Global Journal on Innovation, Opportunities and Challenges in AAI and Machine Learning
Vol. 1, Issue 1 - 2017

APPLICATION OF TAGUCHI TECHNIQUE TO OPTIMIZE THE PERFORMANCE OF A VIBRATORY BOWL FEEDER

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ABSTRACT

Rapid industrialisation and technological advancements in assembly processes and the demand for feeding the components in assembly lines has grown significantly. It, therefore, becomes essential to optimize the assembly process. Automated or mechanized assembly can be achieved by the use of feeders. Taguchi technique is used to optimize the process parameters such as part population, part size and vibration frequency. The analysis of variance and signal-to-noise ratio with the Taguchi method were also used to understand the influence of the input parameters on feed rate. The mathematical model so developed would prove to be useful to establish quantitative relationship between the response parameter and the process parameters.

KEYWORDS:Mechanized Assembly, Taguchi Technique, Signal To Noise Ratio, Mathematical Model.

INTRODUCTION

With modern day industries moving towards automation to increase their rate of production, automated feeding of parts become an important accessory for them [1]. In automated assembly systems, part feeders play a very important role as they are responsible for supplying the machine continuously segregated parts at a specific flow rate and orientation. In such automated feeder systems part feed rate is as important as the orientation because at the point of assembly the critical requirement is that the part must be available in the correct orientation that further necessitates designing of a special delivery chute which is part geometry specific. Part feeders are used to orient and deliver parts like nuts, bolts, capsules, tablets, pins and other small components at a specific feed rate and to desired locations usually on a conveyer belt or machine [2].

GENERALREQUIREMENTS OF PART FEEDERS

The following are some of the general considerations that must be followed while designing a part feeder.

1. In a mechanized assembly, the output of parts from the feeder is constantly limited by the machine being nourished. The machine will by and large utilize parts at an entirely uniform rate and this might be alluded to as the machine rate. In the plan and testing of part feeders, it is regularly advantageous to watch the bolster rate when the feeder isn't associated with a machine.

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The feed rate under this circumstance is referred to as the unrestricted feed rate which must be more noteworthy than the machine rate.

2. With part feeders reasonable for programmed machines it is important that every one of the parts be introduced to the machine in a similar introduction. A few feeders can bolster and situate numerous kinds of parts while others are just ready to deal with an exceptionally constrained scope of part shapes.
3. A section feeder ought to be dependable i.e. it ought to be composed with the goal that the likelihood of parts sticking in the feeder is limited or disposed of.

Some part feeders are noisy in operation and some tend to damage certain types of parts [3].

EXPERIMENTAL SETUP

Figure-1 shows the setup which consists of a hopper which is a container into which the components are loaded in bulk i.e. the parts are initially randomly oriented. A feed track is used to move the components from the hopper to the location of the assembly work head maintaining proper orientation of parts during the transfer. Here the powered feed track uses vibratory action to force the parts to travel along the feed track towards the assembly work head.

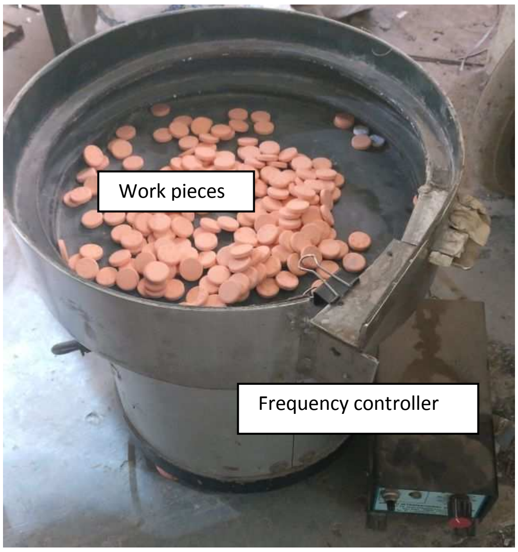

Figure-1.Vibratory bowl feeder

IDENTIFICATION OF INPUT PARAMETERS AND ESTABLISHING THEIR OPERATING RANGES

A series of trial runs were conducted to check the effect of various input parameters on the feed rate and it was found that following individually controllable three input parameters (Table-1) had the most significant effect on the feed rate. The operating ranges of these parameters are also mentioned in the same table. The high level of the parameters are coded as (3), whereas the lower value is coded as (1)

Table1.Input Parameters and their operating ranges

FACTOR	NAME	UNITS	HIGH LEVEL (3)	LOW LEVEL (1)
A	Vibration Frequency	Hz	45.00	35.00
B	Part Size	mm	16.00	8.00
C	Part Population	-	450.00	150.00

RESEARCHMETHODOLOGY

This research study starts with the concept of Design of Experiment (DOE).The levels of parameter were entered into robust design Taguchi Method (Minitab 18) to generate the design matrix (Table-2).

Then experiments were conducted based on input parameter and level setup [4]. Total 9 experiments were conducted based on L9 orthogonal arrays as shown in Table-2. The primary effect of various input parameters such as part population, part size and vibration frequency on feed rate was analysed. The observed values of feed rate with their S/N ratios are shown in Table-3.

Taguchi method is a systematic method for design and analysis of experiments. Now-a-days Taguchi method has become a very powerful tool for improving the quality output without enhancing the cost of experiment by reducing the number of experiments. Taguchi technique is used to optimize the process parameters such as part population, part size and vibration frequency.

Taguchi method recommends the signal to noise (S/N) ratio, which is a performance characteristic, instead of the average value. Ideal conditions were resolved utilizing the S/N proportion from trial comes about. ANOVA is an intense measurable instrument to break down the S/N proportion. The term flag implies the attractive esteem while commotion implies bothersome esteem.

Distinctive information parameters are advanced by utilizing Taguchi orthogonal cluster (OA) trial plan and other measurable devices, for example, Analysis of Variance (ANOVA) and Pooled ANOVA procedures.

EVALUATING THE SIGNAL TO NOISE (S/N) RATIOS

In present research, an L9 OA with 4 columns and 3 rows was used. This array can handle three level process parameters. Nine experiments were conducted to study the process parameters using the L9 OA. In order to evaluate the influence of each selected factor on the response, the S/N ratio for each control factor was calculated. In the present research work, feed rate of the work pieces was identified as the response, therefore, for feed rate "higher the better" characteristic was chosen for analysis purpose.

S/N= -10×Log10 (sum $(1/Y^2)/n$)

Table2.Response values obtained for the chosen input parameters

S. No.	Frequency	Part Size	Population	Feed Rate	SNRA	MEAN
1	35	8	150	193	45.7111	193
2	35	12	300	10	20.0000	10
3	35	16	450	32	30.1030	32
4	40	8	300	264	48.4321	264
5	40	12	450	76	37.6163	76
6	40	16	150	135	42.6067	135
7	45	8	450	425	52.5678	425
8	45	12	150	279	48.9121	279
9	45	16	300	302	49.6001	302

RESULTS

EFFECT OF INPUT PARAMETERS ON FEED RATE

ANALYSIS OF S/N RATIOS

The effects of input parameters on the feed rate can be observed and analysed through the analysis of the S/N ratio. Table-3 gives the S/N ratio values in the larger the better type for the feed rate. In Table-3, the term 'rank' denotes the effects of the input parameters on the feed rate. It can be seen that the frequency is the most influencing input parameter for feed rate followed by the part size and part population. The linear model coefficients for S/N ratios of tensile strength are estimated with R-squared value of 93.99%.

Table3.Response table for signal to noise ratios (Larger is better)

Level	Frequency	Part Size	Population
1	31.94	48.90	45.74
2	42.98	35.51	39.34
3	50.36	40.77	40.10
Delta	18.42	13.39	6.40
Rank	1	2	3

The effects of input parameters on the feed rate are also understood from Figure-2. It is observed that the feed rate increases with frequency. The optimal value for:

1. Frequency is 45 Hz.
2. Part size is 8 mm.
3. Part population is 150.

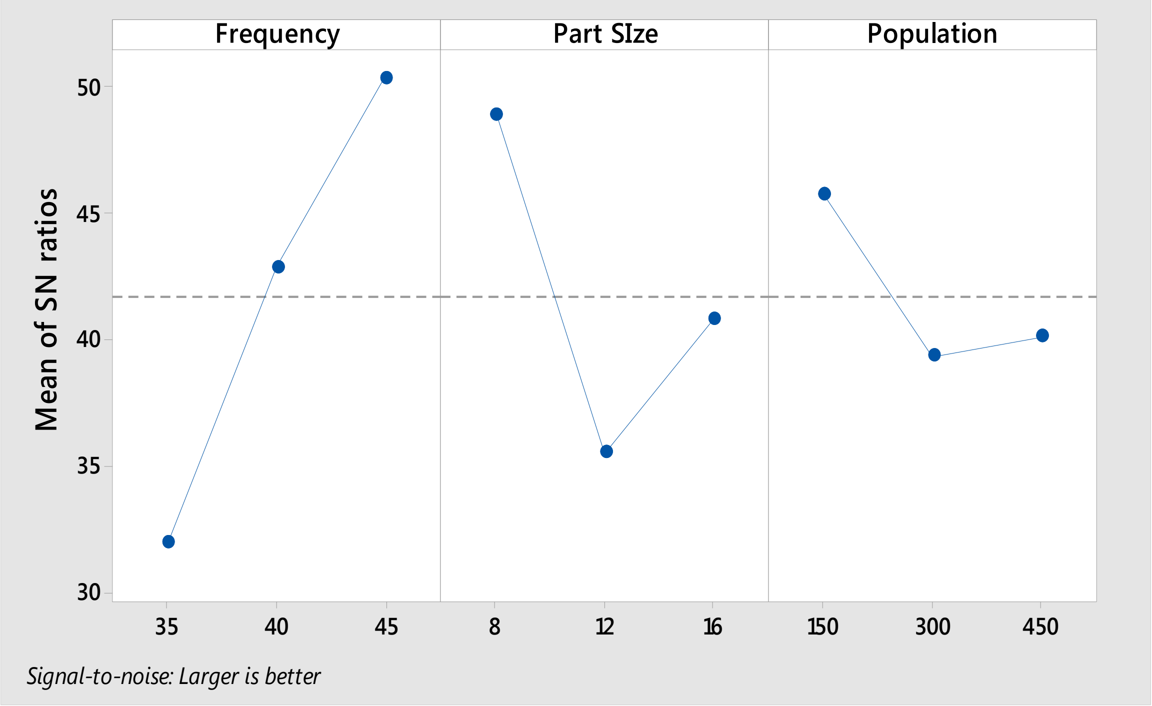

Figure 2.Main Effects Plot for S/N ratios

ANALYSIS OF MEANS

In the present research work, the effect of input parameters on feed rate was analysed. Table-4 clearly shows that the optimum condition for maximization of feed rate is A3B1C1.

Table4.Response table for means

Level	Frequency	Part size	Population
1	78.33	294.00	202.33
2	158.33	121.67	192.00
3	335.33	156.33	177.67
Delta	257.00	172.33	24.67
Rank	1	2	3

It is evident from figure-3 that:

- The feed rate increased with increase in frequency from 35 Hz to 45 Hz. The probable reason for this could be that with the increase in frequency the opportunities for the parts to get on the feed track increases.
- Feed rate decreased with the increase in part population. The probable reason for this could be that with the increase in population the interaction between the parts increases hence hindering their relative movement on the feed track.
- Feed rate decreased from 8 to 12 mm because the pre dominant effect of the increase in part size is decrement of feed rate. From 12 to 16 mm the feed rate increased because the positive effect of frequency overtakes the negative effect of part size and becomes dominant.

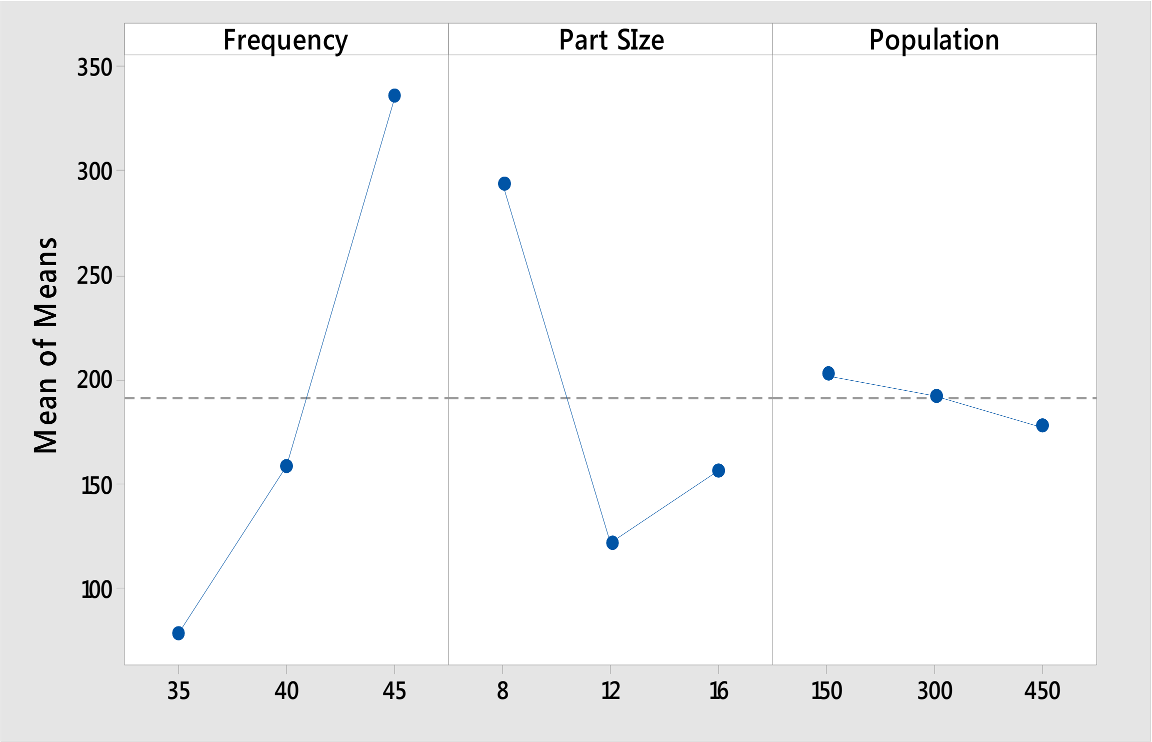

Figure-3.Main Effects Plot for means

ANALYSIS OF VARIANCE

Analysis of variance for feed rate is given in Table-5. From this table frequency is of significance following part size and part population. Table-6 shows the analysis of variance for feed rate. It clearly shows the frequency most significantly affects feed rate with p-value of 0.097 followed by part size with p-value of 0.168.

Table-5.Analysis of variance for S/N ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Frequency	2	515.08	515.08	257.54	9.35	0.097
Part Size	2	273.24	273.24	136.62	4.96	0.168
Population	2	73.41	73.41	36.71	1.33	0.429
Residual Error	2	55.09	55.09	27.55		
Total	8	916.82				

CONCLUSIONS

In the present research work, the following conclusions can be obtained:

1. Taguchi design of experiment method is very efficient for optimizing the input parameters in manufacturing operations.
2. The optimum process parameters are found to be frequency of 45 Hz, part size at 8 mm and part population at 150.
3. Frequency has a positive effect on feed rate whereas part population has a negative effect on feed rate. Initially the effect of part size is negative but it becomes positive after a while due to its interaction with frequency and part population.
4. Frequency most significantly affects feed rate with a p-value of 0.097 followed by part size with p-value of 0.168.

REFERENCES

[1]. Yadav, H., Chawla, M., and Khanna, P., “Development of A Mechanical Rotary Part Feeding System with Performance Analysis”, 2017.

[2]. Khanna, P., Goel, S., Anju “Design, Fabrication and Analysis of Centreboard Hopper Part Feeder”, 2008.

[3]. Gupta, A., Saraf, A., Luthra, J., Gupta, N., Khanna, P., “Mathematical Modelling And Performance Analysis Of A Tumbling Barrel Hopper Feeder”, 2010.

[4]. Rizvi S., Tewari S., Ali W., “Applications of Taguchi Technique to Optimize Parameters of MIG Welding on IS2062 Steel”, 2016.