage of fine particle (<10 microns) is quite low, cyclones are suitable.

Cyclones are also suitable as classifiers for applications like wheat flour mill, pulse/rice grinding mills, where different size products are classified according to its sizes. Some portion of finer particles escapes these cyclones, which may need to be passed through filter cloth bags. The filter cloth bag arrangement should have appropriate intermittent / continuous dust cleaning and removal mechanism without which the filter cloth gets choked with time thereby adversely affecting the overall system efficiency.

Cyclones are most suitable as pre-collectors to capture the coarser particles thereby reducing dust load on the final treatment equipment like bagfilter.

Advantages of cyclones are that they are simple, rugged, and inexpensive. Also, they collect the PM in a dry form so that it can be re-used.

The major disadvantage is that the collection efficiency tends to be quite low for controlling finer particles (< 10 micron size).

Efficiency of cyclone for various particle sizes

Fractional efficiencies of a typical cyclone is given below:

Typical efficiency of cyclone for dust from Cleaning section (Pulse)

Range (Microns)	Mean Particle Diameter	Percent Distribution for cleaning	Fractional Efficiency	Fractional Efficiency
0-5	3.5	32.4	60	19.44
5 to 10	7.5	23	85	19.55
10 to 20	12.5	15.5	95	14.73
20-30	17.5	10.2	98	10.00
>30	25	19.1	99.9	19.08
Total efficiency =				82.79

Typical efficiency of cyclone for dust from milling section (Pulse)

Range (Microns)	Mean Particle Diameter	Percent Distribution for cleaning	Fractional Efficiency	Fractional Efficiency
0-5	3.5	23.6	60	14.16
5 to 10	7.5	29.6	85	25.16
10 to 20	12.5	35	95	33.25
20-30	17.5	9.8	98	9.60
>30	25	2	99.9	2.00
Total efficiency =				84.17

The above table indicates that the cyclone type dust control system has only 50% or less efficiency in controlling less than 10-micron particles. Typically the percentage of fines below 10 micron is in the range of 45 to 53% in grain processing mills.

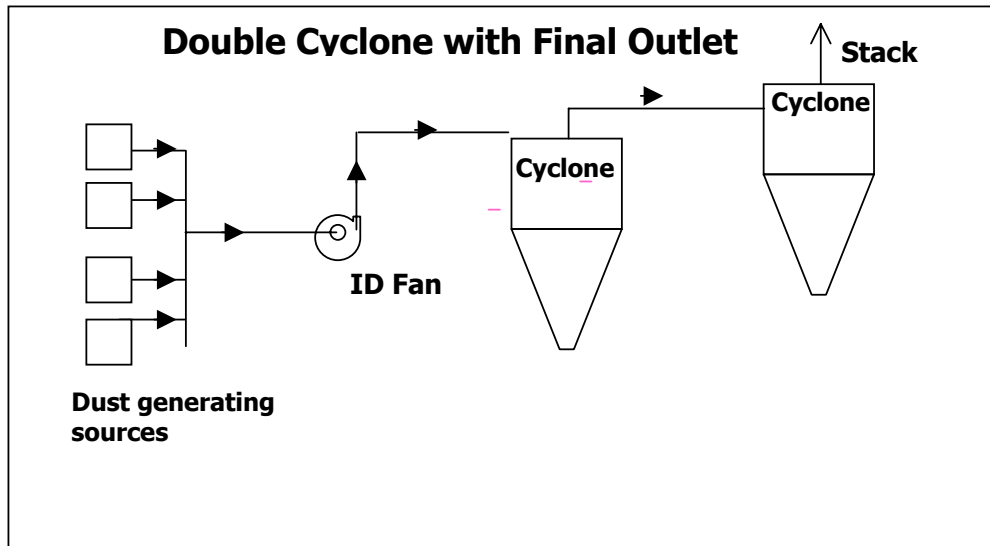
Assessment for suitability:

Suitable only for capturing heavy/ larger size particles (> 10 microns). The finer particles are only partially collected. Since the emissions from pulse/wheat/rice mills comprise substantial amount of fine particulates (45 –53 % below 10 micron size), the cyclones as final control equipment are technically not adequate to achieve emission levels in the range of 150 mg/Nm³. The cyclones could however be suitable as pre-collectors.

Double cyclones in series

In this type of system, shown schematically below, dust is extracted from various dust generating points with the help of an ID fan and it is passed through a set of

two cyclones in series. Generally most mills install the second cyclone as an add on item, thinking that more dust would be collected which was not collected in the first cyclone. However, technically, the dust that could not be collected in the first cyclone contains maximum percentage of fine particles below 10 micron size which cannot be collected efficiently in any number of subsequent cyclones in series but it would only increase the system pressure drop and would ultimately reduce the volume extracted by the fan which would lead to fugitive emissions from the dust sources.



Assessment for suitability:

Such double cyclone system could be suitable for capturing heavy/ larger size particles (>.10 microns). The finer particles are only partially collected. Since the emissions from pulse/wheat/rice mills comprise substantial amount of fine particulates (45 –53 % below 10 micron size), the cyclones as final control equipment are technically not suitable /adequate.

Operational & Maintenance Feasibility

Operation of cyclone does not require any skilled manpower and continuous attention. Cyclone can be installed at any place in the plant, as it no moving parts does not make any noise. , If any change occurs in design or operating variables which tend to increase collection efficiency also tend to increase pressure drop at a greater rate than the collection efficiency. Efficiency will increase with an increase in particle size, particle density, gas inlet velocity, cyclone body or cone length, and the ratio of body diameter to gas outlet diameter. Decreased efficiency is caused by an increase in gas viscosity, gas density, cyclone diameter; gas outlet diameter; and inlet widths or area.

The actual in-field performance of cyclone units will vary because of changes in operating conditions such as dust load and gas flow.

Erosion of the cyclone inner surface is a major problem with handling the cleaning/milling dust. Erosion in cyclones is caused by impingement and rubbing

of dust on the cyclone walls. It becomes increasingly worse with high dust loading, high inlet velocities, larger particle size, and more abrasive dust particles. Any defect in cyclone design or operation, which tends to concentrate dust moving at high velocity will accelerate erosion.

Continuous and effective removal of dust in the dust outlet region must be maintained in order to eliminate a high circulating dust load and resultant erosion.

Another major problem is the fouling of cyclone. Decreased efficiency, increased erosion and increased pressure drop result from fouling in cyclones. Fouling generally occurs either by plugging of the dust outlet or by building up of materials on the cyclone wall. Dust outlets become plugged by dust or by break off of material caked on the cyclone walls. The finer and the softer the dust like milling dust, greater is the tendency to cake on the walls.

However cyclone has its own advantages like easy to install and replace defective parts, constructed of wide variety of materials to overcome the erosion and fouling. Minimum space requirements low capital and maintenance costs etc.

Economic Viability

Cyclones are typically low cost treatment technologies as compared to equipments like bag filters and therefore economically viable. The cost of the cyclone system depends on the volume to be treated, the efficiency requirement, the nature of dust, etc. The cost primarily depends on thickness of sheet used for fabricating the cyclone, higher the thickness for more abrasive dust and for longer life expectancy.

8.1. 5. Wet Scrubber

Wet scrubbers operate on the principle of collision between particles and water droplets, collecting particles in the larger, heavier water drops. The water is brought in contact with the upward-flowing gases, colliding with and removing particles, and accumulates in the bottom of the scrubber. The “dirty” water is pumped from the scrubber and treated to remove the solids as a wet sludge.

Technical viability for various mills:

Collection efficiencies for wet scrubbers are highly variable and primarily depend on the type of scrubber design and nature of dust to be treated. Conventional scrubbers rely almost exclusively on inertial impaction for Particulate matter collection. Scrubber efficiency that relies on inertial impaction collection mechanisms is higher for larger particle size.

Even though Wet scrubber type system could control the fine particulates at a high efficiency level, it is not technically suitable for pulse/wheat/rice mill type operations as it would wet the dust and would adversely affect the usability of

collected material as by-product. More over, since the dust is collected as a wet slurry and generate wastewater that would need additional treatment. Disadvantages of scrubber are that there is a high potential for corrosion, a high use of water, and a waste liquid or wet sludge effluent that must be treated and/or disposed.

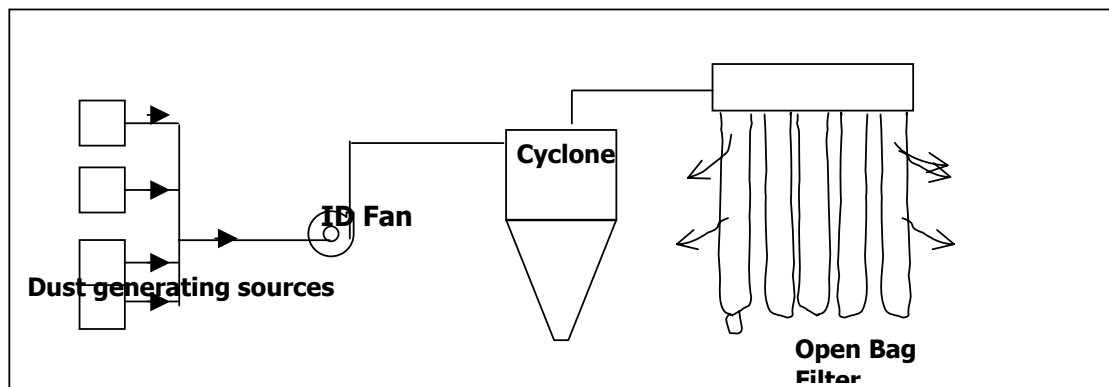
Keeping in view the above discussions, scrubber is not a suitable control equipment for pulse/ wheat/ rice mill process applications. However, the scrubber may be suitable for controlling emissions from rice husk fired boiler applications.

8.1. 6. Open Hanging type Bag Filter (without cleaning arrangement and stack)

This is most pre-dominantly adopted type of dust control system particularly in pulse making and wheat flour mills. In this system, dust is extracted from various dust generating points with the help of an ID fan and the dust-laden air is passed through a Cyclone and the cyclone outlet is connected to a ring type enclosure with holes in bottom and on these holes loose cloth bags are tied, as shown below.

In such systems, the heavier particles get collected in the cyclone and the finer particles, escaping cyclone, get deposited on the filter bag cloth. In the absence of any periodical bag cleaning mechanism, the dust deposits on filter bags keep building and eventually leads to blinding of the cloth and subsequently choking after few hours of operation. This leads to high pressure drop across the filter bags, which result, into either puncturing of the bags or reduction in suction capacity of the fan. Any puncturing in the filter bags gives rise to spreading of fine dust through the hole into the shop floor area. On the other hand, the reduced suction capacity of the fan leads to reduce volume, which leads to fugitive emission from the dust generating sources.

In this system, there is no final discharge stack where dust sampling can be undertaken.



Technical Viability:

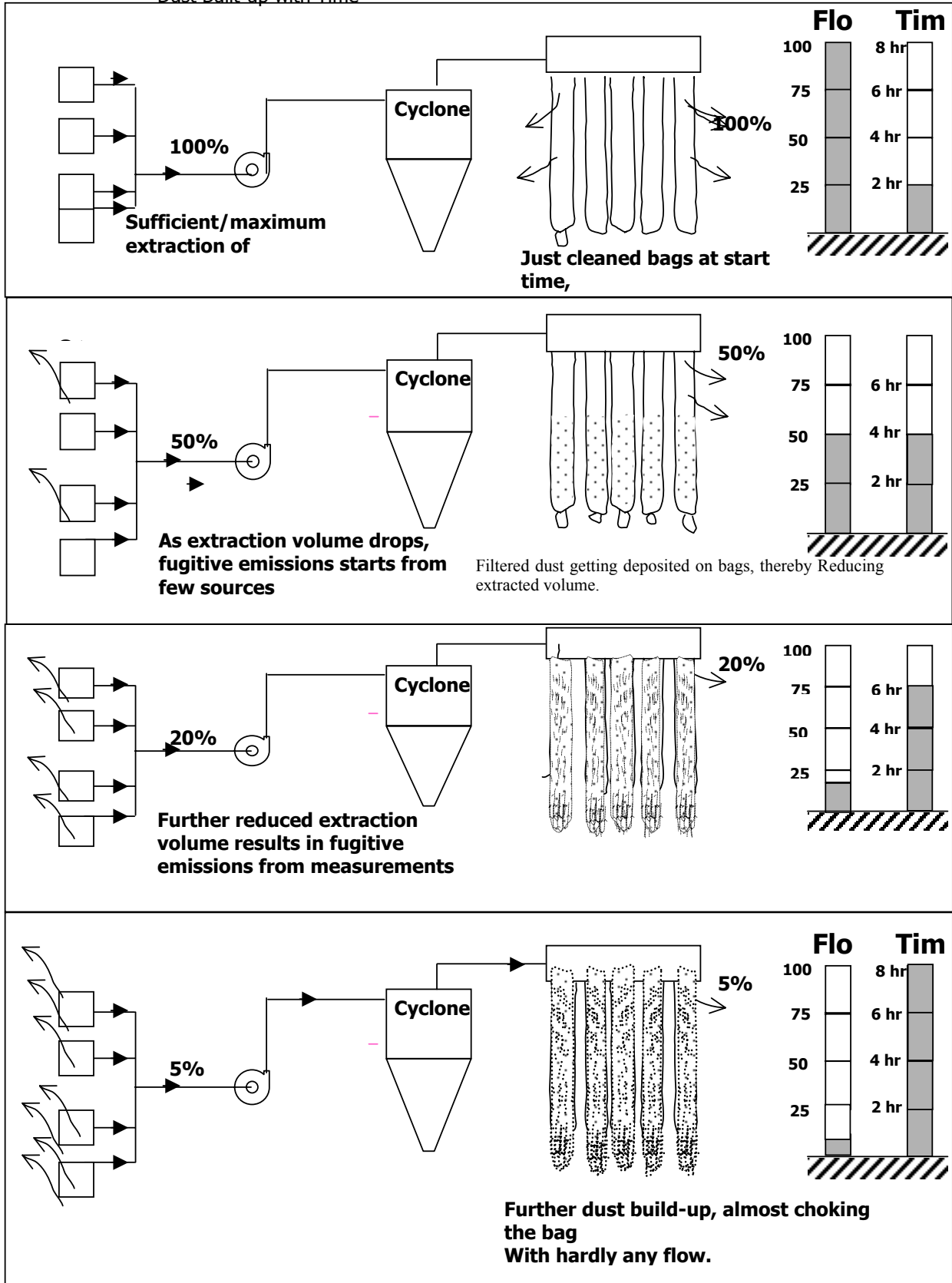
In the open type bag filter arrangements, the dust deposit on the inside surface of the filter bags keeps building-up due to the absence of any bag cleaning

mechanism. This increasing dust built-up with time increases the system pressure drop across the filter cloth, which results into reducing suction capacity and in turn the extraction volume. Due to this reduced suction capacity, fugitive emissions start from the dust sources and the same keeps increasing with time. A stage even reaches when there is hardly any extraction, even though the ID fan is running. Such system invariable is observed in pulse making mills.

This phenomenon of reducing effectiveness of the dust extraction cum control system with time has been explained at figure 6.1 through schematic presentation in various time stages.

The figure enclosed gives the comparative analysis of reducing flow with respect to time in four stages. In the subsequent stages, as the dust keeps building up on the filter cloths, the extraction volume decreases and results into fugitive emissions from the dust generating points.

Figure 8.1 Reducing Effectiveness of Open Bag Filter System due to increasing Dust Built-up with Time



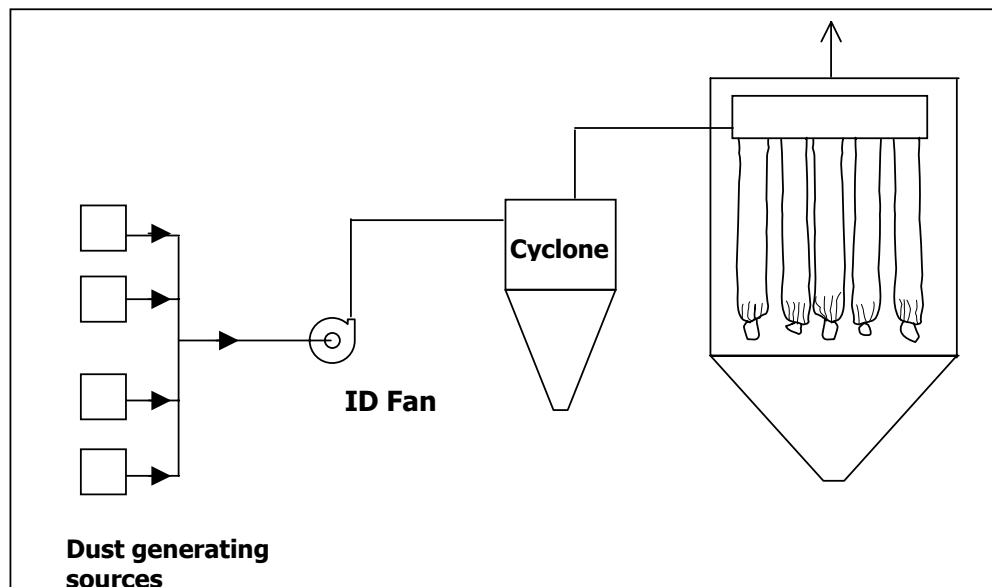
Assessment for Suitability

This type of open hanging bag filter without stack is technically not suitable due to following reasons:

- Final emissions not discharged above roof level through stack, no stack monitoring possible to judge whether system meets prescribed limit or not.
- Lack of bag cleaning mechanism leads to excessive dust deposits on filter bags, which increases system pressure drop and thereby reduces dust extraction effectiveness.
- Inadequate extraction of dust leading to fugitive emissions.

Externally closed, open hanging type filter bag arrangement

In some mills where above discussed system of cyclone cum open bag filter system without cleaning arrangement is originally installed, has been modified by way of providing enclosure to the filter bags and with the stack installed at the top of enclosure. Such modification has been done to meet the criteria defined by some Pollution Control Boards to discharge final emission through stack above roof level along with the sampling provision. But without any bag cleaning arrangement, problem discussed in the above scheme of higher-pressure drops and reduced suction capacity of fan still remains.



Assessment of suitability

Such externally closed bag filter arrangement, do have the problem of increasing dust built-up in filter bags which can not be periodically cleaned and this ultimately results into fugitive emissions at dust generating sources and therefore such systems are not technically suitable /adequate.

8.1. 7. Bag filter (with cleaning & stack arrangement):

In this system, dust is extracted from various dust generating points with the help of ID fan and the dust-laden air is passed through bag filter house (with or without Cyclone as pre-collector) and the final emission is discharged through stack. In this system, the dust collected in the bag is discharge to the hopper by means of a suitable bag cleaning arrangement. Periodical cleaning of the bags does not allow the pressure drop across the filter bag to increase beyond a desired range and therefore suction capacity of the fan remains within a desired range.

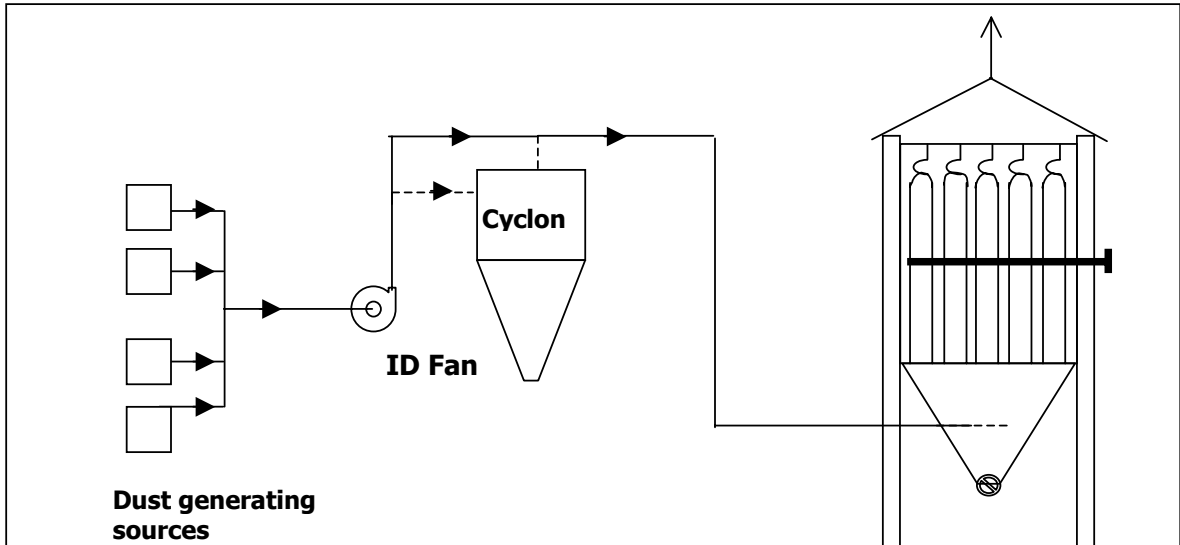
The bag filter designs vary with the type of filter bag arrangements and cleaning mechanism adopted, like:

- Shaker type bagfilter
- Compressed air pulse jet cleaning type
- Cassette type with compressed air jet cleaning

Cleaning system knocks the dust collected on the filter cloth, which is collected in the bottom hoppers from where it is removed, either continuously or intermittently. Either of the above type of bagfilters are technically viable for cleaning and milling sections of Dal mill, Flour mill as well as rice mill. The most prominently used bagfilters are discussed below.

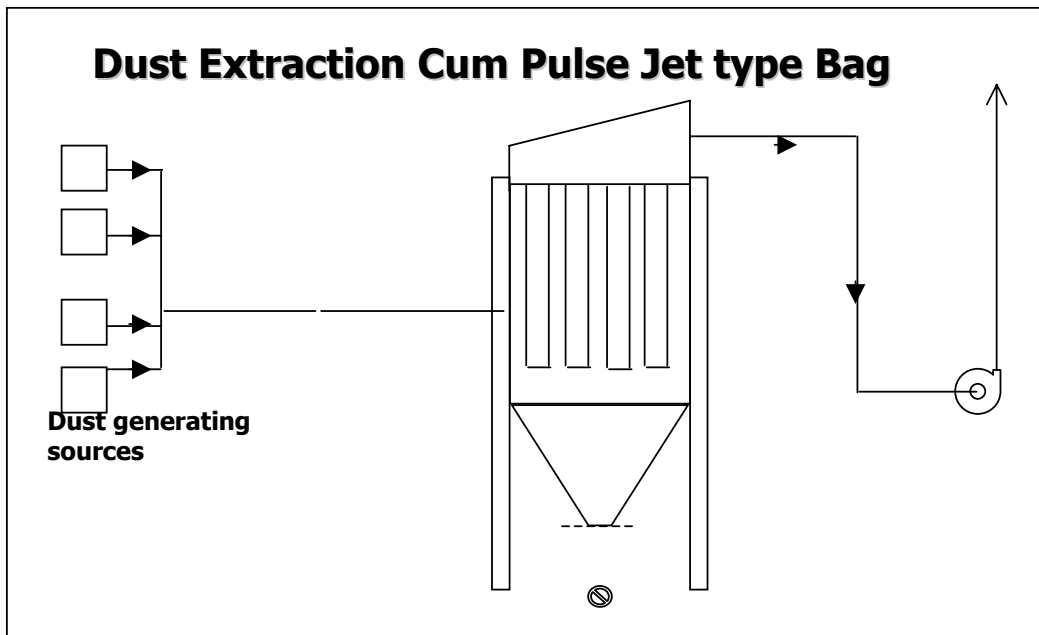
Shaker type Bagfilters :

In this type of design, the dust, deposited on the filter cloth is shaken loose either mechanically or manually, which falls into the dust hopper provided below. The dust is periodically removed from the hopper into gunny bags and sent for disposal or recycling. Periodical cleaning of the bags does not allow the pressure drop across the filter bag to increase beyond a desired range and therefore suction capacity of the fan remains within a desired range. A schematic of shaker type bag filter is given below.



Pulse Jet type bag filter:

In this system, dust is extracted from various dust generating points with the help of ID fan and the dust-laden air is passed through a bag filter house and the final emission is discharge through stack. In this system, the dust collected in the bag is discharge to the hopper by means of pulsejet type bag cleaning arrangement. Periodical cleaning of the bags does not allow the pressure drop across the filter bag to increase beyond a desired range and therefore suction capacity of the fan remains within a desired range.



Technical viability for various mills:

One of the most efficient methods for collecting particles is filtration in Bag house with efficiency above 99% for almost all types/sizes of particulates.

The efficiency of the bag-filter especially of controlling fine particulates is given in the table below

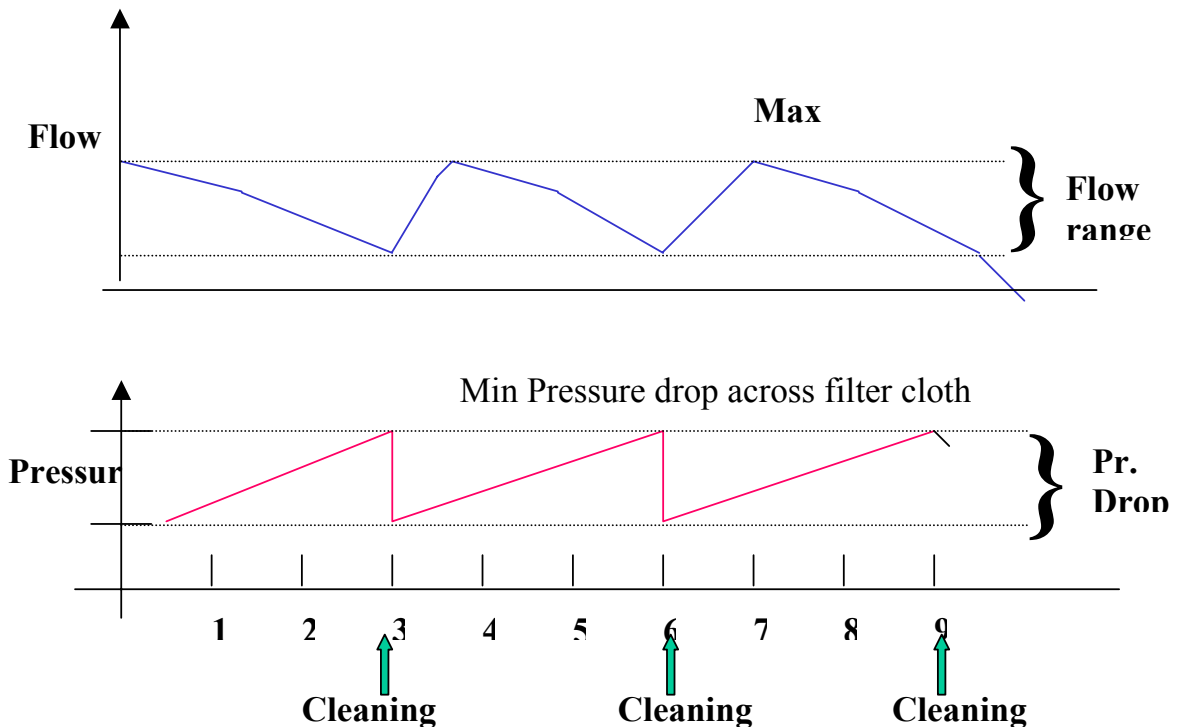
Efficiency of fabric filter (bag-filter) for various particle sizes

0 to 2.5 micron	2.5 to 6 micron	6 to 10 micron
99.0 %	99.5 %	99.5 %

The above table indicates that the bag filter type dust control system has very high efficiency in controlling the fine particles less than 10-micron size and hence the most appropriate dust control equipment.

Due to periodical cleaning of the dust from the filter cloth surface, the dust build up does not allow growing beyond the desired range and as a result the pressure drop across the cloth doesn't increase beyond desired range. After every cleaning, the pressure drop comes down. The flow variation with respect to pressure drop variations remain in desired range without substantially reducing the extraction capacity of the system. The same has been presented in the form of graph below.

Graph showing Flow Vs. Pressure relationship for bag filter systems :



As regards to the technical feasibility for various type of bag filter designs, either of the conventional and standard designs such as pulse jet cleaning type, reverse air cleaning type, cassette type, mechanical shaker type, manual shaker type, etc.

are technically feasible. However, the economic viability of the type of bag filter design for a pulse/wheat/rice mill, in terms of investment cost, may vary from unit to unit.

Operational & Maintenance Aspects

The bag filter house needs to be properly operated and maintained to achieve satisfactory performance of the system. Especially the cleaning mechanism needs to be inspected regularly for its appropriate operation and corrective actions are immediately taken for ensuring its proper functioning.

In pulse jet bag filters, the compressed air should be dry, moisture free and the desired pressure needs to be maintained or else the air pulse may not be effective. The solenoid valve timer assembly also needs to be dust free or else the valves may leak thereby resulting in improper pulse of air leading to inadequate cleaning. The ineffective cleaning may lead to built-up of dust deposits leading to excessive pressure drop, which may adversely affect the extraction capacity of the fan.

In shaker type bagfilters, the shaking mechanisms need to be periodically operated to avoid excessive pressure drops due to dust built-up. The filter bags also need to be kept under proper tension for effective shaking. Periodic inspections are required to check appropriateness of the cleaning system.

Since pulse jet systems have electronic circuits controlling the cleaning mechanisms, if it malfunctions, in small scale pulse, wheat & rice mills where qualified personnel in electronic circuit repairs are hardly available, it calls for requesting supplier to send concerned personal to carryout repairs and make the cleaning system functional. This may require long stoppages of the system.

In shaker type bagfilters, in the absence of any electronic circuits, repairs if any in the cleaning mechanism can be internally carried out immediately and system need not be stopped for long durations. The maintenance is easier in these type of systems and therefore suitable for small size mills.

The filter bags may get damaged at times due to reasons like tearing, damaged stitching, etc which needs to be repaired / replaced or it may lead to excessive stack emissions.

As per recommendations, two units have installed shaker type bagfilters for controlling the emissions and the case studies of both these units are presented at Annexure 8.5.

Economic Viability:

The typical cost towards installation of the shaker type low cost bag filter systems for typical pulse mill of 15 – 20 Tons /shift capacity, for both cleaning and milling section, would be in the range of 2 – 4 Lakhs. This cost towards installation of bag filters works out to be in the range of less than 10% of the investment in plant and machinery and therefore financially viable.

For the Wheat Flour mills, shaker type bag filters could be viable in some sections like cleaning, but for sections like milling, pneumatic conveying, etc, pulse jet type bag filter systems with automatic online cleaning mechanism are required. The cost would depend on the size of the bagfilter, type of design, extent of automation and number of systems required in a mill.

Pulsejet cleaning type bagfilters have high investment & maintenance costs as compared to Mechanical shaker type Bag filters.

8.1. 8. **Electrostatic precipitator (ESP)**

Electrostatic precipitator (ESP) removes particulate matter from a gas stream by creating a high voltage drop between electrodes. A gas stream carrying particles flows into the ESP and between sets of large plate electrodes; gas molecules are ionized, the resulting ions stick to the particles, and the particles acquire a charge. The charged particles are attracted to and collected on the oppositely charged plates while the cleaned gas flows through the device.

Technical viability:

Electrostatic precipitators are capable of collecting greater than 99 percent of all sizes of particulate. Collection efficiency is affected by several factors including dust resistivity, gas temperature, chemical composition (of the dust and gas), and particle size distribution. The dust characteristics can be a limiting factor in the applicability of dry ESPs to various industrial operations. Sticky or moist particles and mists can be easily collected, but often prove difficult to remove from the collection electrodes of dry ESPs. Dusts with very high resistivity are also not well suited for collection in dry ESPs. Dry ESPs are susceptible to explosion in applications where flammable or explosive dusts are found.

Electrostatic precipitators are usually not suited for use on processes, which are highly variable, since frequent changes in operating conditions are likely to degrade ESP performance. Electrostatic precipitators are also difficult to install on sites, which have limited space because ESPs must be relatively large to obtain the low gas velocities necessary for efficient particle collection.

As discussed above the ESPs are not technically viable for the application of Dal, flour and rice mills due to the following reasons.

- Smaller scale of operations, high investment costs
- Common treatment system not possible for all sections, smaller volumes to be treated in number of treatment systems
- Space is very limited for most of these mills.
- Dust is inflammable.

Operational and Maintenance aspects:

ESP present very little resistance to gas flow therefore cause only a slight pressure drop even when operating on flows as large as a million cubic meters per hour. Therefore their operating costs are lower.

Economic viability for various mills:

ESPs are generally of a large size as compared to cyclones and baghouse and expensive, especially for smaller gas volume applications.

Keeping in view the high Investment cost and non-suitability for low gas volume rates (below 100,000 m³/hr), ESP's are economically not viable for Pulse, Wheat, and Rice milling/grinding applications.

8.2 USEFULNESS OF RECOVERED MATERIAL

While controlling emissions from pulse/wheat/rice mills, some of the material collected has usefulness to the industry as a saleable or recyclable by-product. The various types of materials recovered and their usefulness, if any, is discussed below:

Pulse Making Mills

The dust collected from the cleaning section contains primarily the dirt, silica, dead insects, damaged grains and other foreign material carried from farmlands. This dust does not have any usefulness and would need to be disposed for land filling.

The dust collected from the milling section is primarily the powder generated while processing pulses during removal of shell (chilka). This dust can be sold as animal feed. Once the dirt and silica etc. is separated in the cleaning section, the quality of the dust collected in the milling section is certainly better and fetches higher price.

Wheat Flour Mills

In the wheat flour mills, the dust recovered in the cleaning section primarily contains the dirt, silica, dead insects, damaged grains and other foreign material carried from farm lands and does not have any usefulness and needs to be disposed of.

In the subsequent sections (like scouring, aspiration, purifiers etc), the particulate matter collected by the emission control systems is primarily wheat powder, which has usefulness in terms of saleable by product. Especially after effective separation of dirt / silica in the cleaning section, the recovered material in the milling section is of better quality and could fetch higher price.

In the pneumatic conveying section of the wheat flour mill, the recovered material in efficient equipment like bag filters can directly be mixed along with the final products since the same is not contaminated and therefore useful. In the absence of efficient control equipments, substantial quantity of fine powder is emitted to the environment, which apart from creating air pollution, is a loss of product to the company.

Wheat Processing mills :

In the wheat processing mills like roasters, the dust captured in the cleaning section primarily contains the dirt, silica, dead insects, damaged grains and other foreign material carried from farm lands and does not have any usefulness and needs to be disposed of.

Rice Mills

The dust collected in the cleaning section, which primarily contains silica, dirt and also empty paddy shells etc. could be useful for the purpose of burning into the husk fired boiler. The rice husk extracted from the milling section could also be used either for burning in the boiler.

Dry Rice/pulse grinding :

Generally the grinding units receive raw rice or pulses produced by rice mills or pulse making mills, either owned or externally sourced. The dust produced during grinding is nothing but fine powder of rice or pulses and has usefulness in terms of mixing that powder along with the product if un-contaminated or could be sold as animal feed.

8.3 SUITABILITY OF WASTEWATER TREATMENT TECHNOLOGIES FOR WHEAT FLOUR MILL (WET TYPE) EFFLUENT:

Suitability of various types of wastewater treatment technologies for wet type wheat flour mill effluent is described below. This includes the existing treatment technology practiced in wet type wheat flour mills.

Review of existing control system practiced:

Presently, the wet type flour mills treat their effluent generated from washing operation of wheat in a Soak Pit. The details are discussed below:

Soak-pit:

Soak pit is a well type structure, which is filled with gravel, coarse & fine sand. The wastewater is allowed to pass through the soak pit into the ground water. But, due to inadequate size of soak pit compared to the quantity of wastewater discharged and due to clogging of soak pit in due course of time, the wastewater does not percolate underground through the soak-pit. But eventually overflow, which is

directly discharged into the municipal sewer. The soak pit eventually acts like a wastewater storage tank.

Based on the characteristics of wastewater from the wheat flour mill (refer-Page 5.16, Table 5.10), which requires certain degree of BOD removal efficiency for discharge to either municipal drain, land or surface water; which can not be achieved with the soak pit type of control system. The typical BOD removal efficiency requirements for different recipient media are given below:

Measured maximum BOD concentration of Effluent	Discharge to	Allowable BOD limit, mg/l, max	BOD removal efficiency requirement
600 mg/l	Municipal drain	350	42%
	Land	100	83%
	Surface water	30	95%

Therefore, the existing soak-pit technology is not suitable.

Suitable Treatment Technology:

Based on the characteristics of effluent, the suitable treatment schemes are discussed below:

a) Primary Treatment:

Screen: The wastewater generated after washing of wheat carry floating waste agricultural material (like stem, husk, etc.). These materials clog the drain and obstruct during pumping of wastewater from one treatment unit into other. It may lead to frequent breakdown of pump. Therefore, to avoid these difficulties, it is recommend to install a two stages screening system consisting of coarse and fine screens.

To facilitate manual cleaning of the screens, a screen chamber should be constructed based on the peak flow. The location of screen chamber should be below the level of the main drain. The suspended/floating solids retained on the screen would be manually removed as and when required and would be disposed off as solid waste in a safe manner.

The screened wastewater should either flow by gravity or pumped to the settling tank/primary clarifier. In case of pumping, a pump sump should be constructed to collect and transfer wastewater coming from screen to the settling tank/primary clarifier.

Oil & Grease Trap:

The oil & grease concentration in the wastewater is in the range of 5~10 mg/l. It is meeting the normal discharge limit and it won't affect the biological treatment. Therefore, there may not be a need to install Oil & Grease Trap.

Chemical Treatment

The pH of the wastewater generated from washing operation of wheat flour mill is in the range of 6.4~7.5. There is no possibility of the presence of heavy metals. Therefore, there is no need for going in for chemical treatment.

Settling Tank/Primary Clarifier:

The suspended solid concentration varies between 215~325 mg/l. The desirable suspended solid concentration should be less than 600 or 200 or 100 mg/l for discharge into Public Sewer or land for irrigation or inland surface water respectively. Therefore, a settling tank/primary clarifier is required to be installed for the settlement of suspended solids for discharging either on land or surface water.

b) Secondary Biological System:

The BOD concentration of the wastewater varies in the range of 450~600 mg/l. The desirable BOD concentration should be 350 or 100 or 30 mg/l for discharge into Public Sewer or land for irrigation or inland surface water respectively. Therefore desirable BOD efficiency varies between 42 to 95%. This could be achieved by means of different modes of activated Sludge Process (ASP) such as high rate, conventional, extended aeration process etc.

A sedimentation tank/secondary clarifier should be installed close to the aeration tank for solid liquid separation and sludge re-circulation, so as to maintain the desired range of MLSS concentration, as discussed in the above table.

c) Tertiary Treatment System:

There is no need to go for tertiary treatment of the wastewater. The proposed limit of discharge could be achieved through primary and secondary treatments, discussed above.

Recommended level of various pollution parameters:

The applicable pollution parameters and their recommended limit of discharge into the different recipient bodies is given below:

Sl. No.	Parameters	Standards		
		Inland Surface water	Public Sewer	Land for irrigation
1.0	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
2.0	Suspended solids, mg/l, max	100	600	200
3.0	Oil & Grease, mg/l, Max.	10	20	10
4.0	Biochemical Oxygen demand, BOD (3 days at 27 deg C), mg/l, max	30	350	100

5.0	Chemical Oxygen demand (COD), mg/l, max	250	-	-
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Note: Since the wastewater is biodegradable in nature, the COD value will be achieved by adopting above suggested control technologies.

8.4 SUITABLE TECHNOLOGIES FOR HANDLING STORM WATER FROM PULSE MAKING MILLS.

Suitability of various types of storm water handling practices for pulse making mills is described below.

Review of existing practice:

The storm water from pulse making is currently discharged without any treatment to the municipal drain. Since, it may carry organic material such as broken pulses, shells, powder etc which may add BOD load in the storm water & therefore this practice is not technically suitable.

Suitable Storm water Handling Practice:

Based on the characteristics of the storm water samples collected at different time of storm water discharge (Refer Table 5.9, Page-5.15), it is evident that during the initial rain period, the storm water contains higher levels of TSS, BOD and also Oil & Grease. The TSS varies in the range of 184 to 820 mg/l, the COD from 528 to 1238 mg/l and BOD from 360 to 830 mg/l and Oil & Grease from 20 to 10 mg/l. After some time, the above parameters have lower concentration in the subsequent storm water as mentioned in the Table 5.9 (Page 5.14).

To overcome high concentration of above pollution parameters for short duration and intermittent discharge of storm water, and subsequent dilution with the clean storm water, the following storm water handling measures are recommended:

- Storm water generated from the sun drying area should pass through a fine mesh (3mm mesh) screen fitted at entry of the water discharge pipes.
- The screened storm water should be collected separately in a settling tank. The design of settling tank should be made based on the maximum rainfall rate (per hour) and minimum retention time of 3 hours
- The settled suspended impurities be removed from the water (as sludge) and only the overflow from the tank shall be discharged in to the recipient media, preferable for rainwater harvesting purpose.

Note:

1. To prevent contamination of storm water it is recommended that the sun-drying area may be covered with HDPE sheets during rains.
2. In addition to above, regular cleaning of the sun-drying area should be carried out.

Recommended level of storm water pollution parameter:

The applicable pollution parameter for storm water discharge is suspended solids and its limit shall not exceed 100 mg/L, 200 mg/L or 600 mg/L respectively for discharged into inland surface water bodies, on land for irrigation & public sewer.

8.5 NOISE PREVENTION MEASURES RECOMMENDED

For noise generating sources, such as rotary/vibratory screen, bucket elevators, screw conveyors and grinders, motors etc, following noise prevention cum control measures are recommended.

- Providing Vibration dampening pads to prevent noise generated due to vibration
- To provide rigid enclosure for rotary/vibratory screens
- Bucket elevator transfer points to be covered with rigid enclosures
- Ear plugs, ear muffs may be provided to workers exposed to higher noise levels.

CHAPTER 9: PROPOSED ENVIRONMENTAL STANDARDS

9.1 Basis for Evolving Standards

- Consideration based on capacity and size of units

All the units whether a dall mill, a rice mill or a flour mill or a grinding unit (for rice or dall), have similarity in term of operations, only the size of the equipments or material of construction may vary depending on capacity or type of grains processed.

The similarities are tabulated below.

Section	Common equipments/machines	Common for
Cleaning	<ul style="list-style-type: none"> ➤ Unloading of grains ➤ Material handling (Bucket elevator, belt conveyor etc.) ➤ Screening (Vibratory or rotary screens) ➤ Destoner (gravity type, magnetic) 	<ul style="list-style-type: none"> ➤ Dall Mills ➤ Rice Mills ➤ Flour Mills ➤ Besan Mills ➤ Dry Rice Grinding ➤ Wheat Processing
Milling	<ul style="list-style-type: none"> ➤ Bucket elevator/Belt conveyor ➤ Rollers for breaking/grinding (emery, rubber) (Cylindrical or flat type) ➤ Product grading equipments (Screens or centrifugal type graders) 	-do-

Generally the cleaning operations are performed only in day shift (about 8 to 10 hrs.), as it involves material unloading labour. Whereas, the milling operation could be carried out round the clock. Both these cleaning and milling operations are carried out separately and there is no direct inter-dependence. The cleaned raw materials are stored in intermediate storage. As required, some processing is done to prepare the clean raw material prior to milling, such as wetting or drying or applying oil etc.

Irrespective of the sizes and capacities of the equipments like bucket elevator, belt conveyor, vibratory screen, rotary screen, grinding and crushing equipments etc., the requirement of providing adequate enclosure to contain the dust and requirement of extractions of some volume of air from each of the above equipments is necessary. Larger the size or capacity, more would be volume to be extracted.

It is therefore, the requirements under the standards could be common for all types of industries covered under the project in terms of

- Enclosures for the dust generating locations
- Extraction of airborne dust from key locations.

The quantities/volume could be decided based on the area and size of the equipments, using guidelines given in table.

Suitable control equipment

As regards to requirement of the final dust control equipment, the deciding factor is percentage of fines (below 10 micron) in the total emissions.

The PSD analysis data shows, that in most of the emissions from cleaning and milling of pulse/rice/wheat, the percentage of fines less than 10 microns is substantial in the range of greater than 25 to 30 %. As it is possible to economically capture these fines in small size bagfilters, which is techno-economically feasible, bagfilter could be considered as the final control equipment for all type of industry applications under the project.

Also the dry collection of material has usability in terms of selling the collected dust from milling section as “animal feed”, it has payback investment, apart from effecting emission control.

These bagfilters generally meet final emission levels of about 150 mg/Nm³ or lesser, as per past experience and hence final limit of 150 mg/Nm³ could be considered for all applications.

Based on above discussions, the proposed standards are described below.

9.2 PROPOSED EMISSION STANDARDS:

The following emission standards are applicable for Pulse making mills; pulse grinding mills, wheat flour mills, wheat processing mills, rice mills and dry rice grinding mills.

9.2.1 Part I- Engineering Design Requirements For Emission Prevention & Treatment of emissions

- As a general guidance, the loading, unloading, handling storage & processing of raw material, products, wastes or by-products should be carried out so as to minimize the release of visible dust emissions.
- Without prejudice to the generality of the above requirements, the following control measures shall be implemented
- All dust generating locations should be provided with dust extraction arrangement. The recommended extraction points (as applicable) should include the following:
 - All bucket elevators (except elevators with no dust)
 - All rotary (classifying) screens
 - Vibratory screens
 - Gravity Discharge points of pipes

- Grinder outlet locations
- Destoner
- Scourer/dehusking machines
- Aspirators
- Purifiers
- The extracted dust emissions should be treated in a bag-filter house type final control system for efficient capture of fine particulates. Cyclones, Settling Chambers etc may be used as pre-collectors to reduce dust load on bagfilters or for gradation purposes.
- Separate Air Pollution Control Device (APCD) for the cleaning & milling sections should be provided, so as to segregate useful by-product from milling section & dirt, soil, etc from cleaning section
- All APCD's should have
 - ✓ Final chimney discharging treated emissions above roof level (at least 12 m from ground level or 2 m above roof level whichever is higher), along with appropriate sampling porthole and platform arrangement to measure final emission levels.
 - ✓ Appropriate dust cleaning and removal mechanism to periodically clean /remove the dust out of the system continuously or intermittently to avoid re-entrainment and excessive pressure drop buildup resulting in reduced extraction volume and efficiency.
 - ✓ Branch line dampers to enable finer adjustments of airflow quantities from various points
- The APCD could be considered adequate & appropriate, only if, there are no visible fugitive emissions from all material handling as well as process equipments. The fugitive emissions would be said to be in excess if the work environment SPM (Note: SPM measurement for 8 hour using High Volume Samplers with flow rate > 1.1m³/min measured at most central location of the work environment) exceeds OSHA specified occupational exposure limit of 10 mg/m³. Alternatively, the extraction will be considered adequate if the ingress air velocity measured at all openings of the equipment enclosures would be in excess 1 m/sec, this would ensure negative pressure in all equipment enclosures.

9.2.2. Part II- Emission Limit

The emission limits applicable to all emissions during normal operations including load variations should be less than 150 mg/Nm³ (milligram per cubic metre), measured at final outlet stacks attached to the control equipments. The introduction of dilution air after final control system to achieve the emission limits is not permitted.

9.3 PROPOSED NOISE LEVEL STANDARD

- The ambient noise level should not exceed 75 dB(A) Leq in day time and 70 dB(A) Leq in Night Time.
- All material handling & process equipments should be completely enclosed inside rigid enclosures to prevent/reduce noise levels at source.

9.4 PROPOSED EFFLUENT STANDARDS FOR WET TYPE WHEAT FLOUR MILLS

The following standards are proposed for discharge of effluents from wet type wheat flour mills.

Sl. No.	Parameters	Standards		
		Inland Surface water	Public Sewer	Land for irrigation
1.0	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
2.0	Suspended solids, mg/l, max	100	600	200
3.0	Oil & Grease, mg/l, Max.	10	20	10
4.0	Biochemical Oxygen demand, BOD (3 days at 27 deg C), mg/l, max	30	350	100
5.0	Chemical Oxygen demand (COD), mg/l, max	250	-	-

9.5 PROPOSED STORM WATER HANDLING PRACTICES

Following storm water handling measures are recommended for pulse making mills using sun drying method for drying pulses.

- Storm water generated from the sun drying area should pass through a fine mesh screens fitted at entry of the water discharge pipes.
- The screened stormwater should be collected separately in a collection tank
- The floating /suspended impurities be removed from the water and only the overflow from the tank shall be discharged in to the recipient media.
- To prevent contamination of storm water it is recommended that the sun-drying area may be covered with HDPE sheets during rains.
- In addition to above, regular cleaning of the sun-drying area should be carried out.
- Keeping in view of the increasing importance of rainwater harvesting, it is recommended that the rainwater from a portion of the roof-top, not being used for sun drying, should be utilised for rainwater harvesting purpose.

- The applicable pollution parameters and their recommended limit of discharge into the different recipient bodies is given below:

Sl. No.	Parameters	Standards		
		Inland Surface water	Public Sewer	Land for irrigation
1.0	Suspended solids, mg/l, max	100	600	200

10.0 EMISSION STANDARD APPROVED BY THE CENTRAL BOARD FOR NOTIFICATION

Following Emission standards recommended by Peer & Core Committee of CPCB during 2007 are given below:

1.0 PROPOSED ENVIRONMENTAL STANDARDS

1.0 PROPOSED EMISSION STANDARDS:

Emission Limit: (Pulse/Wheat/ Rice Mills)

S.No.	Parameter	Limit (mg/Nm ³)
1	PM	150

The emission limits applicable to all emissions during normal operations including load variations should be **less than 150 mg/Nm³ (milligram per cubic metre)**, measured at final outlet stacks attached to the control equipments.

1.2. Engineering Design Requirements For Emission Prevention & Treatment of emissions

As a general guidance, the loading, unloading, handling storage & processing of raw material, products, wastes or by-products should be carried out so as to minimize the release of visible dust emissions.

Without prejudice to the generality of the above requirements, the following control measures shall be implemented.

- All dust generating locations should be provided with dust extraction arrangement. The recommended extraction points (as applicable) should include the following:
 - All bucket elevators (except elevators with no dust)
 - All rotary (classifying) screens
 - Vibratory screens
 - Gravity Discharge points of pipes
 - Grinder outlet locations
 - Destoner
 - Scourer/dehusking machines
 - Aspirators
 - Purifiers

- The extracted dust emissions should be treated in a bag-filter house type final control system for efficient capture of fine particulates. Cyclones, Settling Chambers etc may be used as pre-collectors to reduce dust load on bagfilters or for gradation purposes.

- Separate Air Pollution Control Device (APCD) for the cleaning & milling sections should be provided, so as to segregate useful by-product from milling section & dirt, soil, etc from cleaning section
- All APCD's should have
 - ✓ Final chimney discharging treated emissions above roof level (at least 12 m from ground level or 2 m above roof level whichever is higher), along with appropriate sampling porthole and platform arrangement to measure final emission levels.
 - ✓ Appropriate dust cleaning and removal mechanism to periodically clean /remove the dust out of the system continuously or intermittently to avoid re-entrainment and excessive pressure drop buildup resulting in reduced extraction volume and efficiency.
 - ✓ Branch line dampers to enable finer adjustments of airflow quantities from various points
- The APCD could be considered adequate & appropriate, only if, there are no visible fugitive emissions from all material handling as well as process equipments. The fugitive emissions would be said to be in excess if the work environment SPM (Note: SPM measurement for 8 hour using High Volume Samplers with flow rate > 1.1m³/min measured at most central location of the work environment) exceeds OSHA specified occupational exposure limit of 10 mg/m³. Alternatively, the extraction will be considered adequate if the ingress air velocity measured at all openings of the equipment enclosures would be in excess 1 m/sec, this would ensure negative pressure in all equipment enclosures.

2.0 PROPOSED NOISE LEVEL STANDARD

S.No.	Paramater	Limit	
		During Day time dB (A) Leq	During Night time dB (A) Leq
1.	Ambient Noise level	75	70

Note:

- All material handling & process equipments should be completely enclosed inside rigid enclosures to prevent/reduce noise levels at source.

3.0 PROPOSED EFFLUENT STANDARDS FOR WET TYPE WHEAT FLOUR MILLS

The following standards are proposed for discharge of effluents from wet type wheat flour mills.

Sl. No.	Parameters	Standards		
		Inland Surface water	Public Sewer	Land irrigation for
1.0	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
2.0	Suspended solids, mg/l, max	100	600	200
3.0	Oil & Grease, mg/l, Max.	10	20	10
4.0	Biochemical Oxygen demand,	30	350	100

	BOD (3 days at 27 deg C), mg/l, max			
5.0	Chemical Oxygen demand (COD), mg/l, max	250	-	-

4.0 PROPOSED STORM WATER HANDLING PRACTICES

Following storm water handling measures are recommended for pulse making mills using sun-drying method for drying pulses.

- Storm water generated from the sun drying area should pass through a fine mesh screens fitted at entry of the water discharge pipes.
- The screened stormwater should be collected separately in a collection tank
- The floating /suspended impurities be removed from the water and only the overflow from the tank shall be discharged in to the recipient media.
- To prevent contamination of storm water it is recommended that the sun-drying area may be covered with HDPE sheets during rains.
- In addition to above, regular cleaning of the sun-drying area should be carried out.
- Keeping in view of the increasing importance of rainwater harvesting, it is recommended that the rainwater from a portion of the roof-top, not being used for sun drying, should be utilised for rainwater harvesting purpose.
- The applicable pollution parameters and their recommended limit of discharge into the different recipient bodies is given below:

Sl. No.	Parameters	Standards		
		Inland Surface water	Public Sewer	Land for irrigation
1.0	Suspended solids, mg/l, max	100	600	200