Design, Development of Industrial Flexible Hopper Feeding Mechanism

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***Abstract*-Technological advancements are taking place day-by-day and industrial growth has been the key aspect of development of any nation. In plastic injection moulding machine, the provision is to transfer powder raw material from ground to the hopper is not provided or the powder transfer can be done manually in machine. Many small scale industries has moulding machine where they have to fill the raw material at a height where a human efforts are needed which increases the production time rate, leads to increases the wastage of raw materials. Also limited space and hence the system cost increases. In this paper, design of flexible hopper feeding mechanism is made as per small scale industries need by considering the above constraints and accordingly, theoretical design calculations are made for cone design, mini hopper, material volume. The three different types of raw materials Polyvinylchloride, Polypropylene, and Polystyrene are selected and testing their total fill time, empty time, mass flow rate, and power consumption rate with respect to height in a design of industrial flexible hopper feeding mechanism.**

Keyword: Plastic Granules, Injection Moulding Machine, Dies.

I INTRODUCTION

Technological advancements are taking place day-by-day. Industrial growth has been the key aspect of development of any nation. With increase in development there is an equivalent growth in the demand. This increase in demand forces the small-scale industry to increase the productivity in limited time. A survey of 6 small industries was conducted to get information about the problems due to this increase in demand. During the survey it was observed that material loss during production was common in most industry. Plastic granules (raw material) are the major aspect in any injection molding industry. Wasting of plastic granules is a major loss, since approximately 2kg of plastic is been wasted per day. This accounts for Rs.250/- day of the raw material. This chunk amount of capital cost for an industry is a major loss, since that amount can be contributed to some other aspect of an industry. All this limitation motivated to make amends to make for the loss. Hence, the idea of making an automatic feeding machine was established, to reduce wastage of plastic granules and thereby, decreasing human labor and saving capital.

Therefore, to design industrial flexible hopper feeding mechanisms the following problems will be overcome by the machine as: i) Material can be feed to the main hopper of the machine from the ground quickly. ii) The setup is movable and compact, therefore the problem of space constrain is eliminated. iii) Requirement of multiple setup for different machine is eliminated as this machine will feed material to multiple machine. iv) Different types of powder can be transferred with the help of single machine. Flexible hopper feeding machine deals with replacement of standard human effort by automation. It deals with transfer of plastic granules by means of vacuum through a hose pipe to the mini hopper thereby into the main hopper. Detailed design of each and every component is given. The machines available in the market are quite costly. Therefore, an idea of making the machine cheap as well as resemble with each and every machine, thereby reducing human efforts. An automatic feeding systems available in the market to reduce the raw material wastage and save time. These systems are generally costly and their use is limited to one machine only as well as it occupies some space. Our main aim will be to solve this issue by manufacturing a system that Is flexible as well as cost effective. Earlier industries used to fill the hopper manually by means of human labor. Technologies were not advanced during that period of time. Hence, man power was the driving force in the industry. As the advancements took place industries began to grow and productivity became the major goal of the industries. Man used to feed material by their power and granulated material was feed into the hopper. This resulted into wastage of plastic pellets as some quantity of material was been wasted. [1]. Auto feeding hopper loaders were used for filling the machine hopper with the required raw material without human intervention. The hopper loader consists of a vacuum

pump, receiver vessel and an inlet for the tube. One end of the tube is connected to the receiving vessel which generally fits on top of the hopper and the other end of the tube is connected to the source of the raw material (which could be an open gunny bag containing the material, a master tank containing the raw material). The vacuum pump is being activated and the material is used to feed in the hopper. Depending on the capacity of the hopper on which the hopper loader is fitted, the operator has to set the time on the hopper loader. At that designated time the hopper loader is activated and stays active for a certain amount of time thus filling up the hopper with the material. [2]. Feeding system plays an important role in flexible hopper feeding machine. The invention relates to an improved system for supplying an even flow of powder from a fluidized powder source to a powder spray gun or hopper of such a powder spray system. [3]. A hopper loader, also known as a shot hopper, for processing machines such as molding machines is provided which is particularly useful in supplying particulate material to a molding machine, such as an injection molding machine. The hopper loader broadly includes a receiver where particulate material to be processed is conveyed, preferably pneumatically, a hopper assembly which includes an upright side wall defining therein a chamber where the particulate material is collected and a feed throat for delivering the particulate material to the processing machine. [4]. The material loader of the present invention includes a material hopper, an air filter, a hopper support and a control box. The filter is positioned on top of the hopper, and the hopper is positioned on top of the hopper support. [5]. In the operation of plastic molding machines fresh plastic, in granular form, which is received from the manufacturer in barrels or drums is fed to the hopper of the molding apparatus, either with or without the addition of a predetermined amount of used plastic which has been reduced to granular form in a suitable apparatus. [6]. A multibladed wheel is situated to rotate just above the track at the bottom of the hopper. To avoid jamming, the top level of the parts in the hopper should be lower than the plane containing the axis of rotation of the wheel. [7]. Shear tests are a common method in powder technology to characterize the flow ability of granular materials and powders. [8]. According to this invention, means are provided forming an entrance port for the powdery material together with its entrapped air, downstream of the polymer entrance but upstream of the polymer exit, and vent means are provided in the extruder barrel, upstream of the point at which the powdery material is introduced, but downstream of the polymer entrance. [9]. This invention relates generally to mobile and stationary industrial vacuum loaders having bag house filtration systems for the collection of dust escaping from material being sucked into the hopper and, in particular, to means for removing collected dust from the bag house and returning it to the hopper. [10]. All the above literature reviews gives us an insight of all the advancements during the course of time. During the earlier times man used to feed the material in the hopper by his shear power and strength. As the progress took place, vibratory tray was used to feed the material into the injection process which was placed above the hopper. In the plastic injection molding process the material in the combustion chamber becomes gummy which resulted in the blockage of the plastic pellets. In order to overcome this air lift device were installed, which provided easy flow of material. A new type of hopper feeding system was studied called bladed hopper feeder, one type of non-vibratory feeder.

II THEORETICAL CALCULATION OF FLEXIBLE HOPPER FEEDING MECHANISM

Flexible hopper feeding mechanism uses a vacuum pump as the main component and it works on the principle of that of the pump. Vacuum pump removes gas molecules from a sealed volume to leave behind a partial vacuum. In our case the partial vacuum is created in the mini hopper by the vacuum pump during the suction process and simultaneously the material is sucked and transferred to the mini hopper from ground reservoir. With the help of hose pipes the material is transferred into the mini hopper. Control electrical circuit is used to regulate the movement of the gate in the mini hopper. A low pressure is created when the vacuum sucks all the air from mini hopper which results in pressure difference between the mini hopper and the ground reservoir, as a result material moves into the mini hopper. A vacuum pump is a device that removes gas molecules from a sealed volume in order to leave behind a partial vacuum. The molecules will only move only if there is a difference in the pressure between two regions. The region that has the smaller number of molecules will be the low pressure region and the area with more molecules will be considered the high pressure.

Table 1
Summary of parameters for input data design system

1	Volume of the material, V	5.5×10^{-3} m^3
2	Volume of cone,	$0.0327 m^3$
3	Volume of mini hopper	$5.74 \times 10^{-3} m^3$
4	Mass capacity of mini hopper	5.25kg
5	Pressure due to PVC material, P_1	$568.4 N/m^2$
6	Pressure exerted by self-weight of mini hopper, P_2	$216.5 N/m^2$
7	Atmospheric pressure – vacuum pressure = P_3	$99950 N/m^2$
8	Longitudinal stress, σ	$440601.8 N/m^2$
9	Weight on stand	510 N
10	Diameter of pillar	10mm
11	Time required to fill the mini hopper	12.16s
12	Time required to vacant the ground reservoir	12.16s
13	Total time for the process	2 min

The complete components design calculations are made for the feeder hopper mechanism like selection of pump, volume of materials, reservoir dimensions like radius and height, volume of mini hopper, pressure due to PVC material, self –weight of mini hopper, weight of stand, time required to fill. The mini hopper and vacant the ground reservoir, and total time for the process. The Table 1 shows the summary of calculated parameters values obtained after calculations.

III EXPERIMENTATION

When the system is turned on, supply is given to the pump and both the circuits i.e. pump circuit and gate circuit. There are two proximity switches in the mini hopper one at the top level and one at the bottom level, whose combined output is given to both the gate circuit and the pump circuit. Fig 1. Shows the experiment set up of Flexible Hopper Feeding Mechanism. Initially when the mini hopper is empty, the proximity sensors will detect it and send the signal to the pump circuit and the pump will start. The vacuum pump draws air from mini hopper, delivery pipe and suction pipe. Vacuum thus created draws the material from ground reservoir and is transferred to the mini hopper via the delivery pipe due to pressure difference created. The mini hopper designed can hold a capacity of up to 5 kg. Once the mini hopper is fully filled it indicates that both the proximity switches are activated and their signal is sent to the gate circuit. At the same time a part of the output of the switches will be sent to the pump circuit and pump will stop. The proximity switches are connected in series and only their combined output will drive the circuit. When the mini hopper is full both the switches will sense it and in turn the transistors in the circuit will drive the linear actuator solenoid valve connected to it which will open the gate of the mini hopper.

Fig 1. Experiment set up of Flexible Hopper Feeding Mechanism.

Now when the mini hopper is empty then the proximity switches will detect it and send signal to both the gate circuit and pump circuit which will in turn close the gate and start the pump and the process will start again and it will continue till the main hopper of the machine is filled. The testing is carried out and measured the various parameters like fill and empty time, time required for 10 impulses, power consumption and mass flow rate measured of different materials like: i) Polyvinylchloride, density, ρ =1467 kg/m^3, ii) Polystyrene, density, ρ =1040 kg/m^3. iii) PolyPropylene, density, ρ = 946 kg/m^3.

IV RESULTS AND DISCUSSION

The experiments were performed for different materials and the following conclusions are made. The power consumption, total fill time, empty time and mass flow rate with respect to height are plotted in the following graphs and it can be discussed as below. In Fig. 2 the power consumption rate increases for Polyvinylchloride material than Polypropylene and Polystyrene at a height of 0.5m at initial stage. The power consumption required for both materials Polyvinylchloride and Polystyrene are almost same for the required height is increases further the required filled time is also increases. Whereas the other two materials both have taken almost the same time for the height as the density of materials for both materials are almost same.

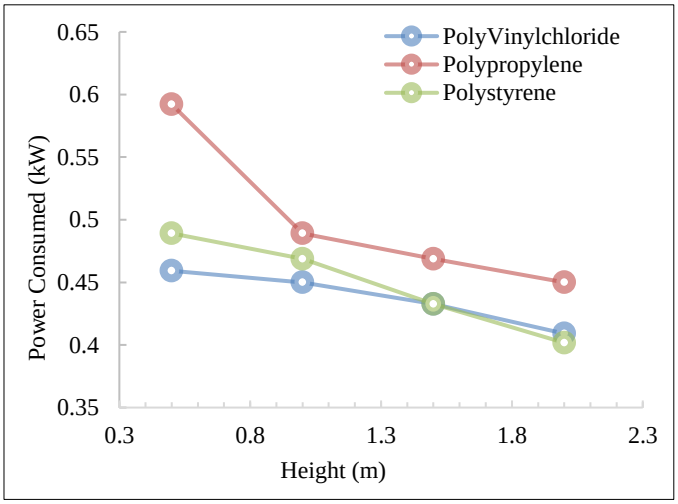

Fig.2. Plot of Power Consumed Vs Height for different materials

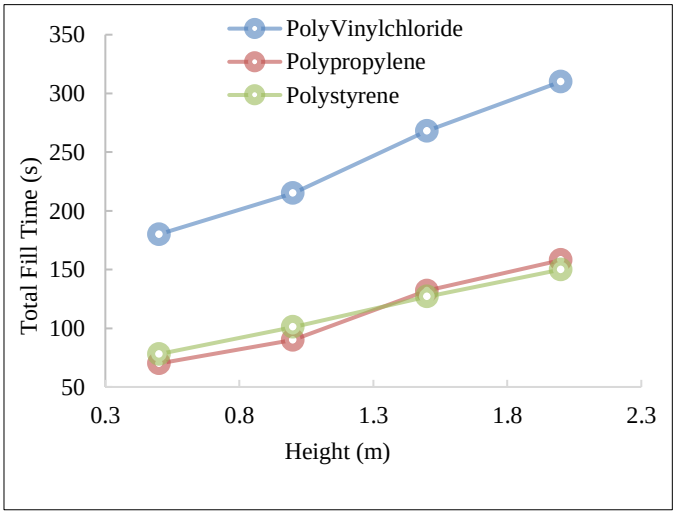

Fig.3. Plot of total filling Vs Height for various materials.

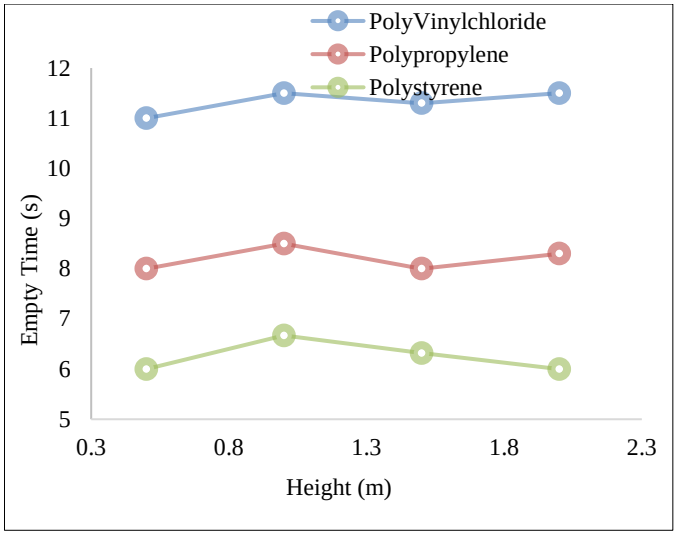

Fig.4. Plot of Empty Time Vs Height for different materials

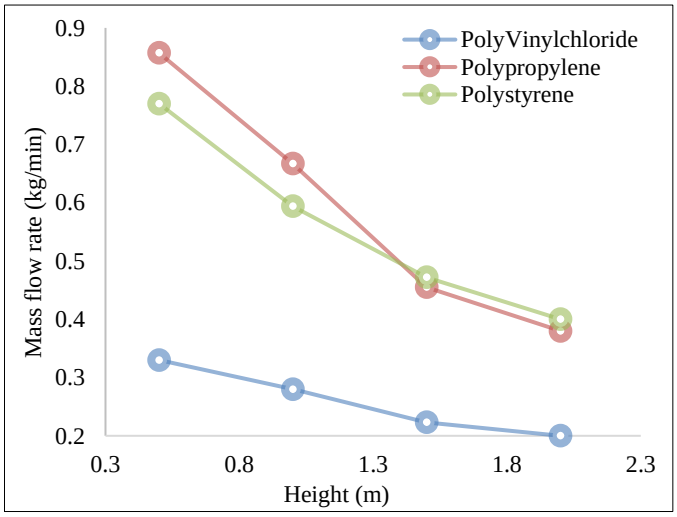

Fig.5. Plot of mass flow rate Vs Height for different materials

From Fig.3, it is observed that Polyvinylchloride have highest density and hence time required to fill up the hopper is increases as the height. The emptying time is proportional to the density of the material. The densest material i.e. PVC has the highest emptying time. To decrease the emptying time the outlet is give more slope as shown in Fig.4. As the height increase the mass flow rate increases. The mass flow rate is the function of density, conveying pipe, conveying height and the vacuum motor. The Polyvinylchloride material have mass flow rate is less compared to the other two materials. Whereas, the other two materials have almost same nature of mass flow rate due to almost same density of both materials as shown in Fig.5.

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