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Air Pollution Control from Rice Shellers - A Case Study

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Abstract**—**A Rice Sheller is used for obtaining polished white rice from paddy. There are about 3000 Rice Shellers in Punjab and 50000 in India. During the process of shelling lot of dust is emitted from different unit operations like paddy silo, paddy shaker, bucket elevators, huskers, paddy separator etc. These dust emissions have adverse effect on the health of the workers and the wear and tear of the shelling machinery is fast. All the dust emissions spewing out of these unit operations of a rice Sheller were contained by providing suitable hoods and enclosures while ensuring their workability. These were sucked by providing an induced draft fan followed by a high efficiency cyclone separator that has got an overall dust collection efficiency of more than 90%. This cyclone separator replaced two cyclone separators and a filter bag house, which the Rice Sheller was already having. The dust concentration in the stack after the installation of cyclone separator is well within the stipulated standards. Besides controlling pollution, there is improvement in the quality of products like bran and the life of shelling machinery has enhanced. The payback period of this technology is less than four shelling months.

Keywords**—**Air Pollution, Cyclone Separator, Pneumatic Conveying, Rice Sheller.

I. Introduction

RICE is a staple food in many parts of India. It is obtained from the paddy crop by shelling in Rice Shellers. The paddy processed in these Shellers contains dust and other biomass impurities. These Rice Shellers are generally using conventional technology in India and there is hardly any improvement in the rice milling process for the last so many decades. These conventional Rice Shellers consume excessive thermal and electrical energy besides causing severe air pollution problem. However, certain progressive Rice Shellers are resorting to modernization of technology. In these rice mills, the whole grain rice and other biomass by products like husk and bran are obtained. 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 whole grain rice. Most of these Shellers have a capacity of 2 tonnes per hour. A typical line diagram depicting different unit operations is shown in Fig. 1. For conveying the paddy from one unit operation to another bucket elevators are used.

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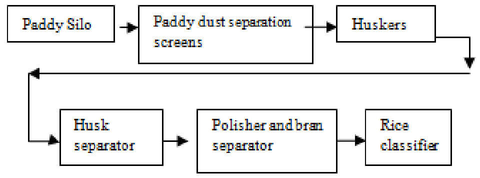

Fig. 1 Line diagram showing different unit operations in a Rice Sheller

II. Brief Process Description

The major unit operations used in the process of shelling are discussed briefly as under [1]:-

1. *Paddy silo:* Paddy procured from fields contains dust. Paddy silo is used for regulating the flow of dust-laden paddy. Some separation of dust takes place here itself.
2. *Elevators*: Generally, there are seven to eight bucket elevators in a Sheller, which are used for transferring paddy from one unit operation to another. These elevators are generally covered with either wooden frame or steel frame.
3. *Paddy Dust Separation Screens:* Here, the dust-laden paddy is fed from the top with the aid of elevators. These screens are fitted with a mechanical shaker, which imparts vibration to them. Because of shaking, paddy is retained as the over size of screen and dust is collected at the bottom as the under size.
4. *Huskers:* After the separation of dust, the paddy is fed to the rollers, which imparts centrifugal force to it for its shelling, resulting in removal of husk from the paddy.
5. *Husk Separator:* It utilizes sieves of different sizes for separating husk effectively from unpolished rice. Paddy, which could not be shelled in the paddy husker, is left as such**.** It is also separated here and is recycled back to the paddy silo with the help of elevators.
6. *Polishers:* These are generally three to four in number depending upon the capacity of the Sheller and are used for the removal of bran.
7. *Bran separator:* Removal of bran from rice takes place in these separators. Polished rice of different grades is recovered from the top of these separators.
8. *Rice Classifier:* This is used for separating rice from broken rice.

III. Development of Suitable Cost Effective Air Pollution Control Technology

Initially when this task of developing suitable cost effective air pollution control device was taken up, there were lot of fugitive emissions and it was difficult to stand inside the shed of the Rice Shellers, not to talk of working efficiently within the shed of the Industry. The various sources (transfer points) from where the dust was spewing out were critically identified. These are described as under:

A. Sources of Dust Emissions

The dried paddy is transferred to the Paddy Silo from where it is transferred to the pre-cleaner / vibrating screens through elevators. These screens are fitted with a mechanical shaker. As a result of shaking, paddy is retained as the over size of screen and dust is collected at the bottom as the under size. The cleaned paddy is fed to the husker to remove the husk from the paddy grains. The husk is separated in the husk separator from unpolished rice. The brown rice is sent to the polishers for the removal of bran. Thereafter, the rice is fed to the rice classifier for separating rice from broken rice. During this process, dust is emitted from following sources:

1. While unloading the paddy in Paddy silo. A photograph showing duct emissions from the paddy silo is in Fig. 2.
2. Paddy cleaner / vibrating screen.
3. Bucket elevators used for lifting and discharging the paddy.
4. Loading of dry paddy in Paddy silo.
5. Paddy cleaner / vibrating screen.
6. Huskers and the space between huskers.
7. Paddy separators.
8. Bucket elevators used at different stages for lifting and discharging paddy.

Fig. 2 Dust emissions from paddy Silo

IV. Containment of Dust Emissions

Dust Spewing out of various unit operations, mentioned earlier was tapped by designing/fabricating suitable hoods/enclosures. Special care was taken to ensure workability while fabricating these enclosures. The network of ducting was done with the help of flexible plastic pipes, which offer minimal resistance to the system. A small capacity in-built fan, mounted over the paddy dust separation screen, was used for sucking dust from different sources. These are shown from Figs. 3 to 6.

After containment of all the emissions from various sources these were brought pneumatically to a common duct. This duct was joined to the inlet of the centrifugal fan. The induced draft fan having the following specifications was used for the purpose:

- Air flow rate: 4000 cubic meter/hour. At 25 ^{o}C.
- Pressure drop: 6 inches of water.

These specifications were arrived at by selecting a suitable pneumatic conveying velocity and pressure drop within the ducts and various bends.

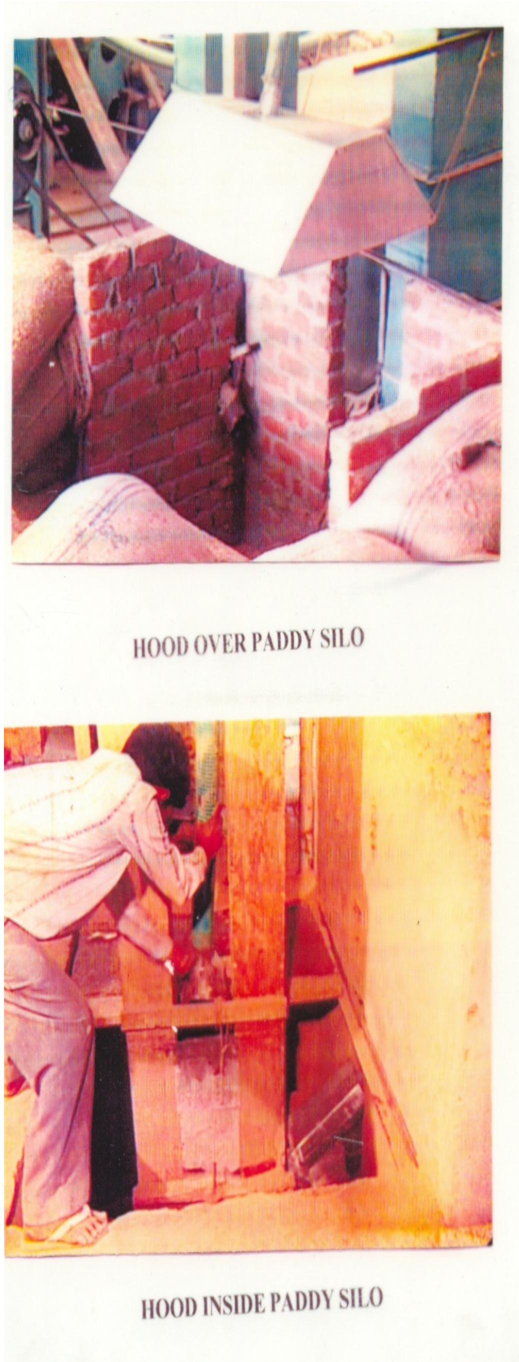

Fig. 3 Containment over Paddy silo and Bucket elevators

Fig. 4 Hoods and Enclosures over vibrating screens

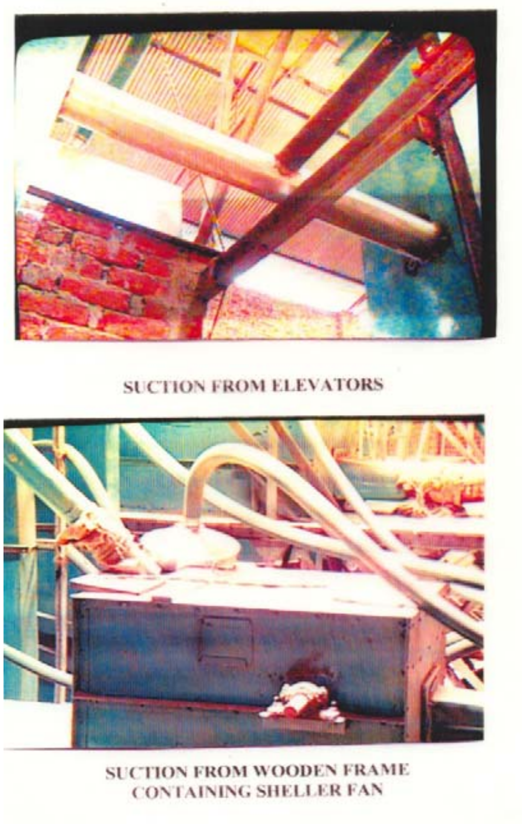

Fig. 5 Hood over Sheller fan

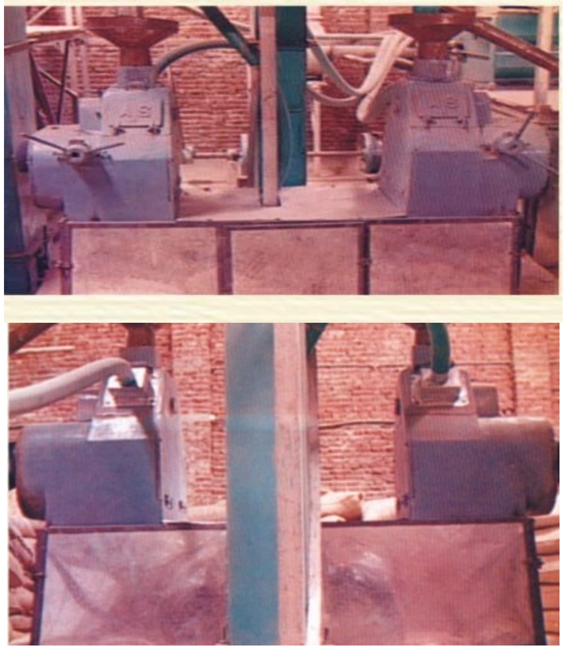

Fig. 6 Enclosures and hood over Huskers

After the installation of the fan monitoring was carried out using stack monitoring kit. It was observed that the dust concentration in the main duct was around 4000 mg/Nm^3 which is indicative of the effective suction of the dust. These emissions were earlier spewing out in the entire shed of the Rice Shellers. After installing this system there was a considerable reduction in the fugitive emissions within the shed of the industry.

The particle size distribution of the dust was obtained by using Seishin-SKA-5000 Micron Photo sizer [2]. This duct has a median diameter of 12 microns and the size distribution in tabular form is shown in Table I.

TABLE I
PARTICLE ANALYSIS OF DUST

Particle diameter range (microns)	Weight %
0-5	30
5-10	15
10-15	7
15-20	20
> 20	28

After successfully containing the dust emissions, a high efficiency cyclone separator having unique dimension ratios was designed, got fabricated and installed. Here the inlet to the reverse flow cyclone [3]-[5] is having an involute entry, which considerably decreases the pressure drop across the cyclone, rather than a conventional tangential entry. The overall dust collection efficiency of this cyclone separator was 94%. Monitoring was also done after the installation of cyclone separator and the dust concentration in the stack was well within the standards laid down by the Punjab Pollution Control Board.

Fig. 7 Rice Sheller along with integrated APCD

Hopper and Rotary Air Lock were also designed and got installed below the cyclone separator. The torque for rotating the shaft of this rotary air lock is to be drawn from the main shaft of the Sheller. After the installation of the APCD there is marked improvement in the industry, the plant operators can do their job more efficiently, and their health has improved. Earlier they used to have respiratory problems. A photograph of the APCD, different unit operations in a Rice Sheller is shown in Fig. 7.

V. Comparison of this Technology with Already Existing Technologies

1. *Cost Effective:* The cost of the total pollution control system is about Rs. 2,00,000/- vis-a-vis Rs. 5,00,000, which was the cost of existing air pollution control system already installed in different Rice Shellers in the State.
2. *No additional Motor Required*: In the case of existing Rice Shellers having an APCD, a motor of 15 HP is required. But in this case, arrangements were made in such a manner that no additional motor is required for operating the ID Fan and all the power requirements are met from the motor of the Rice Shellers.

Fig. 8 Inner view of Paddy Husker

3. Already installed pollution control systems have two cyclone separators for the removal of coarser particles followed by a filter bag house for capturing fine and superfine particles. In the present case, a well-designed high efficiency cyclone has been developed which is simple and easy to operate and fulfils the requirement of all the three APCDs mentioned above.

A. Economic Gains Due to Adoption of Cleaner Technology for Rice Sheller

It has been observed that after the installation of air pollution control device, cyclone separator, most of the dust in the paddy is removed from the initial unit operations like paddy silo, elevators and paddy dust separation screens. As a result, there is marked improvement in the quality of bye-products like rice husk and bran. The life of the rubber rolls used in the paddy Husker (Fig. 8) has also increased due to reduction in friction. The additional benefit to the Rice Sheller due to the above mentioned factors is around Rupees 3,00,000 per season and thus has a payback period of only four shelling months.

VI. Conclusion

A reverse high efficiency cyclone separator can be used to contain effectively the dust emissions from a small scale industry like Rice Shellers. Besides controlling pollution, there is improvement in the quality of bye-products like bran and husk, increase in the life of rubber rollers used in paddy husker and slower depreciation of the shelling machinery. Due to these benefits the cost of air pollution control device along with other ancillary equipment can be recovered back in about four months.

Acknowledgment

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