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Research Article

Performance Analysis of a Vibratory Bowl Feeder

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Abstract

Automation plays vital part in industries to increase the productivity and quality. With automation higher demand of customers can be achieved within time limit. It not only reduces human efforts and time required in the production process but also improves the quality of the product with maximum efficiency. Vibratory bowl feeders are used to achieve this goal. Vibratory bowl feeders plays crucial role for reorientation and feeding components into assembly process. This paper illustrates the design, optimization and analysis a vibratory bowl feeder for feeding flat components like screw. The existing path of the feeder was modified to restrict multiple feeding of screw and their orientation. By varying input parameters such a as frequency of vibration, length of screw and part population the feed rate is studied. Results obtained from the experiments are studied and conclusions are drawn about the effects of various parameters on the feed rate.

Keywords: *Automation, Mechanical feeders, Vibratory Bowl Feeder, Flat components, Orientation*

1. Introduction

For small and medium sized batch production classical automation with dedicated equipment may be feasible but is not flexible. With dedicated machinery like robot higher flexibility can be achieved but getting the robot to pick parts from bulk is seldom trivial. Part feeding is therefore a common problem in automation. In a mass production, part feeding is essential and heavily relies on vibratory bowl feeders. A vibratory bowl feeder is an automatic system and the most common mechanism to deliver parts and materials in the correct quantities at the appropriate location for assembly and for reorienting parts in secondary operations which inspect a product and then package it. A vast range of equipment exists specifically for automated parts feeding, which generally can be divided into 3 types:

1) Systems using the geometric features, including centre of gravity, of the parts for mechanical alignment.
2) Computer-vision based solutions with robot grasping (e.g. bin-picking).
3) Hybrid solutions of the above.

A robotic bin picker provides flexibility but it is time consuming. Hybrid solution depends on speed with which the robot can grasp and pick the objects. Although some work has been put into making low-cost solutions, these flexible feeding solutions remain costly. The option of using purely mechanical feeding such as a vibratory bowl feeder (VBF) generally provides the fastest feeding of parts. Till a date huge work is carried out on VBF designing, use of VBF in different industrial procedures. With actual performance analysis we can conclude the use of system over other traditional approaches.

A vibratory bowl feeder consists of a platform (bowl) and a base as in Fig.1. The bowl has a helical track climbing the inside wall. By giving the bowl a helical vibratory motion, parts dumped into the bowl will climb the helical track in single file. Between the platform and the base, three stacks of prismatic flat-springs are fixed by bolting one end to the platform and the other end to the base as legs in an inclined angle as in Fig.2.

Fig.1 Vibratory bowl feeder

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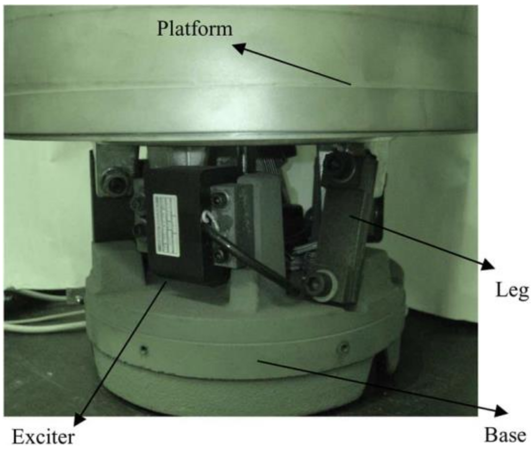

Fig.2 Parts of VBF

The vibratory bowl feeder is driven by the harmonic forces produced by three electromagnet exciters as in Fig.2, which are evenly mounted on the circle on the base. The sinuous excitation forces from the three exciters generate a couple about the center oscillating axis of the platform. The three compliant flat-spring legs, thus, enable the platform to have infinitesimal helical oscillating motion. The vibratory frequencies and modes will greatly affect parts movement and orientation in the bowl.

1.1 Problem Statement

A lot of problems associated with VBFs affect both manufacturers and users. The main problems at present are: The very high resonant vibrations produced by the electromagnets may cause fatigue failure resulting in unstable leaf springs and poor operating frequencies. Smooth continuous feed rates are difficult to achieve and are very often attributed to inadequate tuning procedures. With high feed rate blockage problem at tool location may occurs and this can be cleared manually. With lower feed rate poor unpredictable feeding patterns can occur due to behavioral changes.

1.2 Objective

As stated earlier feed rate plays vital role in performance of vibratory bowl feeder. Till a date lot of work is done on orientation, trap designing, production time reduction by BTW. Feed rate affect a lot on performance of VBF effect on leaf spring. Here include actual performance analysis of vibratory bowl feeder on feed rate with respect to different parameters like size/ length, feed rate frequency, part population, voltage.

2. Literature survey

Many papers have been published for effective utilization of vibratory bowl feeder. Few of them are as follow.

Xilun Ding et al. (2008) propose design of vibratory feeder with a right resonant frequency to fit the right quantity of parts at the right speed. It further provides an operator to finely tune the device with assembly parameters to achieve the right resonant frequency and to provide the right excitation amplitude to achieve a desirable vibration mode.

Winncy Y. Du et al. (2001) discusses the motion tracking of a part on a vibrating plate feeder. The method searches a part of interest by investigating several scan lines. Once the first three boundary points of the part are identified, the boundary tracing and growing process can be quickly and accurately implemented inside a sequence of boundary tracing windows (BTWs). Thus, the time required by boundary extraction is greatly reduced. Onno C. Goemans et al. (2005) illustrates automatic design of Vibratory bowl feeders (VBF) to minimize the time consuming in traditional designing and utilizes rigid body simulation for evaluating design configurations.

Robert-Paul Berretty et al. (1999) developed algorithms for the analysis and design of traps for polygonal parts moving across a feeder track. A complete algorithm will either find a track if one exists or report that no track exists for this part. J.M. Selig et al. (2005) constructed a simple linear model for the dynamics of the bowl supported by a symmetrical arrangement of springs. With this simple model condition for resonance in terms of the design parameters of the device and the driving frequency of the actuators can be analyzed.

All these papers do not include actual performance analysis of vibratory bowl feeder with respect to different parameters like length, feed rate frequency, part population. Here in this paper I have analyzed all these parameters. Effect of all the parameters are studied here.

3. System overview

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 track of the Bowl Feeder. 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. Sensor and counters a are introduced in system which will actually counter the number of elements passed from the track, by which analysis can be carried out. A vibratory bowl feeder consists of a bowl mounted on a base by three or four inclined leaf springs or packs of springs. The springs constrain the bowl so that it travels vertically. As the components move up an inclined track along the edge of the bowl, the tooling in the bowl orients the components into the required orientation or rejects the misaligned parts into the centre of the bowl where they begin their travel up the track again.

One to six electromagnets, mounted on the lower counter weight / heavy base, generates the force to drive the bowl feeder. The Counter weight rests on rubber feet, which serve to isolate the vibration of the

Vibratory feeder. The drive unit vibrates the bowl with both vertical and horizontal (rotational) components, causing the part to be conveyed around the helical track. Figure 3 shows this track traps can be inserted to either push off parts with the wrong orientation or do a reorientation. Automate the design process; the first step is then to select the track type based on the characteristics of the part. The second step in the process is selecting how to handle incorrect orientated parts either by rejection or reorientation. This means to choose the right sequence of traps and optimize the associated parameters for the specific part geometry.

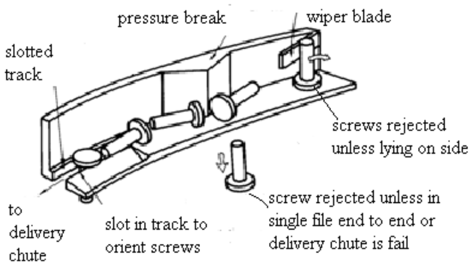

Fig.3 Screw orientation checking

4. Experimental setup

The Fig.4 shows experimental setup. All the screws are kept in a bowl. By changing different parameters performance analysis of vibratory bowl is carried out. The types of parts used for experimentation were screw. Although the performance of the feeder depends on many parameters like size of screw, width of the path, inclination of the path, part population, voltage of operation and length of parts, experimentation has been carried out on the following three variable parameters are:-

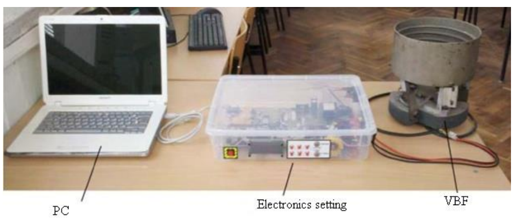

Fig.4 Experimental setup

A. Part Population in the Feeder: It is defined as the number of parts in the feeder bowl at any given time. The different populations used were 100, 200 and 300.

B. DC voltage of Operation: The various operating voltage were; 210V, 220V, 230V, 240V, 250V and 260V.

C. Size of Parts: The different part sizes, in our case screw sizes, were 1.27cm, 2.54cm and 3.81cm.

The graphical analysis has been carried out by using one factor at a time technique. The part population was kept constant with respect to voltage and the numbers of parts coming out of the feeder in one minute were 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 voltage was varied and the same procedure repeated. The above steps were repeated for different screw lengths and the readings were tabulated. For a particular screw length, the feed rates vs. voltage graphs were plotted for varying part populations. Then, for a particular part population, the feed rate vs. voltage graphs were plotted for varying screw lengths.

5. Result and Discussion

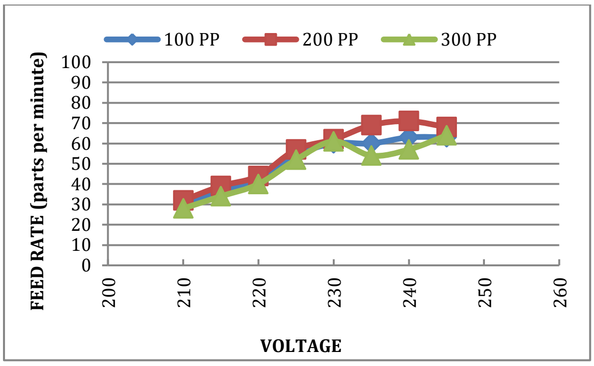

Fig.5 Variation of feed Rate with voltage for 1.27 cm Screw & different part population

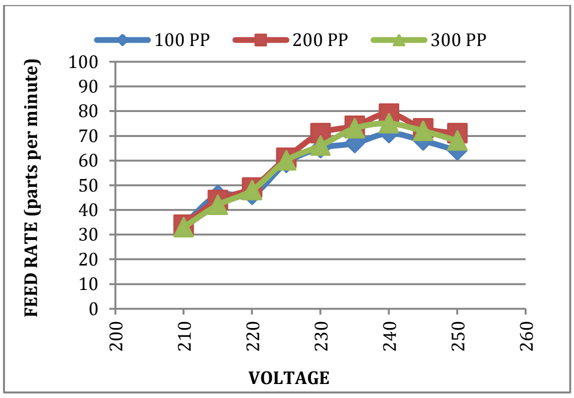

Fig.6 Variation of feed rate with voltage for 2.54 cm screw & different part population

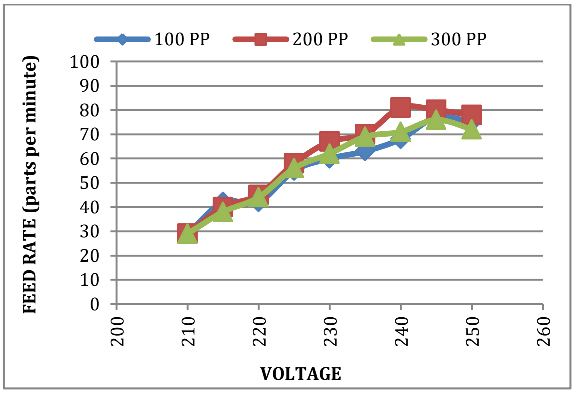

Fig.7 Variation of feed rate with voltage for 3.81 cm screws and different part population

A. Voltage

Figures 5, 6 and 7 obtained from the experiment showed that with the increase in voltage, initially there was an increase in feed rate and after certain voltage, the feed rate leveled off and in some cases, decreased. The reason to such an observation is that at lower voltage the parts did not move due to inertia. When the voltage was increased slightly, the parts showed movement and the feed rate increased. But after a critical voltage, the increase in feed rate is minor and after 240 voltages there was excessive turbulence due to which the screw bounced and fell off the track, thereby decreasing the feed rate.

B. Part Population

As can be seen from the Figures 5, 6 and 7, the feed rate increased with the increase in part population. The reason to such an observation is increased push and interaction between the screws.

C. Length of screw

The screw of length 54 cm showed the maximum feed rate followed by 3.81 cm and 1.27 cm screw respectively. The reason for it could be attributed to the fact that 1.27 cm screw had very less mass and the voltage range 180V-240V caused many of the screw to fall off the path frequently before reaching the modified path. 3.81 cm screw had more inertia than 2.54 cm screw and showed increased feed rate overall but their feed rate was still less than that of 2.54 cm screw because being longer in length (than 2.54 cm screw) they were not able to follow the curvature of the path as accurately as 2.54 cm screw and hence, fell off the track more frequently than 2.54 cm screw. Therefore 2.54 cm sized screw is found to be the optimum size for maximum feed rate.

Conclusion

Path of the existing vibratory feeder was altered to feed screw of different sizes. A study is conducted through experimental analysis to optimize the 3 parameters namely voltage of operation, part population and length of screw to acquire the maximum feed rate. According to observations, the maximum feed rate is obtained for a part population of 200, length of screw 2.54 cm and voltage of 240 voltages.

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