DEVELOPMENT AND EVALUATION OF PNEUMATIC PACKAGING MACHINE FOR PADDY

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PROJECT REPORT

Submitted in the partial fulfillment of the requirement for the degree

Bachelor of Technology
in
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Farm Power, Machinery and Energy
Kelappaji College of Agricultural Engineering and Technology
Tavanur-679573, Malappuram, Kerala
2013

DECLARATION

We hereby declare that this project report entitled "**Development and Evaluation of Pneumatic Packing Machine for Paddy"** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us in any degree, diploma, associateship, fellowship or other similar title of any other university or society.

Place: Tavanur.

Date:

Faseera, A. C. (2008-02-010)

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CERTIFICATE

Certified that this project report, entitled "**Development and Evaluation of Pneumatic Packing Machine for Paddy"** is a bonafide record of project work done jointly by Ms. Faseera, A. C., Mr. Mikhail, P. J. and Ms. Swatha, V. S. under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associate ship to them.

Place: Tavanur,

Date:

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We state with the name of god who is the most beneficial and merciful. We offer him our uncountable thanks, without his blessings and mercy this work could have not been a success.

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Words do fail to acknowledge our parents support, encouragement and help gone a long way in making this attempt a successful one.

Faseera, A. C.

Mikhail, P. J.

Swatha, V. S.

Dedicated

to

Our loving parents

and

Profession of Agricultural Engineering

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVATIONS

%	per cent
/	per
^{0}C	degrees Celsius
A	Ampere
et al	and others
g	gram
kg	kilogram
kg/min	kilogram per minute
mm	milli metre
M ha	million hectare
MT	Metric tonnes
rpm	revolution per minute
s	seconds
T	tonne
V	Volt
viz	namely

Chapter I

INTRODUCTION

Paddy is a monocot plant botanically named as *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most important staple food for a large part of the world's human population, especially in Asia and the West Indies. It is one of the most important agricultural crops in the world and is the grain with the second highest worldwide production according to data for 2010. It is the most important grain with regard to human nutrition and caloric intake, providing more than one fifth of the calories consumed worldwide by the human species. Hence, rice is the unique food grain crop cultivated all over the world due to the virtue of its variety of uses and indent to adopt in the wide range of climatic conditions. Considering the extensive use of rice, it is described as the "grain of life" by the United Nations.

Paddy is cultivated in more than 100 countries in the world. During 2000, paddy occupied an area of 156 million hectares in the world with production of 598852 thousand tons. Paddy is mainly produced in Asian countries with 91% of world production. China is the leading producer of paddy accounting 31.76 % of total world production followed by India with 22.40 per cent. Together these two countries, accounted about half of world paddy area and production. Indonesia (8.52 %), Bangladesh (5.98 %), Vietnam (5.44 %), Thailand (3.91 %) and Myanmar (3.34%t) are the other major paddy producing countries. In India, the food grain production has increased considerably from a meager 51 million tons in 1950-51 to 280 million tons in 1999-2000 (Survey of Indian Agriculture, 2000). Among total food grains, paddy occupies the first place both in area and production in India. The efficient use of agricultural inputs ,judicious utilization of natural resources and adoption of appropriate agricultural implements and machinery have further contributed towards enhancing yield and productivity. Thus in India, paddy occupies about 42 million hectares of land accounting 34% of total area under food crops and 42% of the area under cereal crops. India is also one of the leading producer and consumer of rice having share of about 15% of rice export in the world market.

In Kerala, the southernmost state of India, there is vast green paddy fields, since it is the most important cereal and staple food produced and consumed. The state of Kerala has total area of 21.84 lakh hectare under cultivation in which 4.3 lakh hectares are covered by rice. Paddy cultivation was part of the proud culture of Kerala State. Kuttanad is known as ‘rice bowl’ of Kerala because of the highest production of rice in the state. Trissur and Palakkad are the other two places where large scale rice cultivation is done.

In the present scenario it is difficult to do rice cultivation in the state due to high labour cost and shortage of labour and because of this, the paddy fields are being converted into filled up land. Therefore mechanization of the different operations is the only possible solution to sustain rice cultivation in the state. The development of machinery and mechanical power to make man’s effort more effective and productive, is one of the most prominent features of mechanization. Presently a wide range of machinery are available to carryout the different operations involved in paddy cultivation. Many of them are well utilized by the farmers to overcome the situation of labour scarcity. Harvesting is the classic example of such operations. Now most of the farmers in the major rice growing areas are harvested using combine harvesters only.

It has been estimated that total post harvest losses of paddy at producers’ level was about 2.71 per cent of total production. To minimize post harvest losses, precautions should be taken to follow proper post harvest practices. They include timely harvest at optimum moisture level (20 per cent to 22 per cent), use of proper method of harvesting, avoid excessive drying, and proper packing and transportation. Proper packing and storage are necessary to avoid the contamination of grains and protect from insects, rodents and birds and helps in reduction in losses. Thus packing of paddy plays a significant role in paddy transportation and storage for the purpose of processing and exportation.

Good packaging not only provides convenient handling in transportation and storage but also attracts consumers to pay more. Packaging is essential to avoid spoilage and to prolong the quality. Packaging of paddy is also important for long-term storage to fulfill the demand of rice in the market. More care is required in packaging of rice meant for export. This is because of demonstrative effect and the requirements of consumers in different countries. Good package protect rice very well, long lasting, look clean, convenient to handle and carry out from the store easily. The packages shall be free from insect infestation, fungus contamination, deleterious substances and undesirable or obnoxious smell. In paddy, usually jute bags are used for packaging. The initial cost of packaging varies according to the type of method and material used for making bags. Paddy is stored in jute bags, for 3 months or more.

In recent years, as there is lack of sufficient work forces, harvesting with combine harvesters is in vogue. Tractor operated and self-propelled combine harvesters are commercially available in India. About 700-800 combine are sold annually in the country. Combine harvester is available in India with track type traction device is primarily for paddy crop. The combines of 8-14 ft. cutter bar size are available but the combines having 14 ft. cutter bar length are most popular size operated by 60-75 kW engines. These machines cut the crop, thresh it and store the clean grain in the grain tank. Many models of combines store around 1 tonne of grain in the grain collection tank. Farmers use combine harvesters on custom hire basis and therefore harvesting became cheaper compared to manual harvesting. In places like Kuttanad, majority of the farmers where practicing the mechanical harvesting using combine harvester. It is estimated that around 300 high capacity harvesters were in use in the Kuttanad region alone during the peak harvesting season. These combines can harvest at least 1 to 1.5 acres of paddy in an hour. The combine harvesters unload the grain into a polyethylene sheet or to a level surface in the field when the grain tank is filled. The direct packing of paddy from the combine consumes more time and thus leaks the money in the form of hire charges. The unloaded paddy in a heap is then packed manually and is transported. Several times the farmers find it difficult to pack this paddy in sacks and transport it to mills due to the shortage of labours.

Plate 1.1 Views of Manual packing of paddy harvested by combines

In paddy cultivation the only operation which depends on availability and capacity of labour is packaging of harvested paddy. Mechanization will make paddy packaging profitable and attractive, not only by reducing the time required for packing and drudgery but also by increasing the rate of packing. Manual packing is labour intensive and time consuming and the rate of post-harvest loss is very large with reduction in the net recovery of paddy.

The preliminary survey conducted among the paddy cultivators revealed the need of developing a paddy packing machine which can pack a reasonable number sacks per hour, so that the paddy harvested from a hectare can be packed within one day. Therefore a project was under taken at Kelappaji College of Agricultural Engineering and Technology to develop a model of pneumatic packing machine for paddy with the following objectives:

- To study the mechanical and engineering properties of paddy relevant to pneumatic packing of paddy.
- To design and develop a model of pneumatic packing machine for paddy.
- To evaluate the developed model under field conditions and suggest the modification in view of developing a prototype.

Chapter II

REVIEW OF LITERATURE

This chapter gives reviews and general information on paddy, its mechanical and engineering properties, packaging methods, vacuum conveying system, cyclone separation system and vacuum pumps. Research done in these fields are reviewed and presented here.

2.1 Paddy

Paddy is a self-pollinated crop botanically belongs to *Oryza sativa L.* of Gramineae family. A complete seed of rice is called paddy and contains one rice kernel. In world paddy production, Asia's share is more than 90 per cent. Paddy is a primary food grain crop of India and occupies about 37 per cent of the area under food grains and contributed more than 40 per cent of food grains production in the country during 2000-01. During 1999-2000, in the states like Andhra Pradesh, Assam, Kerala, Orissa, Tamil Nadu and West Bengal, rice consumption accounted for more than 80 per cent share in total cereal intake (Mehdi et al., 2007).

2.1.1 Origin

In India, paddy has been cultivated since ancient period. According to DeCandolle (1886) and Watt (1892), South India was the place, from where cultivated paddy originated, whereas Vavilov (1926) opined that India and Burma should be regarded as the center of origin of cultivated paddy.

The two most important cultivated species of paddy are *Oryza sativa* and *Oryza glaberriumn*. There are around 18 wild species of paddy grown in the continents of Asia, Africa and America. While *Oryza sativa* is grown in most parts of the Asian and American continents, *Oryza glaberriumn* is grown only in Africa. There are three sub species of paddy in the world i.e. Indica (long grain), Japonica (round grain) and Javanica (medium grain). Indica rice is grown in warm climate zone of Indo-China, India, Pakistan, Thailand, Brazil and Southern U.S.A. Japonica is mostly grown in cold climate zone of Northern China, Korea, Japan and California. The Javanica is grown in Indonesia only (Vavilov et. al., 1926).

2.1.2 Physical and engineering properties of paddy.

Physical and engineering properties are important in many problems associated with the design of machines and the analysis of the behavior of the product during agricultural process operations such as handling, planting, harvesting, threshing, cleaning, sorting and drying. Solutions to problems in these processes involve knowledge of their physical and engineering properties (Irtawange, 1980).

The knowledge of the coefficient of friction of paddy on the equipment wall and on the silo wall surfaces are necessaries and fundamentals for a rational and safe design of grain moving handling equipment, processing and storage (Lawton et. al., 1980).

Klenin et. al., (1985) mentioned that, the behavior of particles in air stream is diameter of holes in seed metering devices in planting, air suction suitable for seed holding governed by their aerodynamic properties of particles, the critical velocity (terminal velocity) Vcr, resistance coefficient of the air (Kr) and drift coefficient (Kd).

Sitkei (1987) reported that the functioning of many types of agricultural machines (sifters, sowing machines, pneumatic transport systems, etc.) is influenced by the physical properties of the objects participating, and so in order to study a given process they must be described accurately. Also the quality of processing (in chopping and milling) may be characterized by a products mean size and mean standard deviation, or these data may be used to organize a technological process or in designing certain structural elements (mesh dimensions of sifters or dimensions of screen holes). He added that during the treatment of agricultural materials air is often used as the transport medium. Pneumatic transport and cleaning of various agricultural products have been known for a long time. During this process aerodynamic properties play an important role and must be known for optimum design and the operation of the equipment. The two most important aerodynamic properties of a body are drag coefficient and terminal velocity.

Srivastava et. al., (1990) investigated that grain bulk density and angle of repose are related to separator performance, while harvesting grain, such that increasing grain density increases separator capacity, while increasing the grain angle of repose has the opposite effect.

Sabbah et. al., (1994) studied the effect of moisture content on the physical properties for three Egyptian paddy rice varieties. They recorded the increase occurring in seed sphericity (S) due to the increase of moisture content.

Sahrigi (1997) indicated that it is essential to understand the physical and engineering law governing the response of biological material, so that processing and handling machines can be designed for maximum efficiency and highest quality of the end product. Kochhar and Hira (1997) reported that to design equipment and facilities for handling processing and storage, the physical properties of crop grains must be known.

Lgathinathane and Hana (1998) reported that some seeds, fruits and vegetables of spherical in shape with variation along one or both axes. In general, to specify the shape of a food material it is necessary to identify three basic dimensions, namely, length, width and thickness. A body can be defined by one or two significant dimensions only in a few special cases where the body approximates to a regular geometrical shape such as a sphere, cylinder, prolate spheroid or oblate spheroid.

The knowledge of friction coefficients of grain is needed for designing conveying equipment. For instance friction between an un-consolidated material and a conveyor belt affects the maximum angle with the horizontal, which the conveyor can assume when transporting the solid (Shitanda et. al., 2001).

Nimkar and Chattopadhyay (2001) reported that various physical properties of green gram were evaluated as a function of moisture content in the range of 8.39 to 33.40% (db). The average length, width, thickness and the mass of thousand seeds were 4.21 mm, 3.17 mm, 3.08 mm, and 28.19 g respectively at moisture content of 8.39 % (db). Also, the average geometric diameter increased from 3.45 mm to 3.77 mm, where as sphericity decreased from 0.840 to 0.815. They added that by increasing moisture content the bulk and true densities decreased from 807 to 708 kg m^{-3} and 1363 to 1292 3 kg m^{-3}, respectively, whereas the corresponding bulk porosity in creased from 40.77 to 45.16%.

Nonami and Nelson (2002) conducted a study to enable easy seed and waste separation at head feed combine by measuring the terminal velocity. It was found that, it is difficult to separate seeds with primary branches and straws from a single seed in the tank because the terminal velocity of the seed with primary branches and straw was more than the single seed. The suitable limits of the separating air velocity were from 2.3 to 6.5 ms^{-1}.

Matouk et. al., (2004) developed the mathematical relationships relating the changes of the properties with the seed moisture content. The seed principal dimensions, mass of 1000 seeds and seed projection area are generally increased by increasing of seed moisture content. However, both shape-index and coefficient of contact surface are decreased by increasing of seed moisture content. Some physical characteristics of rice such as grain thickness has a major effect on the volume expansion ratio of the cooked rice followed by degree of milling and then by apparent amylase content of the grain (Mohapatra & Bal, 2007).

Fawal et. al., (2009) conduct a study to determine and recognize a database of physical and engineering properties of grains of some main and popular feed, industrial crops which play an important role in designing and developing of specific machines. The studied crops namely fennel flower, rice (Giza101), rice (Giza 177), broad bean, corn (hyb.310), corn (hyb.352), wheat (Giza9) and wheat (Giza 168) and their selection based on their recent coverage area and the expected future expansion of each variety. Various physical properties including grain dimensions (length, width and thickness), the weight of thousand grain, bulk density, percentage of sphericity, projected area, and the mechanical properties including angle of repose and coefficient of friction, in addition to the aerodynamic properties including terminal velocity, drag coefficient and Reynold's number, were determined at storage moisture content 7–12% (wb).

Zareiforoush et. al. conducted a study about the effect of moisture content on some physical properties of paddy grains. In their study, various physical properties of two different paddy cultivars were determined at five moisture content levels of 8, 11, 14, 18 and 21% (db). In the case of Alikazemi cultivar, the average length, width, thickness, equivalent diameter, surface area, volume, sphericity, thousand grain mass and angle of repose increased from 9.83 to 10.05 mm, 2.65 to 2.76 mm, 1.92 to 2.01 mm, 3.72 to 3.85 mm, 39.37 to 42.12 mm2, 26.91 to 29.94 mm3, 37.51 to 38.04%, 27.63 to 31.20 g and 35.67º to 41.23º, respectively, as the moisture content increased from 8 to 21% (db). The corresponding values increased from 10.20 to 10.25 mm, 2.31 to 2.40 mm, 1.85 to 1.92 mm, 3.53 to 3.63 mm, 36.87 to 38.61 mm^2, 23.12 to 25.11 mm^3, 34.53 to 35.27%, 24.43 to 27.80 g and 38.27º to 44.37º, respectively, for Hashemi cultivar. For Alikazemi cultivar, the static coefficient of friction of grains increased linearly against three various surfaces, namely, glass (0.3168-0.4369), galvanized iron sheet (0.4179-0.4965), and plywood (0.4394-0.5264) as the moisture content increased from 8 to 21% (db). The corresponding value for Hashemi cultivar increased from 0.3577 to 0.4650, 0.4629 to 0.5082 and 0.4857 to 0.5452, respectively, against three mentioned surfaces.

2.1.3 Paddy packing methods.

Conventional packing of paddy includes first weighing harvested paddy from the field manually and then fill into sacks for transportation and storage. In industrial packaging it is packed automatically using high-tech paddy packing machines. But these technologies were not available to farmer's community.

i) Packaging materials

The commonly used packaging materials for paddy are Jute bags, HDPE / PP bags, Polythene impregnated jute bags and Cloth bags.

Qualities of good packaging material:

- It should be convenient in operations.
- The packaging material must preserve the quality of produce.
- It should be convenient to stack.
- It should be able to prevent spoilage during transit and storage.
- It should be cost-effective.
- It should be clean and attractive.
- It should be biodegradable.
- It should help in checking adulteration and be free from adverse chemicals.
- It should be helpful in reducing the marketing cost by reducing the handling and retailing cost.
- The packaging material should be made of substances, which are safe and suitable for intended use.
- Packing material should be reusable.

2.2 Vacuum conveying system.

A pneumatic conveying system is a process by which bulk materials of almost any type are transferred or injected using a gas flow as the conveying medium from one or more sources to one or more destinations. Pneumatic conveying provides advantages over mechanical conveying systems in many applications because of three key reasons:

1. Pneumatic systems are relatively economical to install and operate.

2. Pneumatic systems are totally enclosed and if required can operate entirely without moving parts coming into contact with the conveyed material. Being enclosed these are relatively clean, more environmentally acceptable and simple to maintain.
3. They are flexible in terms of rerouting and expansion. A pneumatic system can convey a product at any place a pipe line can run.

Pneumatic conveying can be used for particles ranging from fine powders to pellets bulk densities of 16 to 3200 kg m^{-3} (1 to 200 lb ft^{-1}). As a general rule, pneumatic conveying will work for particles up to 2 inches in diameter at typical density (Bhatia,1989).

Srikant et. al. (2009) studied about bends in pneumatic conveying system. They found that the use of bends such as elbows and sweeps between straight sections enable convenient change of direction of flow of the conveyed solids and hence giving process operators great layout flexibility. Bends are installed in a pneumatic conveying system wherever a change in direction is required along the conveying route. They can be broadly classified into three major categories:

a. Common-radius bends (including el -bows, short-radius, long-radius and long-sweep bends)
b. Common fittings (including tee bends, mitered bends and elbows)
c. Specialized bends and innovative designs.

2.3 Vacuum pump

Equipment used to generate vacuum, as noted earlier, is similar to air compressors. It's even possible to generate compressed air or vacuum with the same machine, depending on how it is installed. Vacuum pumps generally can be considered as compressors in which the discharge, rather than the intake, is at atmospheric pressure. Recall that the essence of air compression is the increased number of molecular impact per second. Conversely, the essence of vacuum generation is the reduction of these impacts. The vacuum in a chamber is created by physically removing air molecules and exhausting them from the system. Removing air from the enclosed system progressively decreases air density within the confined space, thus causing the absolute pressure of the remaining gas to drop. A vacuum is created. Because the absolute maximum pressure difference that can be produced is equal to atmospheric pressure. Vacuum pumps are generally quite reliable as long as they are not too severely mistreated. Among different kinds of vacuum pumps, rotary pressure turbine blower is used for the conveyance of paddy for its packing.

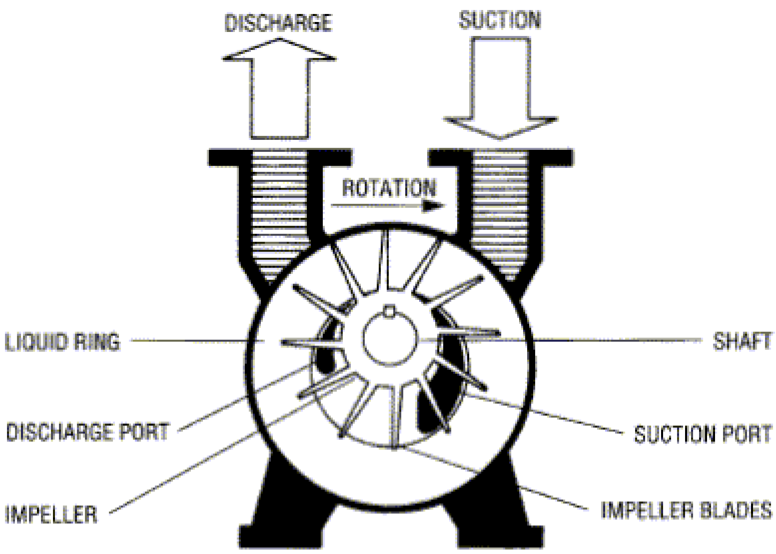

Fig. 2.1 Vacuum pump

Shamus and Yogesh (2009) conducted a study on micro machined Knudsen pump for on chip vacuum pump. This study describe a single-chip micro machined implementation of a Knudsen pump , a type of vacuum pump that work by the principle of thermal transpiration ,has no moving parts, and consequently offers high reliability. A mask process was used to fabricate the pump from ta glass substrate and a silicon wafer. A single stage pump and two integrated pressure sensor occupy 1.5mm x 2mm. Measurements show that the device can evaluate a cavity to 0.46atm while operating at atmospheric pressure and using 80 mW input power. A temperature measurement gives thermal isolation on the order of 104 kW between the polysilicon heaters used to operate the pump and the rest of the device.

Mamor Shoji et. al. (2011) conducted a study on the design of a vacuum pumping system for the closed helical divert or for steady state operation in LHD. A vacuum pumping system is installed in a Closed Helical Divertor (CHD) in the Large Helical Device (LHD) at the National Institute for Fusion Science for active control of the peripheral plasma density and impurity suppression in the core plasma. In the CHD configuration, the distance between the pumping system and the divertor plates (heat and particle source) is very short .One of the major issues in designing the pumping system is the reduction of heat load by radiation and thermal conduction due to the neutral particles being released from the heated diverter plates while keeping a high pumping efficiency. Here the heat load and the pumping efficiency are analyzed using a neutral particle transport simulation and a finite element method based software for multi-physics analysis. We propose a new design for a pumping system with an expanded area of the inlet of the water-cooled blinds and a bottom slit beneath the pumping system. This increases the pumping efficiency by approximately 60% over that of our previous design. It also predicts that the increase in heat load on the pumping system for the new design would be reasonably suppressed by a buffer plate with high emissivity on the surface of the vacuum vessel on the inboard side of the torus.

Xiaohong et. al. (2010) conducted a study on design and verification of an auxiliary system for high vacuum die casting. Vacuum die casting is the optimal method to produce high quality aluminum alloy components. At present, there are still very few systematic studies on vacuum die casting theory and equipment design. On the basis of the existing theories of the vacuum die casting pumping and venting systems, a simplified model is established in this research. The model has an aggregate unit consisted of "vacuum pump + buffer tank" and a cylindrical container (including the shot sleeve, cavity and exhaust channel). The theoretical analysis is carried out between the cavity pressure and the pumping time under different volume models. An auxiliary system for high vacuum die casting is designed based on the above analysis. This system is composed of a vacuum control machine and a new vacuum stop valve. The machine has a human computer control mode with "programmable logic controller (PLC) + touch screen" and a real time monitoring function of vacuum degree for buffer tank and die cavity. The vacuum stop valve with the "compressed gas + piston rod + labyrinth groove" structure can realize the function of whole-process-vacuum-venting. The new system shows great advantages on vacuuming the cavity with a much faster speed by making tests on an existing die casting mold and a 250 t die casting machine. A die cavity pressure less than 10 kPa can be reached within 0.8 s in the experiment and the porosity of castings can be greatly decreased. The systematic studies on vacuum die casting theory and equipment have a great guiding significance for high vacuum die casting, and can also be applied to other high vacuum forming in related theoretical & practical research.

Simon Bruce et. al. (2008) conducted a study on recent experience of mechanical vacuum pumps replacing steam ejectors in VOD and VD processes. Investment in steel vacuum degassing processes, both in new plant and upgrades of existing plant, is continuing as steel companies see the opportunity to increase the value added component of their products by improving quality and supplying more specialty grade steels. In the area of ladle refining recent advances in the degassing process utilizing dry mechanical vacuum systems in place of liquid based water ring and/or steam ejector systems offer clear savings in running costs, maintenance costs, and installation space, and also offer increased speed, flexibility, and overall productivity to steel degassing operations. Large Roots style vacuum booster pumps designed for high dust tolerance are the major component of such mechanical vacuum degassing systems, backed by dry mechanical pumping systems. This paper will discuss the presenters experience with recent installations and comment on the operational results available to date.

Suguna et. al. (2005) conducted a case study of autoregressive modeling and order selection for a dry vacuum pump. Oil-free dry-vacuum pumps are prevalent in semiconductor plants worldwide today. The popularity of such pumps has grown over the years but little research has been done in the area of condition-monitoring of dry-vacuum pumps. Fault detection of one such pump through the use of Auto Regressive (AR) modeling technique and spectral analysis of vibration and acoustic data has been studied. The testing environment is a 5-stage Roots-and-Claw dry-vacuum pump. Usage of spectral analysis for fault prediction in real-time has been conservative due to concerns over large processing requirements especially when large sample sizes and high sampling frequencies are used. In this study it is shown how such concerns can be allayed, to a large extent, by AR modeling, as the AR method has enhanced resolution capabilities compared to the FFT technique even when small sample sizes are used and requires a sampling rate just slightly above Nyquist rate to give good parameter estimates. The AR spectra of both the vibration and acoustic data produced are highly correlated and the frequencies of the maximum peaks are found at the pump's shaft rotational speed and multiples of it. The disadvantage of the AR method is that optimum model order is not known a priori. It was desired to keep the model order low as smaller orders translate to smaller processing requirements for spectral estimation. Several methods of order selection criteria such as AIC (Akaike Information Criterion), FPE (Final Prediction Error), MDL (Minimum Description Length), CAT (Criterion Autoregressive Transfer-function) and the more recent FSIC (Finite Sample Information Criterion) were investigated to find the true order. All the criteria selected approximately the same order. For the vibration data, initial results show that the minimum order required can be as low as 25 and for 90% of the frames the model order does not exceed 45.

Shane et al. (2009) conducted a study on Prediction of Vacuum Pump Degradation in Semiconductor Processing. This paper addresses the issue of vacuum pump degradation in semiconductor manufacturing. The ability to identify the current level of vacuum pump degradation and predict the Remaining-Useful-Life (RUL) of a dry vacuum pump would allow manufacturers to schedule pump swaps at convenient times, and reduce the instances of unexpected pump failures, which can incur significant costs. In this paper, artificial neural networks are used to model the current level of pump degradation using pump process data as inputs, and a double- exponential smoothing prediction method is employed to estimate the RUL of the pump. We also demonstrate the benefit of incorporating process data, from the upstream processing chamber, in the development of a solution.

2.3 Cyclone separator.

Cyclones are widely used for removing industrial dust from air or process gases. They are the most frequently encountered type of gas-solid separator in industry. Cyclonic separation is a method of removing particulates from an air, gas or liquid stream, without the use of filters, through vortex separation. Rotational effects and gravity are used to separate mixtures of solids and fluids. The method can also be used to separate fine droplets of liquid from a gaseous stream. A high speed rotating (air) flow is established within a cylindrical or conical container called a cyclone. Air flows in a helical pattern, beginning at the top (wide end) of the cyclone and ending at the bottom (narrow) end before exiting the cyclone in a straight stream through the center of the cyclone and out the top. Larger (denser) particles in the rotating stream have too much inertia to follow the tight curve of the stream, and strike the outside wall, then falling to the bottom of the cyclone where they can be removed. In a conical system, as the rotating flow moves towards the narrow end of the cyclone, the rotational radius of the stream is reduced, thus separating smaller and smaller particles. The cyclone geometry, together with flow rate, defines the cut point of the cyclone. This is the size of particle that will be removed from the stream with a 50% efficiency. Particles larger than the cut point will be removed with a greater efficiency, and smaller particles with a lower efficiency.

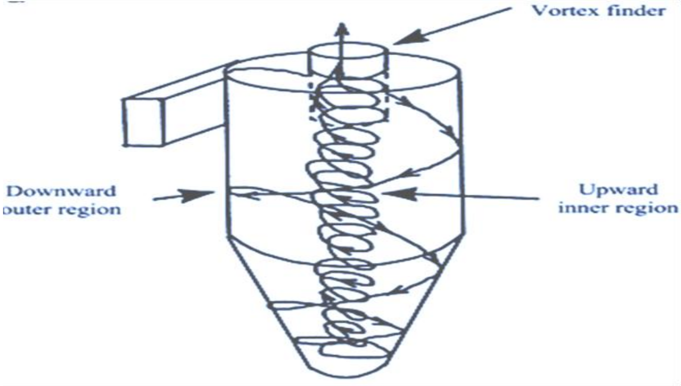

Fig. 2.2 cyclone separator

Ferit et. al. (2010) conducted study on the effects of vortex finder on the pressure drop in cyclone separators by three cylinder-shaped vortex finders with diameters of 80, 120 and 160 mm were designed and manufactured to find out the pressure drop of the cyclones by experimentally investigating the effects of gas inlet velocity, the vortex finder diameter and length on the cyclone performance at different gas concentration. As a result of this experimental analysis, a critical diameter of vortex finder is obtained as 120 mm. Furthermore, analyzing the experimental findings with a statistical regression method indicated that there was a linear relationship between length of vortex finder and pressure loss. Then, according to the analysis results, relevance values were obtained as 98.87, 98.37 and 97.59% for these vortex finders (with diameters of 80, 120 and 160 mm), respectively.

Derksen et. al. (2006) conducted study on Simulation of mass-loading effects in gas–solid cyclone separators Three-dimensional, time-dependent Eulerian–Lagrangian simulations of the turbulent gas–solid flow in a cyclone separator have been performed. The Eulerian description of the gas flow is based on lattice-Boltzmann discretization of the filtered Navier–Stokes equations, where the Smagorinskysubgrid-scale model has been used to represent the effect of the filtered scales. Through this large-eddy representation of the gas flow, solid particles with different sizes are tracked. By viewing the individual particles (of which there are some 107 inside the cyclone at any moment in time) as clusters of particles (parcels), we study the effect of particle-to-gas coupling on the gas flow and particle behavior at appreciable mass-loading (0.05 and 0.1). The presence of solid particles causes the cyclone to lose some swirl intensity. Furthermore, the turbulence of the gas flow gets strongly damped. These two effects have significant consequences for the way the particles of different sizes get dispersed in the gas flow. It is anticipated that the collection efficiency gets affected in opposite senses: negatively by the loss-of-swirl, positively by the reduced turbulence.

Bingtao Zhao et al. (2009) conducted the effects of flow parameters and inlet geometry on cyclone efficiency. A novel cyclone design, named converging symmetrical spiral inlet (CSSI) cyclone, is developed by improving the inlet geometry of conventional tangential single inlet (CTSI) cyclone for enhancing the physical performance of the cyclone. The collection efficiency of the CSSI cyclone is experimentally compared to the widely used CTSI cyclone. The results indicate that the CSSI cyclone provides higher collection efficiency by 5-20% than the CTSI cyclone for a tested inlet velocity range of 11.99-23.85

m/s. In addition, the results of collection efficiency comparison between experimental data and theoretical model are also discussed.

Francisco et al.,(2012)conducted a study on the particle–gas flows in two small sampling cyclone separators are simulated by means of Large Eddy Simulations (LES). In this work, the particle–gas flows in two small sampling cyclone separators are simulated by means of Large Eddy Simulations (LES). The Eulerian–Lagrangian approach is used to calculate the fluid flow along with the particle motion. Unlike Reynolds-averaged turbulence models (RANS), LES modeling is advantageous as it does not demand turbulence dispersion models for the particles, which in turn requires parameter tuning that, may not be applicable to arbitrary cyclone geometries and operating conditions. The result of three integration schemes for the particle motion equations and two collection criteria was discussed. The grade efficiencies computed are compared with the experimental ones and shown to be sensitive to Reynolds numbers and geometry variations. It can be concluded that, besides the independence of adhoc parameters, LES offers a robust, reliable modeling option for such flows.

Vekterisand (2011) conducted a study of the interaction between particles in the acoustic cyclone separator by precipitation process of small particles in the secondary air flow of the cyclone separator. It was established that in presence of acoustic field particles smaller than 5 μm are stuck together, falling then to the bottom of conical section of the cyclone separator.

Elsayed and Lacor (2009) conducted a study on investigation of the geometrical parameters effects on the performance and the flow-field of cyclone separators using mathematical models and large eddy stimulation. In this study the effects of seven geometrical parameters on the cyclone separator performance and the flow field are investigated via eight mathematical models and computational fluid dynamics (CFD) Fluent software. A cyclone separator with tangential inlet was used to estimate the effect of geometrical parameters on the pressure drop and cut-off size (collection efficiency). A prediction model of the pressure drop and cut-off diameter was obtained based on response surface methodology by means of the statistical software. The results show that the vortex finder diameter, the inlet height, the inlet width, and the total cyclone height play an important role in influencing the cyclone performance other than other factors mentioned in publications. The eight mathematical models used in this study, nearly all gave the same conclusion. For more understanding of the effect of the geometrical parameters on the flow field of cyclone separator, Large Eddy Simulation investigations are performed for six test cases.

Syedanooribanu and Syedaarshibanu (2006) conducted a study on simulation and empirical modeling of a design of cyclonic separator to combat air pollution. In all the countries, the cause of air pollution are several, one of the major contributing factors being automobiles' exhaust. Today, there are millions of vehicles allover the world. There has been a rapid increase in vehicle numbers in the world. The import of technologies and transport policy we pursued, are the most important reasons for this development. The main pollutant from internal combustion engines are carbon dioxide (CO_2), unburned hydrocarbons (UHC), oxides of nitrogen (NOX), lead and carbon monoxide (CO) and other particulate emissions. Because of the pollutant of engines in the atmosphere causes harmful to the human. Cyclonic separator is a dust collector which can be used to collect particles from engine exhaust. In the current study, with the help of this program an analytical study of the effect of variables such as cyclone diameter, number in parallel, Inlet gas velocity and exhaust gas temperature on particle cut and pressure drop of the cyclone has been made.

Chapter III

MATERIALS AND METHODS

This chapter describes the materials used and methods adopted for the development of pneumatic packing machine for paddy. As the preliminary investigation, the problems faced by the farmers in the paddy field were studied and investigated. The concepts and techniques on the development of pneumatic packing machine for paddy were sorted out and their practical feasibility was studied.

3.1 Determination of Physical and engineering properties of paddy.

The physical and engineering properties of paddy such as moisture content, bulk density, angle of repose, terminal velocity were determined for the design of paddy packing machine.

3.1.1 Determination of moisture content.

The physical and engineering properties of agricultural grains are necessary for the design of processing equipment. Majority of these properties were dependent on water content of the sample. Therefore determination of moisture content plays an important role in calculation of physical properties of paddy.

Oven dry method is the most accurate method of determining the moisture content, and is, therefore, used in the laboratory. The paddy sample is kept in a clean container and put in a thermostatically controlled oven with interior of non-corroding material to maintain the temperature between 105^0C to 110^0C. Usually the sample is kept for about 24 hours in the oven so that complete drying is assured.

A clean non-corrodible container is taken and its mass is found with its lid, on a balance accurate to 0.01 g. Three samples of the raw paddy after harvesting and threshing are placed in the containers and the lids are placed. The mass of the container and the contents are determined separately and recorded. With the lid removed, the containers were then placed in the oven for drying.

After drying, the containers were removed from the oven and allowed to cool in desiccators. The lid is then replaced, and the mass of the containers and the dried paddy samples were found out. Then the moisture content is calculated from the following expression:

$$W = [(M_2 – M_3) / (M_3-M_1)] X 100$$

where, M_1 = mass of container with lid

M_2 = mass of container with lid and wet sample

M_3= mass of container with lid and dry sample

3.1.2 Determination of bulk density.

The bulk density is the mass of the sample per unit volume. It is an important property which affects the design of equipments where aerodynamics properties are involved in the working. Therefore the paddy samples from the field were collected and were cleaned manually to remove foreign matter such as stones, straw and dirt. The sample is then filled in a clean container with proper shaking to ensure the complete filling without gaps. The weight of the paddy is then found out after removing from the container. The volume of the container also accurately measured. Then the bulk density is determined by using the equation:

$$\rho_b = M_s / V_t$$

where ρ_b = bulk density of paddy, g cm^{-3}

M_s = mass of paddy sample, g

V_t = total volume of the container, cm^3

The experiment is repeated for 5 samples and the average is found out.

3.1.3 Determination of angle of repose.

The angle of repose of paddy was measured using the tilting table method. In this method, a wooden frame full of grain sample is mounted on a tilting top drafting table. The table top is tilted till the grain starts moving over the inclined surface. The angle of inclination of the table with respect to the horizontal is measured which is the angle of repose of the paddy sample.

3.1.4 Determination of terminal velocity

The terminal velocity of grains is determined by measuring the air velocities, required to suspend the grain in a vertical air stream by using terminal velocity apparatus. The apparatus consists of an electric blower which discharge air blast into a transparent tapered tube used as a cyclone which is fixed at the outlet side of the blower through an elbow. A screen is fitted at the bottom of the transparent tapered tube of 8 × 4 cm cross section and a cyclone is fitted at the top of it 15 cm square cross section. A chock valve is built at the bottom of the cyclone to control the air flow rate. The chock valve is manually adjusted by the control lever. Terminal velocity is calculated from the equation:

$$V_t = \sqrt{\frac{C_d A_p \rho_a}{2gF_d}}$$

where V_t = terminal velocity, m/s

C_d = drag coefficient

A_p = projected area of particle, m2

ρ_a = density of air, (1.28 kg/m3)

g = gravity, m/s2

F_d = drag force, N

Plate 3.1 Tilting table apparatus

3.2 Conceptual Design of Pneumatic Packing Machine for Paddy

A model for pneumatic paddy packing machine was developed based on a conceptual design. The basic concept was to develop a simple machine which is easy to operate with maximum efficiency using a minimum power source of 1 hp electric motor. The machine may be capable of packing paddy in sacks fixed on a sack holder. The minimum capacity of the machine may be 100 sacks of 50 kg each per hour. A vacuum pump could be used to suck the grains through a flexible hose to a cyclone separator. The cyclone separator separates the grains and air and the air is allowed to expel to the atmosphere through the vacuum pump. The grains are diverted to the sack fixed in a sack holder. The sack should be easily mounted to and detached from the holder quickly. The sack along with the holder is kept on a digital platform balance to know the weight of the grain filled in it. When the sack is filled to a known weight of 50 kg of paddy, the outlet of the cyclone separator is closed and the sack is removed from the holder and sealed. All these operations could be completed within $^{1}/_{2}$ to 1 minute and with the help of 1 or 2 labourers. The flow chart of the materials as per the conceptual design is shown in Figure 3.1.

3.3 General layout and development of the machine

Based on the conceptual design the packing machine was developed and it consists of the following parts:

1. Main frame
2. Vacuum pressure turbine blower
3. Cyclone separator
4. Sack holder
5. Digital platform balance

3.3.1 Main frame

The main frame assembly was fabricated out of MS equal angle of 25 x 3 mm size. The frame is made as two steps one for cyclone separator at a height of 116 cm from the ground and the second step for turbine blower at a height of 20 cm above the first step. The sketch of the main frame is shown in Figure 3.2. The height of the cyclone separator above the ground is fixed considering the height of sack and the height of the platform balance. The cross sectional dimensions of the frame is fixed as 86 x 70 cm considering the base dimensions of the standard platform balance available in the market.

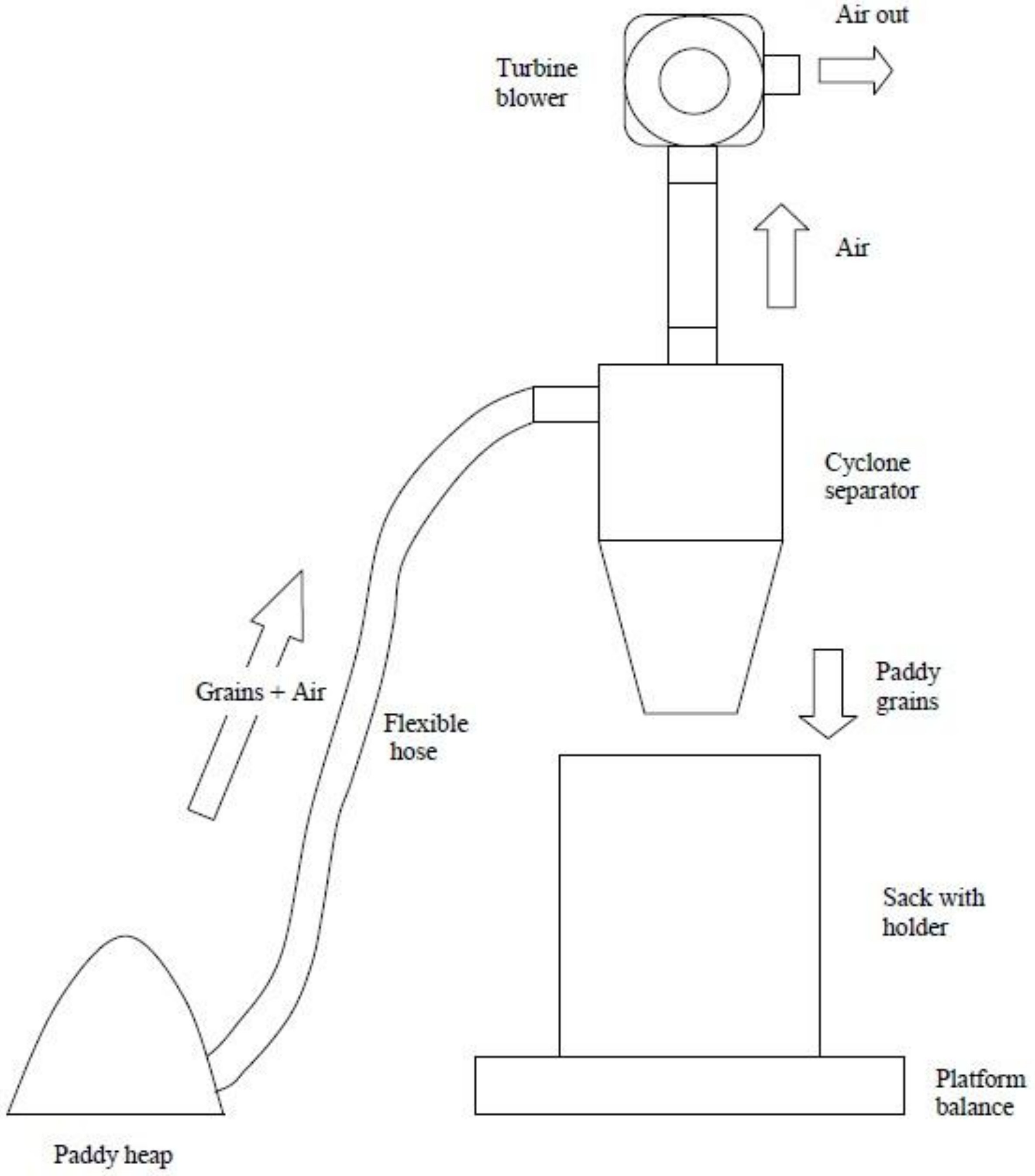

Fig. 3.1 Conceptual design of pneumatic packing machine for paddy

A ring made of MS flat of 25 x 5 mm is fixed at the centre of the 1st step of the frame to fix the cyclone separator. The body of the cyclone separator is screwed to the frame using an L-clamp in order to arrest the rotational movement the cyclone separator during operation. Two MS equal angle pieces of 25 x 3 mm size and 44 cm long are welded at 22 cm apart to the centre of 2nd step to mount the base of the turbine blower. Two sides and open spaces in the top of the frame are covered with MS sheet of 22 gauge. The front and rear sides are kept open in order to facilitate easy placing and removal of sack and sack holder and also to place the platform balance.

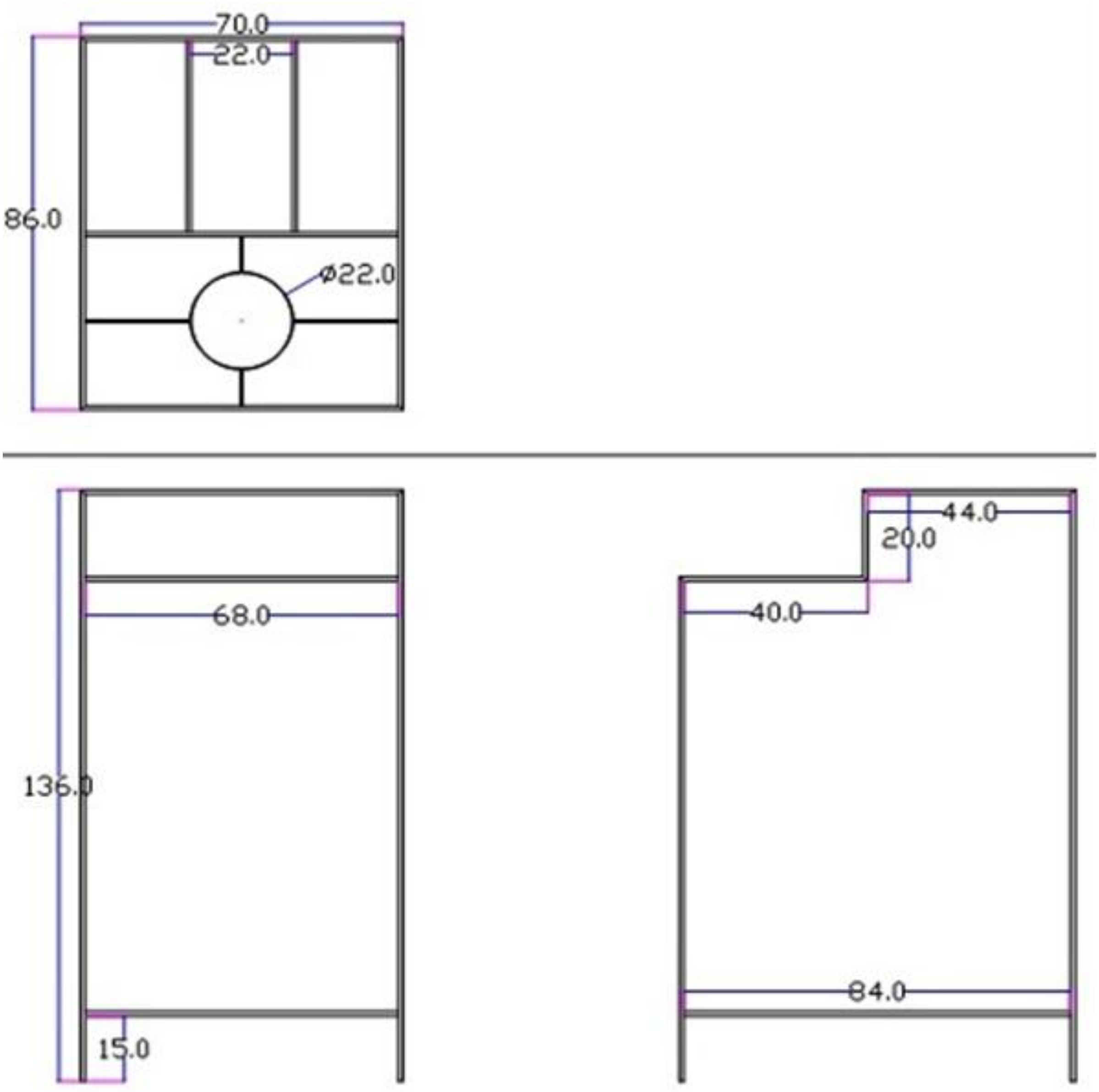

Fig. 3.2 Views of Main frame assembly

3.3.2 Vacuum pressure turbine blower

A turbine blower is selected for generating a vacuum pressure of 180 m bar which is found sufficient to suck the paddy grains to a height of 1.5 to 2 m. A single phase, 220-240V, 2800 rpm electric motor of 1 HP power is used as the prime mover for the turbine blower. The turbine blower's discharge pressure is 250 m bar at a rated volumetric capacity of 120 $m^3 hr^{-1}$. The turbine blower is fastened to the main frame with steel nuts and bolts with a provision of adjusting the position of blower to forward or backward with respect to the frame. Wooden blocks are provided in between the frame and turbine blower to reduce the vibration and noice. 1 ½ inch flexible hose is used to connect the outlet of cyclone separator to the suction side of the pump using and hose connectors and is tightened with hose clamps. Plate 3.2 shows the fixing of vacuum pressure turbine blower to the frame.

The vacuum pump converts the mechanical input energy of the rotating shaft into pneumatic energy by evacuating the air contained within the cyclone separator. The internal pressure level thus becomes lower than that of the outside atmosphere. The amount of energy produced depends on the volume evacuated and the pressure difference produced. This pressure difference sucks the paddy grains form the heap to the cyclone separator in which the grains are dropped and the air is sucked to the blower.

3.3.3 Cyclone separator

Cyclone separators are the most frequently encountered type of gas-solid separator. Cyclonic separation is a method of removing particulates from an air, gas or liquid stream, without the use of filters, through vortex separation. In a cyclone separator, the hard coarse particles moving in the flow of primary air of the cyclone drop out of the flow due to the action of the gravity and centrifugal forces.

In the pneumatic paddy packing machine, a high speed rotating air flow is established within the cylindrical/conical container called cyclone. Air flows in a helical pattern, beginning at the top (wide end) of the cyclone and ending at the bottom (narrow) end before exiting the cyclone in a straight stream through the center of the cyclone and out the top. Being denser the paddy grains in the rotating stream have too much inertia to follow the tight curve of the stream, and strike the outside wall, then falling to the bottom of the cyclone where they can be removed. In this way the harvested paddy which was pneumatically conveyed is separated and dropped to the bottom sack and the air and dust are expelled out through the top. Thus, the cyclone separator offers packing of clean and good quality paddy. The cyclone separator used for the paddy packing machine is shown in Plate 3.3. This unit is mounted to the lower step of the main frame in a ring made of MS flat. Rubber beading is used to prevent vibration and noise. A quick openable lid is pivoted at the bottom outlet of the cyclone separator to close and open the outlet as and when required.

Plate 3.2 Cyclone Separator

3.3.4 Sack holder

Proper holding of sack is very important for quality packaging. Either gunny bags or polythene sacks are generally used for packing and transporting paddy in bulk. In both the cases a good quality quickly fixing sack holder is essential. The sack holder is designed to hold gunny bags or polythene sacks for weight up to 75 kg. The height of the sack holder and size of the rings for holding the sacks are designed based on the average size of sacks available in the market to weigh 50 kg of paddy.

A single leg made of MS square pipe of 25 mm size and 820 mm long supports the sack and holding rings. The foot of the support leg is fixed to a base platform made of MS angle and cross members of MS flat. The top of the support leg is bent forward for 240 mm to shift the centre of gravity of the sack holder to the centre of the base frame. Two rings made of MS flat of 25 x 3 mm size of diameters 310 mm and 338 mm are hinged at single point to form concentric circles comprises the holding unit. The inner ring is having a small projecting leg of 50 mm length which can be inserted to a slot provided on the top bend end of the support leg so that once inserted the rings stands horizontal.

The outer ring is hinged to the inner ring at a single point and can be opened to fix the sack and closed for holding it without slip. Figure 3.3 shows the different views of the sack holder. The first figure shows the top view and the bottom one shows the side view of the sack holder. The Plate 3.4 shows the sack holder with holding a filled gunny bag.

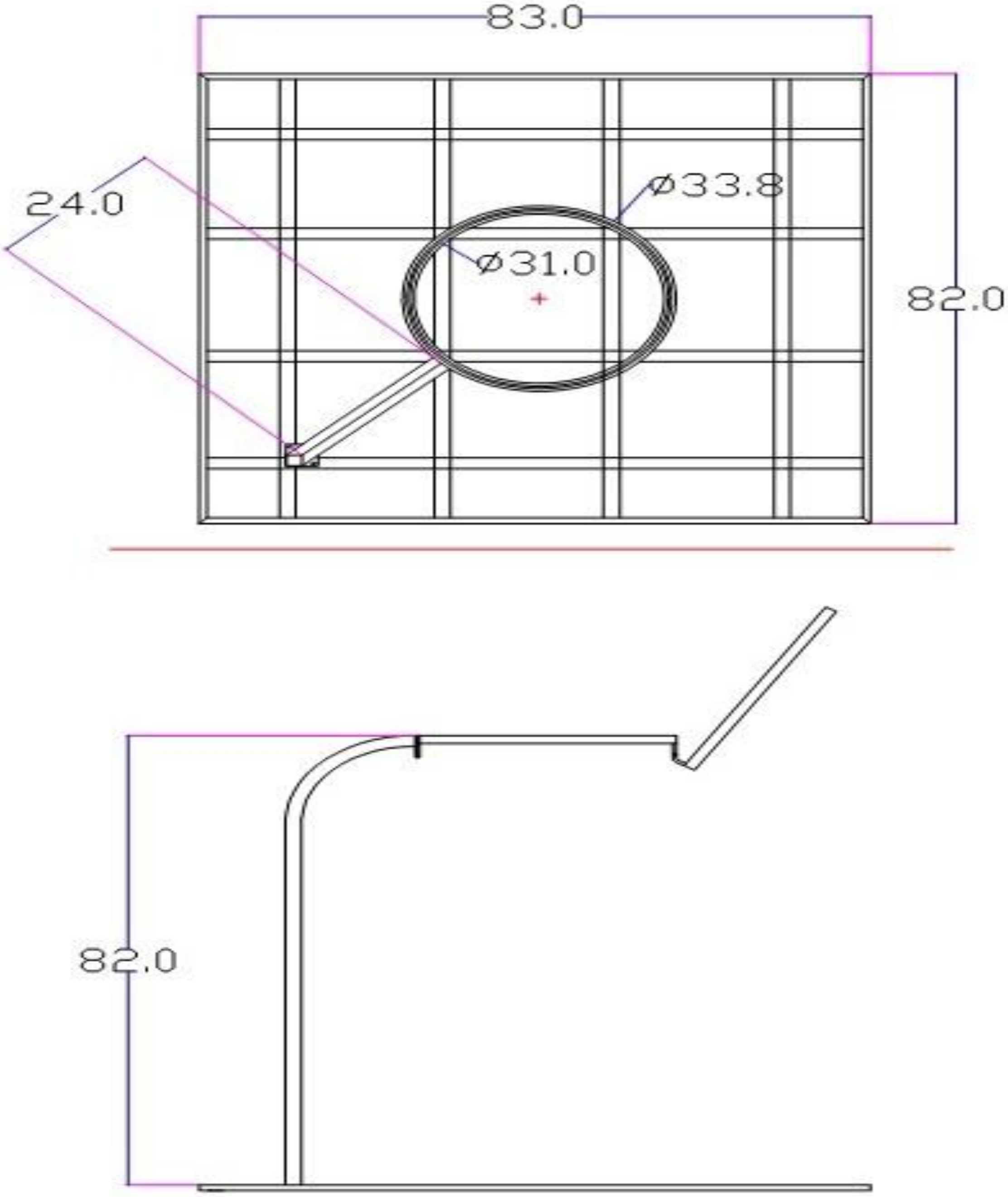

Fig 3.3 Views of sack holder

Plate 3.3 Sack holder with filled gunny bag

3.3.5 Platform balance

A digital platform balance is used for on site weighing of the packed paddy. The sack holder along with the sack is placed on the platform balance. The size of the cross section of the main frame is decided to suit the size of the platform balance. The base dimension of the balance comes to 58 x 58 x 13 cm and digital display is at a height of 100 cm above the base. This arrangement permits the weighing of paddy at the same time of filling itself. When the digital display shows the required weight of 50 kg, the bottom lid of the cyclone separator is closed and the sack is removed from the holder and packed. At the same time next sack can be which was fixed on the sack holder filled with paddy, as the sack holder was placed on the platform balance, it directly gives the reading digitally. Thus the platform balance initiates the automatic weighing and packing of paddy

3.3 Performance Evaluation of Pneumatic Packing Machine for Paddy

The developed model of pneumatic packing machine for paddy was tested in field condition to evaluate power consumption and capacity. The cost of operation of packaging was also found out following standard procedures.

3.3.1 Determination of Power consumption

Power consumed by the turbine blower is found out by connecting an Ammeter in series and a Voltmeter in parallel to the electric supply system. Both the readings were noted during the operation of blower and the power consumption was calculated by multiplying the Ammeter and Voltmeter reading.

3.3.2 Determination of Capacity of Machine.

The capacity of pneumatic packing machine for paddy is considered as the total number of sacks packed using the machine in unit time. For calculating the capacity, paddy is fed to the sack with the packing machine for three known period of times viz., 10, 20 and 30 seconds. The time is kept using stop watch and the weight of paddy grains dropped in the sack in each time period is recorded. The experiment is repeated thrice for each time period and the average weight of paddy filled in the sack is used for calculating the capacity. Time taken to fill paddy in a sack was noted using a stop watch. Knowing the time required for filling a known weight of paddy, the time required for filling one sack full (50 kg) of paddy can be extrapolated. Then the capacity of the machine is calculated by using the formula:

$$N = 72 \times (w/t)$$

where, N = No. of sacks filled (50 kg) per hour, kg hr^{-1}

w = weight of paddy filled in sacks, kg

t = time for required for filling, s

3.4 Cost of operation

Cost of operation of the pneumatic packaging machine for paddy is calculated following the standard procedure and assumptions and the same is given in Appendix-II.

Chapter IV

RESULTS AND DISCUSSION

This chapter deals with the results of the performance evaluation of the developed model of pneumatic packing machine for paddy. The results of preliminary studies conducted such as physical and engineering properties of paddy are also presented.

4.1 Determination of Physical and Engineering Properties of Paddy.

The physical and engineering properties of paddy such as moisture content, bulk density, angle of repose and terminal velocity were determined as described in various sections of Chapter-III.

4.1.1 Moisture content determination by oven drying method.

The moisture content of paddy samples were found out by the oven-dry method as explained in section 3.1.1. The result of the analysis is presented in Table 4.1. The average moisture content of paddy sample was found to be 22.98 % (db) which comes in the range of average moisture level at the time of harvesting.

Table 4.1 Moisture content of paddy

Sample no.	M1 (g)	M2 (g)	M3 (g)	W (moisture content) $[(M_2 - M_3) / (M_3 - M_1)] \times 100$ (%)
1	26.50	61	54.50	23.21
2	27.50	64	57	23.73
3	30	60.5	55	22.00
Average				22.98

4.1.2 Determination of bulk density.

The bulk density is the total mass of the sample was determined as explained in section 3.1.2. The result of the study is presented in Table 4.2. The average bulk density obtained is 1.61 g cm^{-3}.

Table 4.2 Average bulk density of the paddy sample

Sl. No.	Length of container (cm)	Width of container (cm)	Height of container (cm)	Volume (cm^3)	Wt. of paddy (g)	Bulk density (g cm^{-3})
1	24	24	32	18432	30000	1.63
2					29750	1.61
3					29900	1.62
4					29000	1.57
5					30150	1.64
Average						1.61

4.1.3 Angle of repose of paddy.

The angle of repose of paddy was measured using the tilting table method following the procedure explained in section 3.1.3. The angle of repose obtained 5.5^0 which come in the range of standard value of angle of repose for dry paddy.

4.2 Development of Model of Pneumatic Packaging machine for Paddy

The model of Pneumatic Packaging machine for Paddy is developed based on the conceptual design explained in section 3.2 and based on the prepared design drawings. The development procedure and different components of the pneumatic packaging machine were explained in section 3.3. The different views of the developed unit are shown in Plate 4.1.

Plate 4.1 Different views of the Pneumatic Packing Machine for Paddy

4.3 Performance evaluation of pneumatic packing machine for paddy

The pneumatic packing machine for paddy was tested for determining its power requirement and capacity and the result are shown in the table 4.1 and 4.2. The cost of operation of the unit is shown in Appendix II.

4.3.1 Determination of Power consumption.

For power consumption of electric motor of the turbine blower used with the pneumatic packing machine was determined as explained in section 3.3.1 and is presented in Table 4.2. The average power consumption obtained is 792.25 W which is equivalent to 1 hp.

Table 4.3 Power consumption of the turbine blower

Sl No.	Ammeter reading (I) A	Voltmeter reading (V) V	Power (P) W
1	3.8	205	779
2	4	208	832
3	3.8	205	779
4	3.8	205	779
Average			792.25

4.3.2 Determination of Machine Capacity

The machine capacity that is the number of sacks filled in unit time was found by following the procedure explained in section 3.3.2. the result of the trials done to determine the capacity is presented in Table 4.3. It is observed that on an average, the developed model of pneumatic packaging machine for paddy is capable of filling 23 sacks per hour. This is a lower capacity considering the requirements of the farmers. The capacity can be further increased by increasing the handling capacity of cyclone separator. A larger size cyclone separator could be used with the machine to get more continuous out put and increased capacity.

Table 4.4 Capacity of machine

Time of test (sec)	Trials	Weight of paddy (kg)	Capacity (kg/hr)	Average capacity (Kg/hr)	Time per sack (50 kg) (sec)	Sacks filled per hour (Nos./hr)
10	1	3.75	1350	1278	141.08	26
	2	3.40	1224			
	3	3.50	1260			
20	1	6.24	1123.2	1096.2	164.26	22
	2	6.05	1089			
	3	5.98	1076.4			
30	1	8.87	1064.4	1116.8	161.44	22
	2	9.25	1110			
	3	9.8	1176			
Average						23

4.3.3 Cost of operation

Cost analysis as shown in Appendix –II reveals that the cost of packing one sack of paddy using the developed machine comes to Rs 2.62. This is achieved by considering the capacity as 23 sacks in an hour. The packing cost can be further reduced by increasing the capacity of the machine. Considering the scarcity of labour and drudgery involved in manual packaging, the cost of packaging obtained is reasonable.

4.4 Recommendations for future study

The developed pneumatic packing machine for paddy can be considered as a model only. The concept of pneumatic sucking of paddy for packing is simple and working very well. The suction pressure developed by the used turbine blower is sufficient for effective working. The problem associated to the developed model is with the out put capacity and capacity of the cyclone separator. The cyclone separator is to be re-designed to get a continuous operation. The size of the suction hose could be increased for getting more output capacity.

Another suggestion for further study is that the pneumatic conveying of paddy grains through the out put side of the turbine blower with a suitable ventury like mechanism to feed the grains to the tube. Then the separation within the cyclone separator will be much easy and the dust and other particles will not enter the turbine blower casing.

CHAPTER V
SUMMARY AND CONCLUSION

In the context of increasing commercialization of agriculture, mechanization is very important. There has been increase in the use of farm machinery in Indian Agriculture as it contributed to the increase in output due to timeliness of operations and increasing precision in input application. In the case of paddy cultivation, every operation from the very first step of seed bed preparation to harvesting were almost mechanized. The operation in paddy cultivation where mechanization has not yet introduced is the packaging of harvested paddy. So it is decided to develop a paddy packaging machine with an intention of mechanizing the whole operations of paddy cultivation.

The conventional method of packing paddy which is harvested using combine harvester is time consuming and labour intensive. Usually, the big heaps of harvested paddy were kept aside the field for days for packing and transporting. It requires a number of labours for filling of paddy into sacks, weighing each sacks separately, and to stitch it. More often the farmers find it very difficult to pack the harvested paddy due to the non availability of labours. So the development of any kind of packaging mechanism which reduce the labour requirement and drudgery of the operation is the need of the hour.

The concept of pneumatic conveying of grains is a simple and easy to achieve technique. The system involves minimum number of components and could be fabricated easily. The development of a packaging system for paddy is derived from this concept. The major components contained in the conceptual design are a vacuum pressure turbine blower and a cyclone separator. The suction pressure developed by the blower is used to convey the paddy from the heap to the cyclone separator through flexible conduits. The turbine blower may be powered with a suitable capacity electric motor which is widely acceptable power source. Inside the cyclone separator, the air flows in a helical pattern, beginning at the top of the cyclone and ending at the bottom end before exiting the cyclone in a straight stream through the center of the cyclone and out the top. The paddy grains in the rotating stream have too much inertia to follow the tight curve of the stream, and strike the outside wall, then falling to the bottom of the cyclone. A quick openable lid at the bottom of cyclone separator enables the closing and opening of the outlet as and when required. A sack provided beneath the cyclone separator collects the paddy coming out of the separator. A simple sack holding mechanism at the bottom permits easy holding and removal of sacks. The sack holder is placed above a digital platform balance and thus it will initiate the weighing of paddy during the packing itself. The air and dust particles will be expelled out to the atmosphere through the outlet port of turbine blower. Thus flow cycle of paddy from suction line to the sack fitted on sack holder on the platform balance results in paddy packing by combining the operations of conveying, cleaning, weighing and packing.

Some of the physical and engineering properties of paddy such as moisture content, bulk density, angle of repose, terminal velocity etc. were studied in laboratory which could be used for the design of the packaging machine.

Based on the conceptual design the packing machine was developed and it consists of a Main frame assembly, Vacuum pressure turbine blower, Cyclone separator, Sack holder and a Digital platform balance.

The main frame assembly was fabricated out of MS angle as two steps one for cyclone separator and the other for turbine blower. The cross sectional dimensions of the frame is fixed as 86 x 70 cm considering the base dimensions of the standard platform balance available in the market. Two sides and open spaces in the top of the frame are covered with MS sheet of 22 gauge. The front and rear sides are kept open in order to facilitate easy placing and removal of sack and sack holder and also to place the platform balance.

The turbine blower is selected for generating a vacuum pressure of 180 m bar which is found sufficient to suck the paddy grains to a height of 1.5 to 2 m. The vacuum pressure turbine blower converts the mechanical input energy of the rotating shaft into pneumatic energy by evacuating the air contained within the cyclone separator. The internal pressure level thus becomes lower than that of the outside atmosphere. The amount of energy produced depends on the volume evacuated and the pressure difference produced. This pressure difference sucks the paddy grains form the heap to the cyclone separator in which the grains are dropped and the air is sucked to the blower.

A cyclone separator is fixed to the lower step of the frame. Cyclone separators are the most frequently encountered type of gas-solid separator. In a cyclone separator, the hard coarse particles moving in the flow of primary air of the cyclone drop out of the flow due to the action of the gravity and centrifugal forces. In this way the harvested paddy which was pneumatically conveyed is separated and dropped to the bottom sack and the air and dust are expelled out through the top. Thus, the cyclone separator offers packing of clean and good quality paddy.

The sack holder is designed to hold gunny bags or polythene sacks up to a weight of 75 kg of paddy. The height of the sack holder and size of the rings for holding the sacks are designed based on the average size of sacks available in the market to weigh 50 kg of paddy. A single leg made of MS square pipe supports the sack and holding rings. The foot of the support leg is fixed to a base platform made of MS angle and cross members of MS flat. The top of the support leg is bent forward to shift the centre of gravity of the sack holder to the centre of the base frame. Two concentric rings made of MS flat hinged at single point to form the holding unit. The ring can be easily attached or fixed to the sack holder leg. The outer ring is hinged to the inner ring at a single point and can be opened to fix the sack and closed for holding it without slip. The sack holder along with the sack is placed on a digital platform balance which enables the on site weighing of the packed paddy.

The developed model of pneumatic packaging machine for paddy is then evaluated for its performance and cost economics.

CONCLUSIONS:

1. A model of pneumatic packaging machine for paddy is developed based on the concept of vacuum conveying and cyclonic separation.
2. The developed consists of a Main frame assembly, Vacuum pressure turbine blower, Cyclone separator, Sack holder and a Digital platform balance.
3. The over all dimensions of the packaging machine is 1360 x 860 x 700 mm. The machine is fabricated out of MS angles, flats, sheets and square pipes. The design is simple and easy to fabricate.
4. A vacuum pressure turbine blower is used to create the suction pressure for conveying the paddy grains. The vacuum pressure generated is 180 m bar A single phase, 220-240V, 2800 rpm electric motor of 1 HP power is used as the prime mover for the turbine blower. The turbine blower's discharge pressure is 250 m bar at a rated volumetric capacity of 120 $m^3 hr^{-1}$.

5. A simple cyclone separator is used to separate the paddy grains and air conveyed to it and the grains are dropped to the bottom sack and air is expelled out through the top of cyclone separator.
6. A quickly openable sack holder with a single leg beneath the cyclone separator enables the proper holding of gunny bags for packing paddy.
7. The sack holder and sack is placed on digital platform balance for easy and no site weighing of paddy.
8. The physical and engineering properties such as moisture content, bulk density, angle of repose and terminal velocity are studied for the benefit of design of the paddy packing machine.
9. The average moisture content of paddy sample was found to be 22.98 % (db) which comes in the range of average moisture level at the time of harvesting.
10. The average bulk density obtained is 1.61 g cm^{-3}.
11. The angle of repose was found to be 5.5^0.
12. terminal velocity
13. The developed model of pneumatic packing machine for paddy is evaluated for it performance and indicated a fairly satisfactory performance.
14. The average power consumption of the prime mover is 792.25 W which is equivalent to 1 hp.
15. On an average, the developed model of pneumatic packaging machine for paddy is capable of filling 23 sacks per hour.
16. Cost analysis of the developed machine reveals that the cost of packing one sack of paddy comes to Rs 2.62.
17. The packing machine is beneficial for reducing the time, labour, cost and energy of packing to a great extent. From the experimental results, it is obvious that the newly developed machine is technically and economically suitable for packing the harvested paddy from the field.

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APPENDIX 1

Specification of vacuum pressure turbine blower

Model	:	PTBC-100
Capacity	:	120 m^3/hr
Pressure	:	250 mbar
Vacuum	:	180 mbar
Power	:	0.75 kw / 1 HP
Speed	:	2800 rpm
Volts	:	220V- 240 V /1 phase

APPENDIX II

Cost of operation

Particulars	***Formula***	***Values***
Initial cost, P		30000
Life (yrs), L		10
Avg. use/yr (h)	4 x 30 x 10	1200
Rate of interest (%), *i*		10
Packing capacity, Nos/h		23
Salvage value, S=10% of P	0.1 x P	3,000.00
Annual Fixed Charges		
Depreciation (Rs/yr)	(P - S) / L	2700
Interest cost (Rs/yr)	((P + S)/2) x	1650
Total fixed costs (Rs/yr)		4350
Total fixed costs (Rs/h)		3.625
Variable Costs		
Electricity units (kW/h)		0.792
Electric units (Rs/kWh) = @ Rs8/kWh		6.336
Labor cost (Rs/h)	400/8	50
Total variable cost (Rs./h)		56.336
Total Costs		
Total cost (fixed + variable) (Rs/h)		59.961
Total cost, Rs/sack		2.607

ABSTRACT

In the present scenario of the state of Kerala, it is difficult to carry out rice cultivation due to high labour cost and shortage of labour and because of this, the paddy fields are being converted into filled up land. Mechanization of the different operations is the only possible solution to sustain rice cultivation in the state. A wide range of machinery are available to carry out the different operations involved in paddy cultivation except packing of harvested paddy. So it is decided to develop a model of pneumatic packing machine for paddy at KCAET, Tavanur. The conventional method of packing paddy requires a number of labours for filling of paddy into sacks, weighing each sacks separately, and to stitch it.

The concept of pneumatic conveying of grains is a simple and easy to achieve technique. The system involves minimum number of components and could be fabricated easily. The development of a packaging system for paddy is derived from this concept. Based on the conceptual design a packing machine was developed and it consisted of a Main frame assembly, Vacuum pressure turbine blower, Cyclone separator, Sack holder and a Digital platform balance. The suction pressure developed by the blower is used to convey the paddy from the heap to the cyclone separator through flexible conduits. The turbine blower was powered with a 1 HP electric motor. A cyclone separator is used to separate the paddy grains and the air. A sack provided beneath the cyclone separator collects the paddy coming out of the separator. A simple sack holding mechanism at the bottom permits easy holding and removal of sacks. The sack holder is placed above a digital platform balance and thus it will initiate the weighing of paddy during the packing itself. The air and dust particles will be expelled out to the atmosphere through the outlet port of turbine blower.

The developed model of pneumatic packing machine for paddy is evaluated for it performance and indicated a fairly satisfactory performance. The average power consumption of the prime mover is 792.25 W which is equivalent to 1 hp. On an average, the developed model is capable of filling 23 sacks per hour. Cost analysis of the developed machine reveals that the cost of packing one sack of 50 kg paddy comes to Rs 2.62. The packing machine is beneficial for reducing the time, labour, cost and energy of packing to a great extent. From the experimental results, it is obvious that the newly developed machine is technically and economically suitable for packing the harvested paddy from the field.