Design and Performance Analysis of a Slotted Rotary Disk Feeder

[1]Bhuvan Arora, [2]Dharmendra Tarkar, [3]Pradeep Khanna

[1]MPAE Department, [3]Senior Lecturer, MPAE Department
NSIT, Manufacturing Processes and Automation Engineering, New Delhi, India
[1]Email: bhuvan.aurora@gmail.com [2]Email: dharmendra.tarkar08@gmail.com
[3]Email: 4.khanna@gmail.com

Abstract — **In today's world of rapid industrialization, mechanization and automation are becoming an integral part of industries in order to increase the rate of production, efficiency and quality of parts. One of the examples of these processes can be observed in automatic assembly workshops in automobile companies. Introduction of mechanized feeders is a basic step towards mechanization that help in easy sorting of parts and availability of parts at right place and at right time. They are now becoming an essential part of modern manufacturing systems. A physical prototype of a mechanized slotted rotary disc feeder was constructed and the behavior was studied experimentally by varying the speed of rotation of disc, number of parts inside the feeder and the number of fins on the churner. A study on the obtained experimental data was performed and conclusions were drawn about effect of various parameters on the feed rate.**

***Index Terms*—** **Feed Rate, Slotted Rotary disk, Stationary slotted disk, Thrust Bearing.**

I. INTRODUCTION

Parts feeders are machines that are used in automated and semi-automated systems that are used to orient parts for robotic arms, human workers or other automated systems to use or package the parts or components. Applications range from packaging pills in the pharmaceutical industry to sparkplug production in the automotive industry. The main difference between part feeders is in their method of directing the feed.

Vibratory bowl feeders are the most common type of part feeders which consist of a bowl having a helical track. Parts are dumped into the bowl that vibrates and turns. As the parts climb the track they encounter obstacles that orient the parts in a certain way. So that they can be easily used further down the line.

Centrifugal rotary feeders use a cylindrical bowl that spins and forces parts to the outside of the bowl having a hole on its periphery. As the parts are forced out they move through the hole and are channeled into receivers when the parts are in correct orientations. From the receiver, they go on to a conveyor that moves the parts to the next stage of production. Centrifugal feeders are usually faster and less noisy than vibratory feeders.

Pneumatic feeders' move and position the parts by means of a pneumatic piston. Pneumatic systems use compressed air to move the piston. These units are ideally suited to convey closures to capping machines, but are also applicable for handling many other small parts including liners, fitments, corks, capsules, etc.

The bowls of parts feeders are commonly available in two configurations, although custom bowl types are manufactured. Cascade bowls, also known as inside track bowls, are primarily used for feeding easily oriented parts like screws and dowels. They are often quieter and less costly than outside-track designs. Outside-track bowls are used when more intricate tooling is required for proper part orientation, for higher feed rates, or for multiple lines of feed. The outside track is pitched downward to improve the separation and orientation of the parts.

Programmable part feeders are also available. They are more flexible than traditional part feeders and may be programmed to change the way they isolate or orient parts. Programmable feeders are available in several different configurations ranging from programmable frequency of vibration in a traditional type of feeder, to sensor driven actuators that reorient parts. Robotic parts feeders use sensors and manipulators to orient parts are also manufactured. Such feeders are comparatively more costly and more difficult to manufacture due to the higher number of degrees of freedom required in such systems.

In automated assembly systems, part feeders play a very important role as they are responsible for supplying continuously segregated parts at a specific flow rate and orientation to the machine. In such automated feeder systems part flow rate is of primary importance as the orientation in most of the cases can be controlled easily[1]. Part feeders are used to feed parts like nuts, bolts, capsules, and other small components at a specific feed rate and orientation to desired locations usually on a conveyor or a machine.

This paper deals with the study of the SLOTTED ROTARY DISK FEEDER:

Principle of Working:

This paper deals with the rotary disk feeder used for feeding small parts. Two circular disks, of same diameter and having different number of peripheral holes, were given a rotational freedom with respect to each other about their common central-axis perpendicular to their plane of motion. This was achieved by using a thrust bearing, on which the upper disk rested on the lower one. Lower disk had only one hole and upper disk had sixteen at regular intervals on the periphery. Upper disk rotated while lower one was kept stationary. Therefore, when the holes of both disks coincided, the parts in the hole came out through the channel. To make sure that no part remained at the center of the disk, a number of fins were attached to a rotating shaft. The axis of the shaft coincided with that of the discs. The whole assembly was covered via a cylindrical case, made up of GI sheet.

NUMBER OF VARIABLES ON WHICH THE FEED RATE DEPENDS IN THE DESIGN:-

1. Speed of the Slotted Rotary Disk.
2. Parts Population.
3. Number of fins.

II. MATHEMATICAL ESTIMATION OF THE DIAMETER OF PITCH CIRCLE

A mathematical formula for the diameter of the pitch circle can be easily proof from geometry.

Let ‘*D*’ is the diameter of the disk, ‘*d*’ is the diameter of the hole and ‘*N*’ is the number of holes.

Top view of the slotted disk is shown in figure.

Radius of the pitch circle can be observed as:

$$P = D/2 - (d/2 + d/4)$$
$$= D/2 - 3d/4.$$

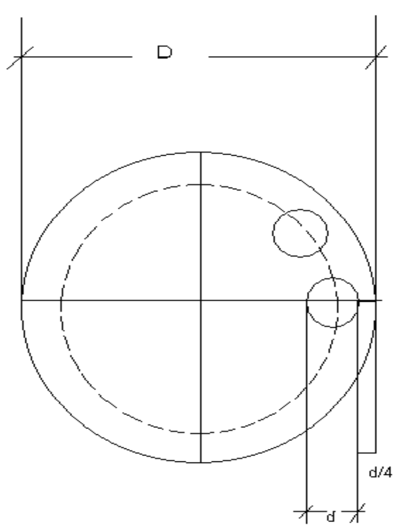

Figure 1. Geometric diagram of slotted disk

III. BRIEF ANALYSIS OF VARIOUS FACTORS

a) Parts population in the feeder

Significant variations in the feed rate take place with change in the total parts population inside the feeder. As the number of parts increases, a greater number of parts are available to come out. Hence the feed rate increases with the increase of number of parts. But after a certain limit, feed rate tends to decreases from previous trend of increasing very slowly since large number of parts as compare to the size of the cylinder, restrict the motion of fins. However if parts are not metallic then the trend will increase as it was increasing previously. Enough torque is provided to the fins via single ac phase motor to overcome the resistance by traffic of parts.

b) Speed of rotation of the slotted disk

The speed of rotation of disk has a very significant effect on the feed rate. As disk-speed increases, the centripetal forces with which the parts come out increases therefore make hindrance at the channel through which parts are collected. So, optimum speed should be chosen as per the size of design

c) Number of fins

Feed rate depends on the number of fins used and the trend increases as the number of fins are increased, but after a certain limit it tends to decrease as friction between the parts and fins increases and it could lead to jamming. More torque would be required if the number of fins are increased beyond a certain limit.

d) Speed and torque of rotating fins

The speed of fins should have a optimum value along with a required torque. It should not be very high as if the speed increases the related torque decreases. Hence, leads to jamming of the rotary motion.

e) Number of holes in the slotted disk

Number of holes depends on the diameter of the disk to be rotated. As the number of holes can’t be more than a specific value for a given diameter of the rotary disk. So the feed rate depends on this factor only when this number is less than this specific number. As the number of holes decreases the feed rate decreases. And to reach a optimum feed rate in this case the speed of rotary disk should be increased.

f) *Shape of feeding parts*

It can be any regular shape which can be accommodated in the holes provided. Recommended one is circular, hexagonal, octagonal and square. This analysis is done with the hexagonal parts.

g) Friction between the parts and the rotary disk

As the coefficient of friction increases between the parts and the disk surface, torque required by the fins is increased hence lowering the sweeping action of the fins, therefore decreasing feed rate.

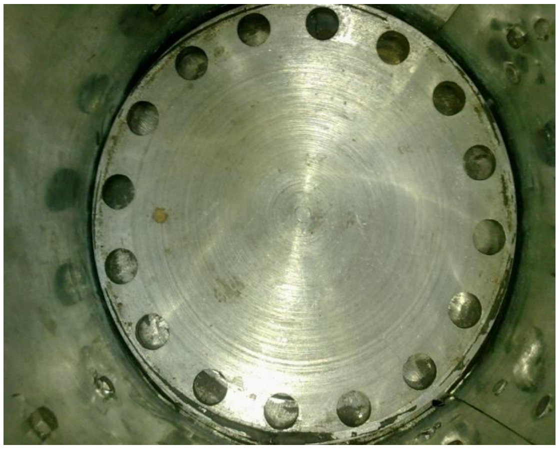

Figure 2. Top view of the rotary slotted disk

IV. EXPERIMENTAL ARRANGEMENT

The feeder consists of a mild steel slotted disk resting on another mild steel disk with only one hole, via a thrust bearing.

The rotating disk is being attached to a DC motor and powered by it. This set up is fixed on a stand and a cylindrical case is provided to cover the disks and to check the falling of the parts outside the disk. Fins are above an optimum distance from the rotary disk so that there is no part can be accommodated in that gape. And these fins are attached to a shaft which is being powered by a single phase AC motor via a gear box to control its speed and provide the required torque.

AC motor is supported on the top via a stand. Under the slot of the fixed disk there is a channel provided to give a path way for out coming parts. The channel is in a direction of tangential velocity of the rotary disk, so that it will be according to the centripetal force of the parts, they are coming with. Hence the parts are given a smooth path to come outside of the feeder through the channel. Fins are made to rotate with the speed different to the disk as both the sources of rotation are different. Speed disk can be controlled via an adaptor providing it the required voltage. The sweeping action of the fins is accomplished by the relative motion of the fins and the disk. The shaft is in the direction of the axis of rotation of **rotary** disk and is concentric with both the disks. The central axes of all the holes are parallel to central axis of both the disk.

Figure 4. Set up of fins.

Table 1: Specifications

Diameter of the rotary disk	28 cm
Thickness of the rotary disk	8 mm
Diameter of the fixed disk	28 cm
Thickness of the fixed disk	12 mm
Number of slots	16
AC motor specification	1 phase , 1400 rpm ,1/4 H.P.
Gear box	1:70
DC motor	10 rpm, 12- 24 V, 5-10 A
Number of fins	Variable (1-4)
Thrust ball bearing	51109 OD= 60 mm Thickness= 14 mm
Diameter of the slots	22 mm

V. EXPERIMENTATION RESULTS

The effect of the two parameters-Numbers of fins, and the part population inside the feeder on the feed rate of the feeder was studied. A factorial analysis was carried out for analyzing the variation of the feed rate by varying the two parameters, each to their corresponding upper and lower limits. Through this an equation was formulated to estimate the feed rate under the influence of these parameters.

The experiment was performed by maintaining a fixed number of parts inside the feeder at any point of time. Numbers of parts coming out of the feeder in a minute were tabulated. This observation was repeated two more times for the same set of values and their average was calculated.

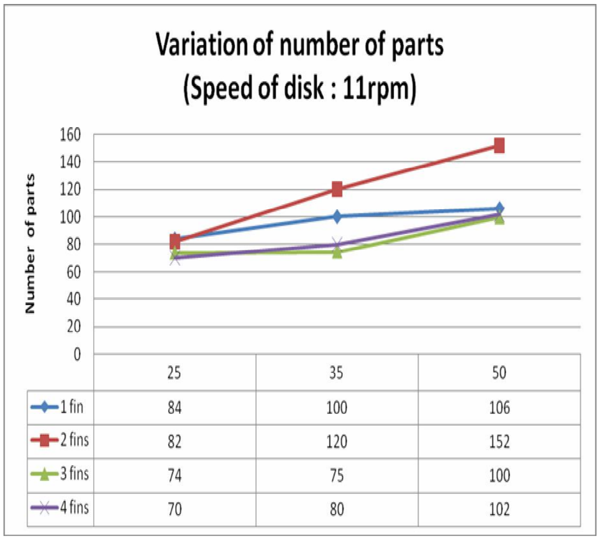

Figure 3. Effect of number of fins used

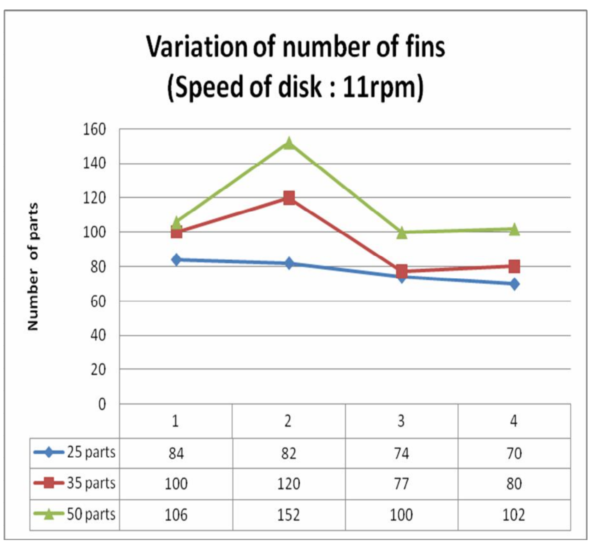

Figure 4. Effect of part population

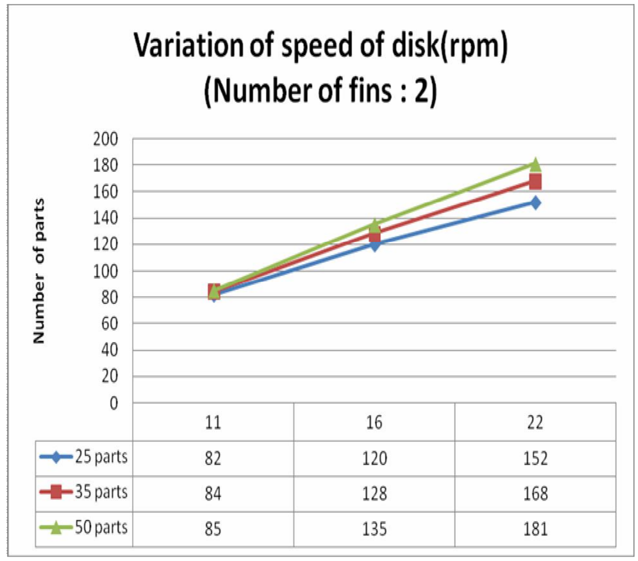

Figure 4. Effect fo speed of rotary disk

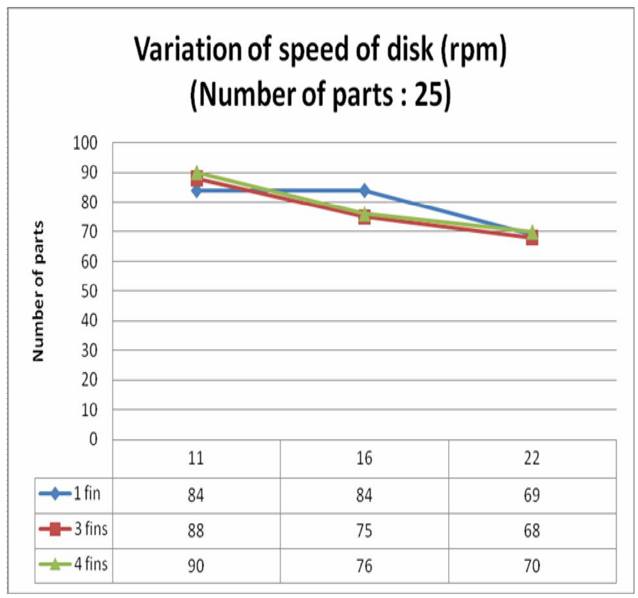

Figure 5. Effect of speed of rotary disk

VI. CONCLUSIONS

a) Effect of Speed of rotation of the slotted disk

It is experimentally observed that the feed rate increases as the speed of rotation of the disk increases. But after a certain limit (25rpm in this case), feed rate decreases. As the speed of the disk is further increased the tendency of the parts to move through the hole decreases and the parts tend to pass-over the hole on the stationary disk instead of moving through it.

b) Effect of number of Parts in the feeder

As the number of parts is increased, a greater number of parts are available to come out, thus the feed rate increases with the increase in parts population. But after a certain limit (150 in this case) the feed rate was observed to decrease due to higher interference between the parts which though present earlier was insignificant.

c) Effect of Number of fins

It is experimentally observed that the feed rate increases as the number of fins is increased from one to two as the churning effect is doubled. A decreasing trend is observed as the number of fins is further increased as the area swept by the fins increases creating a cluster of parts at the periphery thus increasing interference.

d) Effect of Speed of rotating fins

The speed of fins should have an optimum value as very high speed would lead to turbulence with the fins giving a sort of an impact to the parts thus reducing the feed rate as well as increasing the chances of failure while very low speeds would also decrease the feed rate as the parts would take more time to move to the periphery.

VII. RESULT

1. The mechanical equipment for the rotary disk feeder was designed and fabricated. Experimental analysis of influence of various factors on feed rate was carried out by varying three parameters namely number of fins, speed of rotary disk and part population inside the feeder. Variation of parameters is carried out in a way that one of them is varied while rest are kept constant. Hence, we get proper dependency factor of the feed rate, for each variable. We can now have a good approximation for optimum value of variables for having maximum feed rate.
2. In our design the feed rate is found to be maximum for 50 parts, 2 fins and the speed of disk 22 rpm.
3. Design of experiments was carried out and conclusions regarding general trend of variation of the feed rate and varying parameters were drawn.

VIII. ACKNOWLEDGMENT

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IX. REFERENCES

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