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Design, Fabrication and Graphical Analysis of a Pneumatic Reciprocating Block Feeder

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***Abstract*— The project aimed in design, fabrication and graphical analysis of a Pneumatic Reciprocating Block Feeder. The project starts with an extensive study on feeders, their different types, designs, characteristics, performance and applications. It progresses with designing of a Pneumatic Reciprocating Block Feeder. Its individual components were developed and assembled and dimensional accuracy was ensured to maintain a feeding mechanism. The preliminary knowledge and constraints on design of feeder hence developed led to selection of three parameters of interest which are stroke rate (number of strokes per minute) of reciprocating part-lifter, part population and part size (diameter). Some experiments and observations made possible the selection of range of each parameter. A series of experimentation was carried out on feeder wherein each parameter of interest is changed while others are kept constant and corresponding feed rate is recorded. Extensive graphical analysis is done on data so collected. The results and discussions made hence forth, draws a conclusion on conditions of operation for best performance of feeder.**

***Keywords*— design, fabrication and graphical analysis of feeder, feeder, graphical analysis of feeder, pneumatic reciprocating block feeder, pneumatic reciprocating feeder**

I. INTRODUCTION

A. *What are feeders?*

Application of automation to assembly processes is important to meet the requirements of any manufacturing system. Feeders form a critical part of automated assembly lines [1]. Assembly processes require the presence of parts in adequate amounts and correct orientation. Feeders serve this purpose by feeding discrete parts to assembly cells on the production line from bulk supplies.

B. *Types of feeders*

Vibratory feeders are the most widely employed and versatile part-feeding devices in industries [2]. While vibratory feeders remain the part-feeders of choice for general purpose requirements, many other designs of feeders have been developed for feeding parts having special features like headed parts or abrasive materials. Such feeders can usually be classified under:

1. Reciprocating feeders
2. Rotary feeders
3. Belt feeders

C. *Need for optimization*

Part feeders are critical components of automated assembly lines. Ad-hoc setting of system parameters results in either starvation or saturation, where too less or too many parts are delivered to the work cells respectively. Hence, optimization of feeders is a cause of concern [3].

This project aims at design, fabrication and graphical analysis on behavior of a Pneumatic Reciprocating Block Feeder. Tests are designed by carefully choosing different input parameters in an attempt to explore the relationship between the system inputs and outputs.

II. PRINCIPLE OF WORKING

The basic principle of working of a pneumatic reciprocating block feeder is the relative motion between a stationary block and a reciprocating part lifter. Refer to figure 1 and 2. The parts chosen are circular discs of specific dimensions. The stationary block acts as a temporary reservoir for randomly oriented parts. Its walls are tapered internally so as to facilitate the parts to the storage area and hence avoid dead-zone formation. A pneumatically driven part-lifter reciprocates through the storage area past a tapered cut slot in the block.

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It lifts parts during the upward strokes which are subsequently directed towards the window at the end of upward stroke. Top of the part-lifter is machined at an angle to facilitate sliding of parts towards the window; the window cut within the block has dimensions equal to that of a part (with some added tolerances); the stroke length of the pneumatic actuator is equal to the height of part-lifter, where the window has been provided; all factors contributing to delivering of parts to the chute through the window in a specific orientation and position.

III. FABRICATION

A. Components and specifications

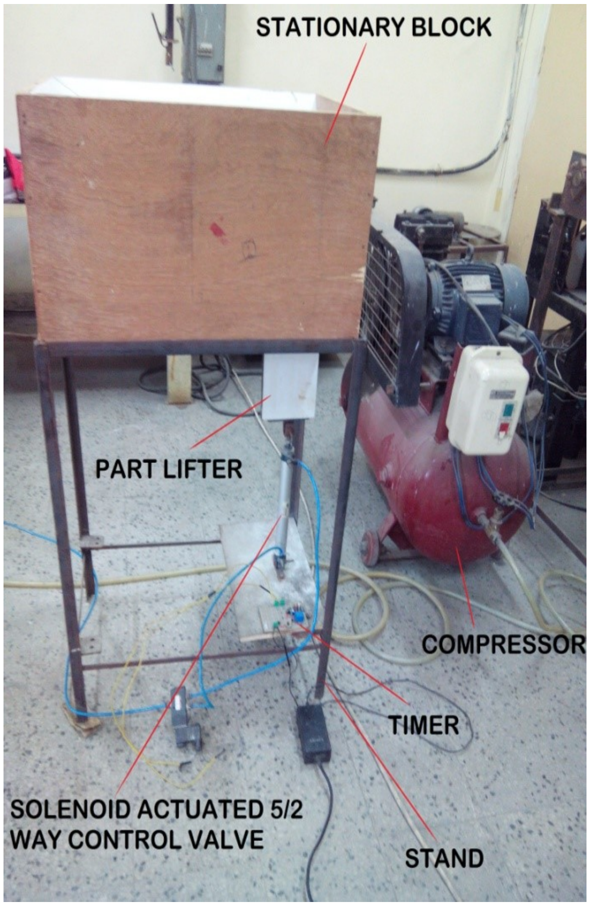

Figure 1: labeled view of feeder

Table I
Components and Specifications

S. No.	Component	Specifications
1	PART	Material- plastic (acrylic sheets) Shape- circular discs Thickness- 5 mm Diameter A- 40 mm Diameter B- 30 mm
2	STAND	Material used- steel Height (of legs)- 1000 mm Length- 550 mm Breadth- 380 mm Height of supporting structure- 100 mm
3	STATIONARY BLOCK	Material used- wood Thickness of plank- 20mm Length- 550 mm Breadth- 380 mm Height- 300 mm Slope of walls- For 2 side walls- 30° from base For 1 back wall- 60° from base Dimensions of slot- Depth- 25 mm Breadth- 9 mm Dimensions of window- Length- 400 mm Breadth- 80 mm Height from base- 160 mm
4	PART-LIFTER	Material used- wood Length of incline- 150 mm Breadth of lifter- 20 mm Height from base- 160 mm
5	DRIVE	Cylinder bore diameter- 16 mm Stroke length- 200 mm Solenoid actuated 5/2 way control valve Compressor- 4 to 6 bars 555 timer Connecting pipes

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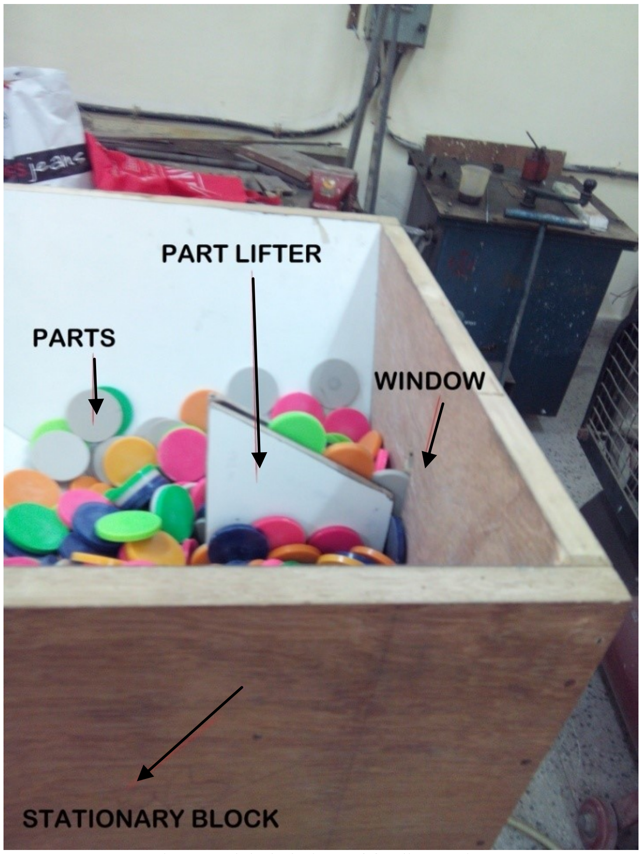

Figure 2: labeled view of feeding action

B. Driving mechanism

The reciprocating motion to the part-lifter is provided by a pneumatic system. It consists of a double acting pneumatic actuator, a 5/2 way control solenoid valve, a 555 timer circuit, a pressure gauge, an air compressor and connecting pipes. Refer figure 2. The pressure gauge controls the pressure being provided to the actuator. The flow control valve on the actuator can vary the flow of compressed air in actuator and hence, intensity of strokes. A 555 timer circuit automates the system, i.e. it controls speed of forward stroke, hold time and speed of return stroke.

Compressed air coming out of compressor, maintained in the range of 4-6 bars, flows through pipes into the control valve and is used to operate the actuator, which in turn drives the part-lifter.

IV. Experimental work

To propose a graphical analysis on performance of feeder, a series of experiments were conducted by varying the values of selected input parameters and recording the corresponding feed rate.

A. Selection of process parameters

The feed rate can be varied by changing various factors like part population, stroke rate, size of parts, shape of parts, slope of walls of block, dimensions of slot, dimensions of window, etc. However, the present analysis has been carried out by varying following parameters:

1. Stroke rate
2. Part population (PP)
3. Diameter of parts

B. Range of parameters

Table II
Range of Parameters

S. No.	Parameter	Min.	Max.
1	Stroke rate (number of strokes per minute)	23	67
2	Part population	50	400
3	Diameter of parts (mm)	30	40

V. Observations and graphical analysis

A. Case A: part diameter A= 40 mm

Table III
Feed Rates for Case A

S. No.	Stroke Rate	Part Population							
		50	100	150	200	250	300	350	400
1	23	8	12	10	12	16	13	12	13
2	32	9	9	17	21	18	19	14	19
3	44	18	19	21	25	29	33	30	26
4	67	16	15	20	27	29	24	28	29

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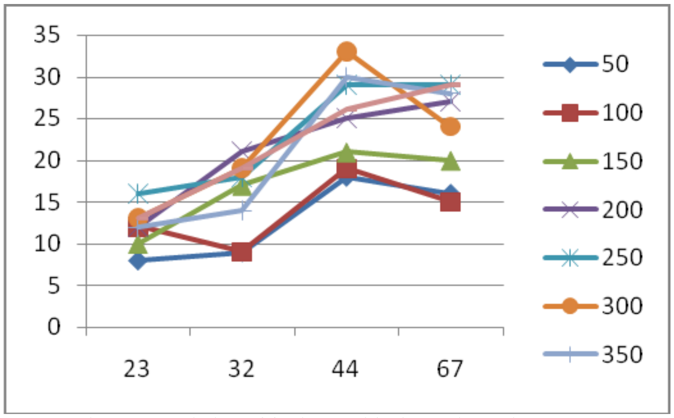

Figure 3: Variation of feed rate with change in stroke rate

- For all values of PP, with increase in stroke rate, feed rate increases from 23-44 spm, obtains a maxima at stroke rate= 44 spm and then eventually decreases for stroke rate= 44-67 spm.

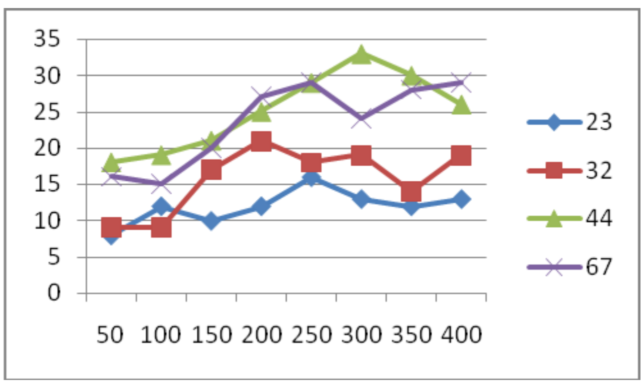

Figure 4: Variation of feed rate with change in PP

- Feed rates do not show a specific trend with change in PP.

B. Case B: part diameter B= 30 mm

Table IV
Feed Rates for Case B

S. No.	Stroke Rate	Part Population							
		50	100	150	200	250	300	350	400
1	23	5	11	14	14	17	16	19	16
2	32	7	18	24	22	24	27	21	26
3	44	14	16	24	24	24	28	31	27
4	67	16	29	35	40	37	47	47	51

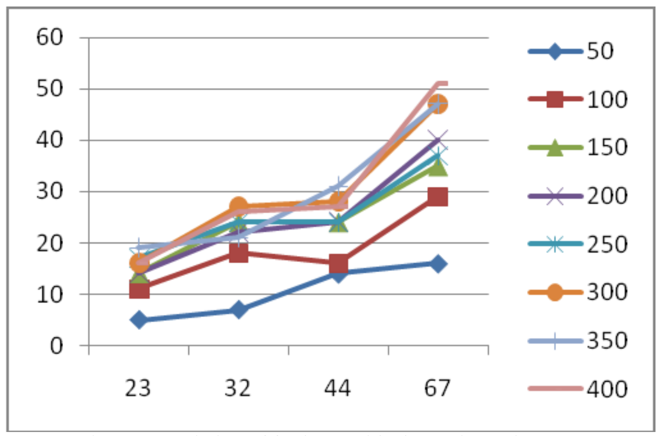

Figure 5: Variation of feed rate with change in stroke rate

- For all values of PP, with increase in stroke rate, feed rate increases.

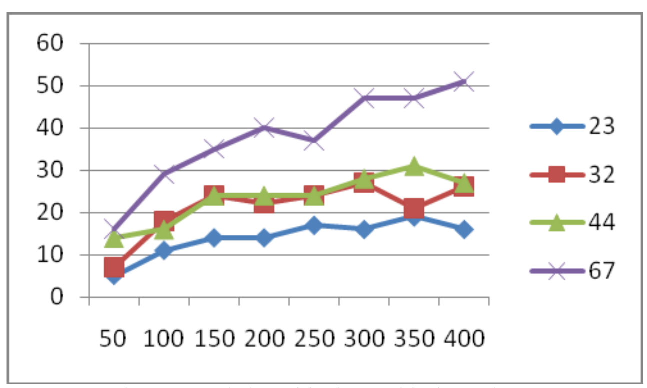

Figure 6: Variation of feed rate with change in PP

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- For all values of stroke rate, with increase in PP, feed rate increases all through the entire range.

C. Comparison of cases A and B

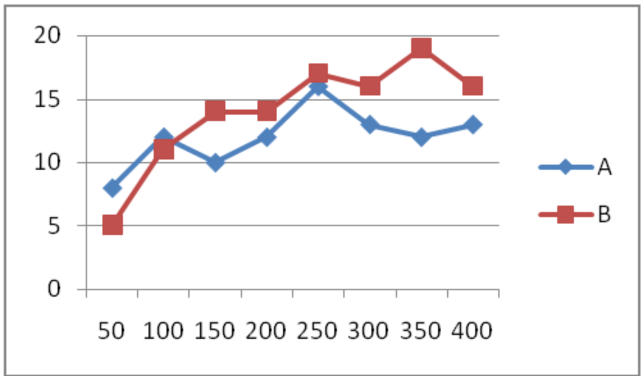

Figure 7: At stroke rate= 23 spm

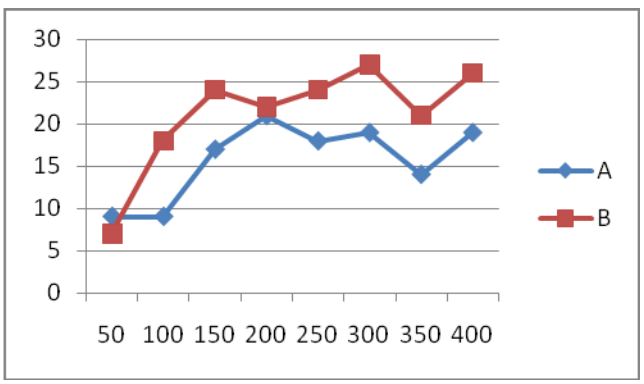

Figure 8: At stroke rate= 32 spm

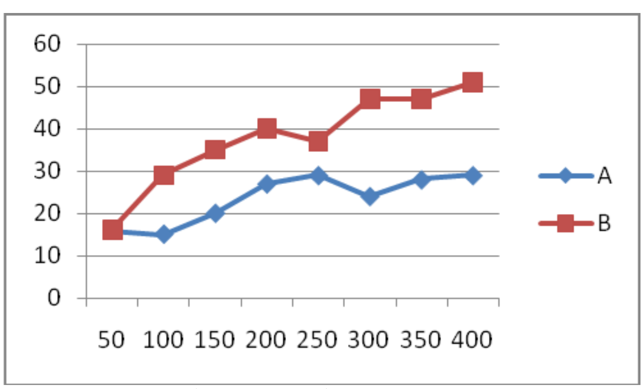

Figure 9: At stroke rate= 44 spm

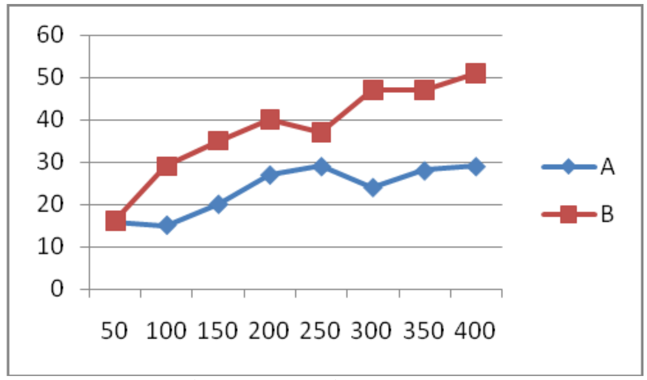

Figure 10: At stroke rate= 67 spm

- For all values of stroke rate, i.e. 23-67 spm, through the entire range of PP, with decrease in part size (from 40-33 mm), feed rate increases. This is evident by red curve lying above blue curve for all graphs shown.

VI. RESULTS AND DISCUSSIONS

To account for the validation of data recorded and graphs so obtained, we must conclude and hence understand the role each parameter of interest serves in feeding mechanism.

A. Role of stroke rate

Result-

- For parts of larger size, with increase in stroke rate, feed rate increases, obtains maxima and then eventually starts decreasing.
- For parts of smaller size, with increase in stroke rate, feed rate increases all through the entire range.

Discussion- Stroke rate or number of strokes per minute is a measure of frequency of reciprocation of part-lifter. The reciprocation of part-lifter results in picking up of parts and delivering it to the next stage.

- Too slow a frequency of reciprocation results in too few parts being delivered as the number of cycles made per unit time is less.
- Too fast a frequency of reciprocation doesn't allow the part-lifter to lift the large sized parts (i.e. case A). There may even be cases of flying of parts. Even if these parts are lifted, they do not get enough time to slide along the incline of part lifter and hence delivered.

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Small sized parts may still be lifted since the probability of picking parts in case B is more than in case A (Refer to subheading C "*Role of part size*" of heading VI). Hence, they follow an increasing.

B. Role of part population

Result-

- For parts of larger size, maximum feed rate is obtained at PP= 300 and stroke rate= 44 spm.
- For parts of smaller size, with increase in part population, feed rate increases all through the entire range.

Discussion-

- If there are an optimum number of parts inside the block, then the probability of part-lifter lifting the parts increases because of the tumbling action of the parts inside. The parts hence follow each other in a specific orientation and exit the block through the window to enter the delivery chute.
- If however the parts are too few in number, little or no parts are lifted. A few cases of completely empty strokes were observed. Thus the feed rate decreases.
- If the parts are in excess in number, they might adversely affect the process by blocking the way of those parts that are already trying to leave the block, and hence, eventually none of the parts leaves.
- For large sized parts, feed rates do not show a specific trend with change in PP since the number of large sized parts lifted in a single stroke is 1 or 2 (in rare cases). Refer to subheading C "*Role of part size*" of heading VI. Hence, with increase in PP, number of parts lifted still remain 1 or 2 (in rare cases) and hence do not get affected with change in PP appreciably.

C. Role of part size

Result- With decrease in part size feed rate increases.

Discussion- The part lifter is designed to lift parts and hence deliver.

- For same value of stroke rate and PP, parts of smaller size are lifted in larger quantities than that of larger size in a single stroke.

Length of incline on part lifter= 150 mm

Case A: Diameter= 40 mm

150/40= 3.75 ~ 3

Hence, a maximum of 3 parts can be lifted in a single stroke. It has been observed that practically 1-2 parts are lifted.

Case B: Diameter= 30 mm

150/30= 5

Hence, a maximum of 5 parts can be lifted in a single stroke. It has been observed that practically 2-3 parts are lifted.

- Further, cases of overcrowding or jamming of parts near the window reduce for smaller part sizes for same size of window, hence contributing to increased feed rates.

VII. Conclusion

In the present setup, an attempt has been made to generate a general procedure of graphical analysis on performance of feeders by taking into consideration a Pneumatic Reciprocating Block Feeder. It is expected that the present study would prove to be beneficial in future research work on the related field. Further, statistical methods based on experimental design of tests and regression analysis can be used to develop a mathematical model defining the feeder.

From experimentation, it can be concluded that the best result is obtained at following input values:

Table V

Input Parameter Values for Best Feed Rate

S. No.	Parameter	Value	Best Feed Rate
1	Stroke rate	67 strokes/ minute	51 Parts/ minute
2	Part population	400	
3	Part size	30 mm	

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