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Graphical Analysis of a Vibratory Bowl Feeder for Spherical Washers

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Abstract—*To serve to the inflating demands of the present competitive industrial aeon and to achieve highest level of productivity and precision automation is the indispensable tool. Automation not only alleviates human efforts and time per component but also ameliorates the quality of the product when compared with conventional machining and provides maximum efficiency. Mechanical feeders are used to sort out the components one at a time out of the bulk in a particular orientation. The intent of this paper is to design, fabricate and analyse the performance of a modified path for a vibratory bowl feeder for feeding circular components like spherical washer. The existing path of the feeder was modified to limit multiple feeding of washers and take care of their orientation. The feed rate was studied experimentally by varying the input parameters such as such as part population, frequency of vibration and outside diameter of washers. Results obtained from the experiments were studied and conclusions were drawn about the effects of various parameters on the feed rate.*

Keywords: Feed rate, automation, part population, frequency of vibration.

1. INTRODUCTION

Most automated assembly systems are designed to perform a fixed sequence of assembly steps on a specific product that is produced in very large quantities. Automated assembly lines are generally preferred where product demand is high, product design is stable, the assembly consists of no more than a limited number of components and the product is designed for automated assembly. Small part feeding in automated assembly lines at desired rate and in desired orientation has now become the need of the hour due to unprecedented industrial growth and technological advancements[6]. Vibratory feeders are also utilized in pharmaceutical, automotive, electronic, and food industry.

2. WORKING PRINCIPLE

Vibratory bowl feeders are currently configured as special purpose part feeders, and are usually dedicated to the feeding and orientating of a one particular part or a small number of similar parts (family). These kinds of vibratory bowl feeders are driven by an electromagnet (solenoid) and are constructed in such manner that a cylindrical or saucer-like vessel, namely a bowl, wherein the machine parts and the other articles are to be stored, may be supported by several sets of plate springs which tilt at a certain angle, that an iron piece, which is stuck to the underside of the bowl, will be made to be vibrated in the vertical direction and simultaneously be put into the angular or horizontal vibration around the vertical shaft, and that the thus resultant vibration in the oblique direction can be transmitted to the bowl. As a result, the machine parts and the other articles standing on call within the bowl are conveyed upwardly along a spiral track provided on the internal circumference while being oriented by some attachments fitted up parallel to the periphery of the above track, thus being carried out of the delivery port at the terminus of the track. The effects of the leaf-spring legs are transformed to forces and moments acting on the base and bowl of the feeder[3] and the fed parts are likely to undergo bouncing motion instead of stick-slip motion[4]. 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[5].

3. CONSTRUCTION

A vibratory bowl feeder as shown in figure 1 is a dynamically balanced vibratory system made up of two essential ‘parts’ or sections connected by springs. The top part consists of a part orientation bowl that is either made of cast aluminium/ synthetic or fabricated stainless steel. An electromagnet striking plate is attached underneath; this is part of the vibratory drive unit. The second part is an electromagnetic coil that is directly connected to the base. Between the bowl and the base a series of leaf springs (commonly three blocks of springs) are connected or arranged at regular intervals along the circumference of a circle in the plane of the bowl. These springs are used to constrain the vibrating system as well as supporting the structure of the vibratory bowl feeder system[2].

Figure 1: Vibratory bowl feeder

4. EXPERIMENTAL SETUP

The existing path of the feeder was recast to restrict multiple feeding at a time and to guarantee that the orientation of all the washers (figure 2) at the exit is same. In addition of recast of the path a sheet metal restrictor was also used.

The shape of the restrictor was such that it allows only one washer to get pass through. A total of two restrictors were used on the spiral path.

The path before the exit was transformed as shown in figure 3 in such a manner that it acts as an obstruction to any washer having top surface with wider cross section and as a result all washers at the exit have same orientation[1].

Figure 2: Spherical Washer

Figure 3: Modified track

5. PERFORMANCE ANALYSIS

The types of parts used for experimentation were spherical washers. Although the performance of the feeder depends on many parameters like material of washers, size of hopper, width of the path, inclination of the path, part population, frequency of operation and length of parts, experimentation has been carried out on the following three: The variable parameters were:-

a) Part Population in the Feeder

It is defined as the number of parts in the feeder bowl at any point of time. The different populations used were 50, 100, 150, and 200.

b) Frequency of operation

The various operating frequencies (Hz) were; 35, 40, 45 and 50.

c) Outside diameter of parts

The different diameters used were 25mm, 20mm, 15mm.

The graphical analysis has been carried out by using one factor at a time technique.

6. EXPERIMENTAL PROCEDURE

Parametric analysis was done by keeping any two of the parameters, namely, part population, frequency and diameter of parts, unchanged while varying one. The part population was kept constant with respect to the frequency and the number of parts coming out of the feeder in one minute was recorded. This was repeated for two readings and their average was taken to get the final feed rate. Subsequently, for the same number of parts the frequency was varied and the same procedure was repeated. The above steps were repeated for different washer diameters and the readings were tabulated. For a particular washer diameter, the feed rates vs. frequency graphs were plotted for varying part populations. Then, for a particular part population, the feed rate vs. frequency graphs was plotted for varying washer diameter.

7. GRAPHS

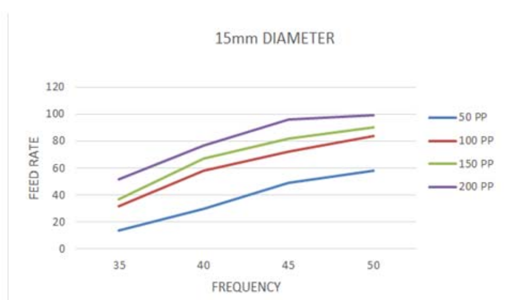

Figure 1: Variation of feed rate with frequency for 15mm diameter and different part population

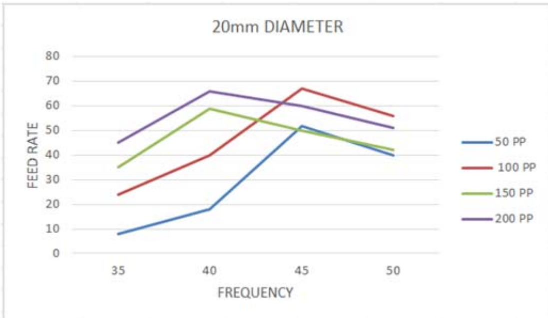

Figure 2: Variation of feed rate with frequency for 20 mm diameter and different part population

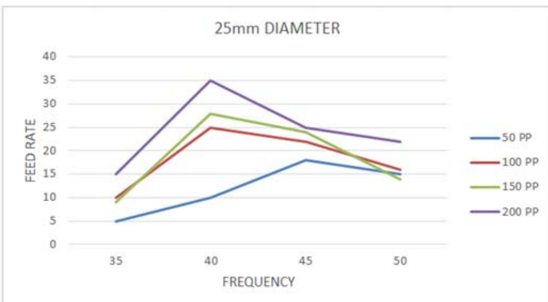

Figure 3: Variation of feed rate with frequency for 25 mm diameter and different part population

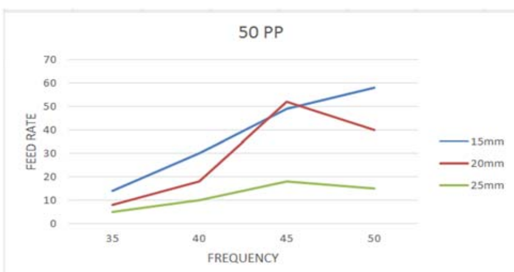

Figure 4: Variation of feed rate with frequency for part population 50 and different length of clips

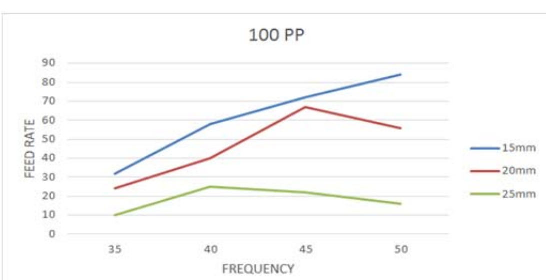

Figure 5: Variation of feed rate with frequency for part population 100 and different length of clips

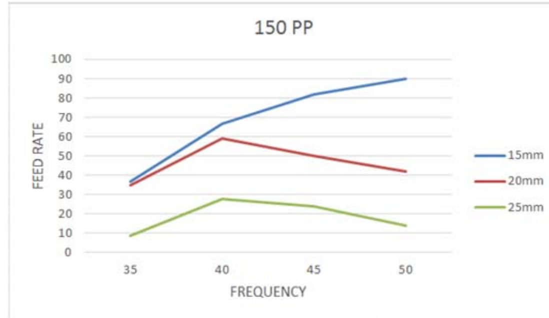

Figure 6: Variation of feed rate with frequency for part population 150 and different length of clips

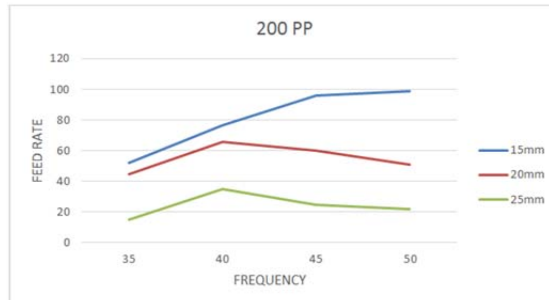

Figure 7: Variation of feed rate with frequency for part population 100 and different length of clips

8. CONCLUSION

A. Frequency

All the graphs obtained from the experiment showed that with a linear variation in frequency, either the feed rate increases throughout the range of frequency or after a critical value of frequency it becomes constant or falls down steeply. The main reason for such a variation is that when the part size is small and part population is below 100, then at higher frequency the parts remained on the track due to smaller size and fewer in number but as soon as either the part size is increased or population is increased then, after a particular value of frequency (depends on part size and population) due to self-collision of the parts feed rate decreases.

B. Part Population

For the smallest size, feed rate always increases with increase in population, whereas for largest size, feed rate increases up to a value of frequency (this value increases as the population increases) then either it remains almost constant or a gradual decrease. The plausible reason for this is the continuous push at high frequency results in falling of some parts back into the bowl.

C. Diameter of washers

From the graphs it is evident that the maximum feed rate is for the washers of 15mm outside diameter (smallest size) followed by 20mm and the least is recorded for 25mm diameter. The most conceivable reason for this could be when the part size was the smallest, more number of parts were able to be present on a particular length of track and so on the exit which results in the maximum feed rate for the smallest size. As the size of parts increases, the number of parts on the track per unit time decreases and hence the feed rate.

9. SUMMARY

The existing path of the feeder was altered to feed spherical washers of different sizes. A complete analysis was carried out with the help of an experiment to optimise the three parameters namely: frequency of operation, part population and outside diameter of washers to attain the maximum feed rate. According to our observations, **the maximum feed rate is achieved for a part population of 200 having an outside diameter of 15mm and at a frequency of 50Hz.**

10. ACKNOWLEDGEMENT

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