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Graphical Analysis of Bottle Caps Feeding in a Vibratory Bowl Feeder

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Abstract

With the technological advancements and human development, a shift towards automation has addressed a sea change. Automation not only reduces human efforts and time required in the production process but also improves the quality of the product with maximum efficiency. Automation in other words has given the people a way to work in a much faster, accurate and precise manner, such that the product is obtained undamaged in its stated quality. The way assembly lines operate in industries across the globe, has seen a major upheaval as a result of unprecedented industrial growth and technological advancements. Vibratory feeders are self-sustained machines that use vibrations to feed materials to other machines. They are suitable for feeding small components in a directed path from a randomly distributed and unaligned bulk of components. The objective of this paper is to analyze and test the performance of a modified path when 2 set of industrial bottle caps having same height but different diameters are fed in the vibratory bowl feeder. The feed rate was studied experimentally by varying the input parameters such as part population, frequency of vibration and diameter of the parts. A research to find an optimum range of operation of the feeder was finally done by manual and graphical calculations.

Keywords: *Automation, Vibratory Feeder, Feed Rate, Bottle Caps, Part Population, Frequency of Vibration*

1. Introduction

The way assembly lines operate in industries across the globe, has seen a major upheaval as a result of unprecedented industrial growth and technological advancements. [2][3]

Vibratory feeders are rugged and robust automatic machines used in places where there is a need to feed discrete components intermittently for assembly on industrial or production lines for the purpose of further application. Feeders form a critical part of automated assembly lines [4]. They are more economical and a suitable alternative to manual labor [5]. These are quite reliable, have high quality, and have low maintenance as compared to other conveying means. They are very economical and cause little pollution. They are wear resistant and cause no damage to the parts they feed. Due to the versatile nature of vibratory feeders, they find large applications in pharmaceutical, automotive, electronics, glass, steel and food industries.

1.1 Working principle of a Vibratory Bowl Feeder

Vibratory feeders rely on the mechanical behavior of a part, such that when gently shaken down a conveyor chute that is shaped to fit the part, they will gradually be shaken so that they are all aligned. They thus leave the feeder's conveyor one-by-one, all in the same orientation. This conveyor then leads directly to the following assembly or packing machine. Vibratory Bowl Feeders are used for feeding of components to various machines. The actuation / Vibrations take place by electromagnets. The Vibratory Bowl Feeder is a device that converts Electro-magnetically produced vibrations into mechanical vibrations. These mechanical vibrations are utilized for movement of the work piece along the helical path/track of the vibratory bowl feeder.

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Magnetic coil, which is fixed to the counter mass, is energized with supply of electric current, producing a force, which in turn attracts and releases the magnet armature. As the magnet is rigidly fixed to the top spring holder and bowl feeder, the vibrations are transferred to the spiral-conveying track of the bowl. Depending on the angle of gradient of the leaf springs and lead angle of the helix of conveying track, the work pieces move with every vibration above the track in small jumps.
Vibrating feeder is composed of feeding tub, vibrator, spring bearing, gear, etc. Tank vibration feeding solutions of vibration source is vibrator, vibrator is made up of two eccentric shaft (master, passive) and gears, drive shaft, driven by a motor through the triangle again by gear meshing driven shaft rotation on the drive shaft, the main, driven shaft rotate reverse at the same time, make the tub vibration, a continuous flow of material, to achieve the purpose of conveying material.

2. Experimental Setup

The path of the vibratory feeder was altered in order to align to the requirements:

- A path using a galvanized iron sheet was designed and fabricated in such a way that the desired type of component was only allowed to pass.
- The rejecter constructed in the fabricated path was designed in such a way that it contained small slots followed by semi-circular metal extrusions of less than half the diameter of the fed caps.
- A sheet metal stopper was inducted in the fabricated path of the feeder in order to ensure that only one component was fed to at a time.
- Precautious measures to avoid jamming of the components were adopted by constructing the fabricated path wide enough for proper passing of the components.

Figure 1: Vibratory bowl feeder (top view)

Figure 2: Bottle caps fed into the vibratory bowl feeder

Figure 3: Fabricated path design

3. Performance Analysis

The parts used for the analysis were flat-base LDPE bottle caps. Although the performance of the feeder depends upon various factors like part population, material of caps, width & inclination of the path, frequency of operation and diameter of caps, experimentation has been carried out on the following three variable parameters :-

A. **Part population in the feeder:** Part population is defined as the number of parts in the bowl of the vibratory feeder at any given time. The

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various part populations used for the analysis were 40, 80 and 120.

B. Frequency of operation: Frequency of operation is that frequency at which the vibratory bowl feeder operates to feed the parts in the bowl at the given time. The different frequencies used were 45, 50 and 55 Hz.

C. Diameter of parts: The part diameters, in our case, diameter of bottle caps, used were 10mm and 16mm.

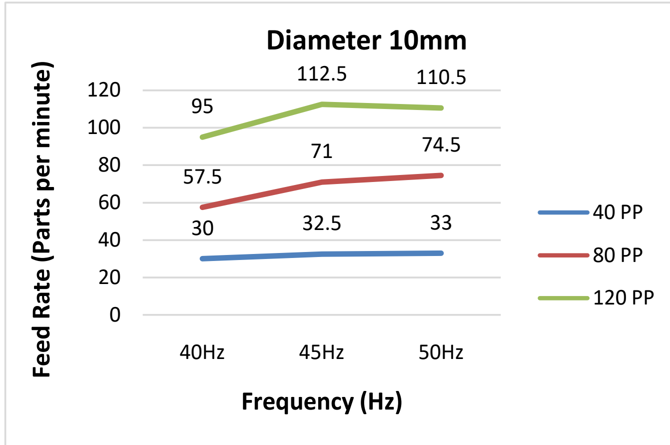
The graphical analysis has been done using the technique of one factor at a time.[1]

4. Experimental Procedure

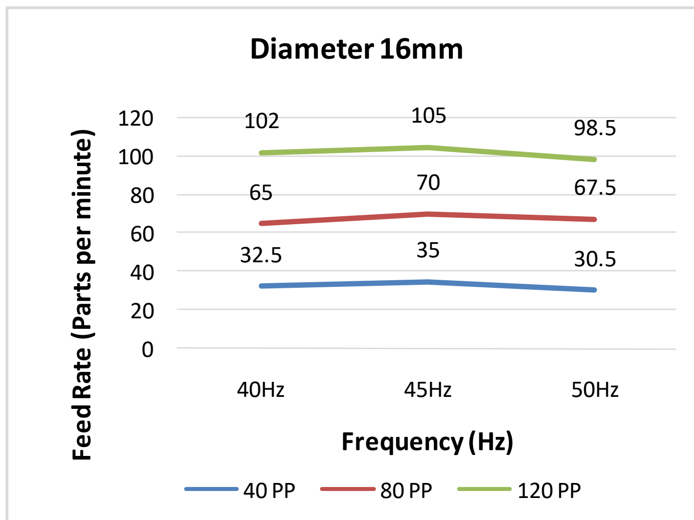
Experimental analysis was carried by keeping any two parameters, namely, part population, frequency and diameter of caps, unchanged while varying one.
For a particular diameter, the part population was kept constant and the number of parts coming out of the feeder in one minute was recorded, while varying the frequency in steps of 5 Hz. This was done for two readings and their average was taken to get the final feed rate. Subsequently, similar procedure was carried out for the other part diameter and readings for the same were tabulated. For a particular diameter, feed rate vs. frequency graphs were plotted for varying part populations. Then, for a particular part population, the feed rate vs. frequency graphs were plotted for varying cap diameters.

4.1 Graphs

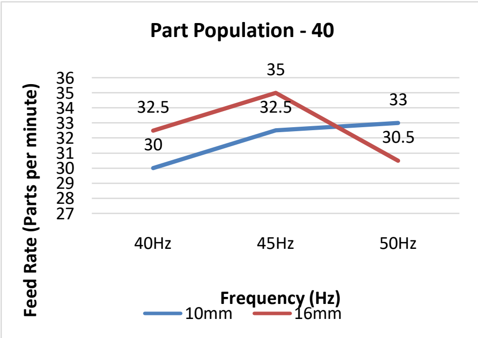
Graph 1: Variation of feed rate with frequency for caps of diameter 10mm and different part population



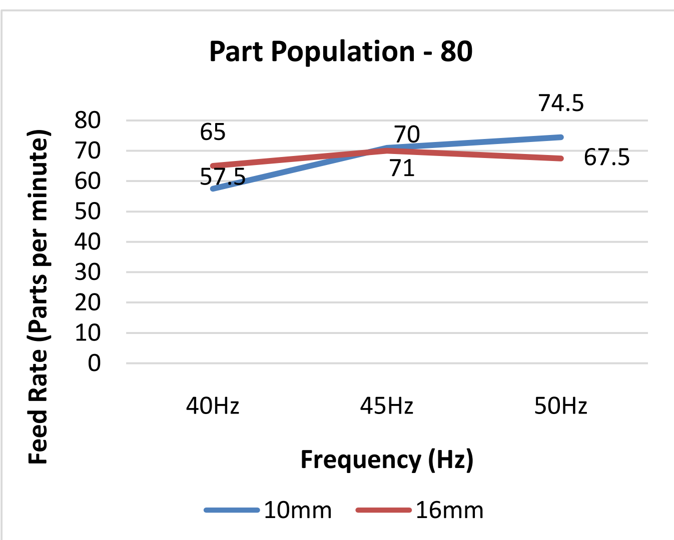
Graph 2: Variation of feed rate with frequency for caps of diameter 10mm and different part population



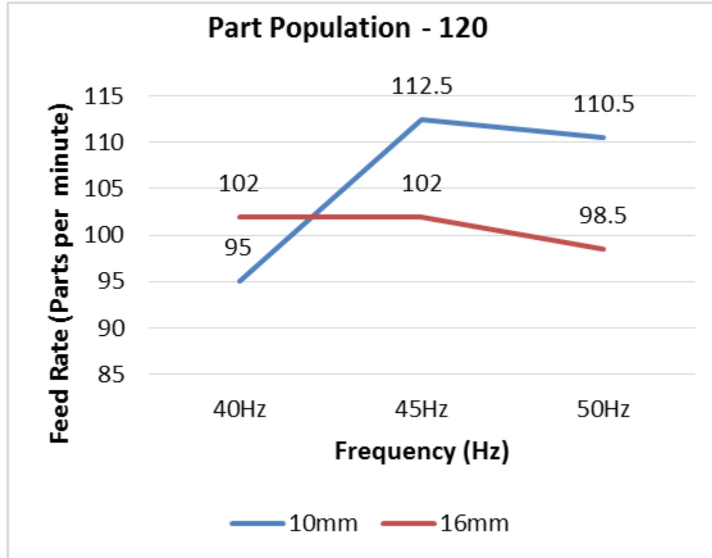
Graph 2: Variation of feed rate with frequency for caps having 40 part population



Graph 3: Variation of feed rate with frequency for caps having 80 part population



Graph 4: Variation of feed rate with frequency for caps having 120 part population



5. Conclusion

a. <u>Frequency</u>: The following tables indicate the percentage of parts (of diameter 10mm and 16mm) being fed per minute for each of the three frequencies:

Table 1: 40Hz frequency

Cap Diameter	**Part Population**	**Average no. of parts fed/min**	**Percentage of parts fed/min**
10mm	40	30	75
	80	57.5	71.87
	120	95	79.16
16mm	40	32.5	81.25
	80	65	81.25
	120	102	85

Table 2: 45 Hz frequency

Cap Diameter	**Part Population**	**Average no. of parts fed/min**	**Percentage of parts fed/min**
10mm	40	33	82.5
	80	74.5	93.12
	120	110.5	92.08
16mm	40	30.5	76.25

	80	67.5	84.37
	120	98.5	82.08

Table 3: 50Hz frequency

Cap Diameter	**Part Population**	**Average no. of parts fed/min**	**Percentage of parts fed/min**
10mm	40	33	82.5
	80	74.5	93.12
	120	110.5	92.08
16mm	40	30.5	76.25
	80	67.5	84.37
	120	98.5	82.08

As is evident from the above tables, at 45Hz frequency the percentage of parts for 10mm diameter showed an increasing trend with part population (81.25%, 88.75% and 93.75%). **Hence it can be concluded that 45Hz is the optimum frequency for parts having 10mm diameter.**

Also, at 40Hz frequency the percentage of parts for 16mm diameter showed an increasing trend with part population (81.25%, 81.25% and 85%). **Hence it can be concluded that 40Hz is the optimum frequency for parts having 16mm diameter.**

b. Part population**:** It is seen from the graphs that with increase in part population, the feed rate increases. The reason for such an observation is increased push and interactions between the parts in the bowl of the feeder.

c. Diameter of caps**:** As depicted in the last three graphs, an increase in diameter of the caps from 10mm to 16mm showed a decrease in the feed rate. This can be attributed to the fact that caps of larger diameter accounted for lesser space on the track. Smaller diameter meant that more number of caps were present on the track at any given time, thereby resulting in more number of caps to be fed per minute. Also, it can be concluded that due to greater mass, caps of larger diameter had more inertia and hence faced difficulty in climbing up the track when compared to caps of smaller diameter.

6. Summary

Path of the existing feeder was modified to feed bottle caps of two different sizes in the desired orientation. An experimental analysis was carried out to optimize the three parameters namely, part population, frequency of operation and diameter of parts so as to obtain the maximum feed rate.
According to our research and detailed study of observations, it is concluded that for maximum feed rate, the frequency of operation is 45Hz (for 10mm part diameter) & 40Hz (for 16mm part diameter) while the diameter of caps is 10mm and part population is 120.

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