PROCESS IMPROVEMENT STUDY ON FEED PUMP ASSEMBLY LINE

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Abstract: This work is intend to study the cycle time and existing method of different work stations and compare it with improved method for the same as to reduce the cycle time and to improve productivity at Bosch India Private Limited, Bangalore. During the plant visit and discussion made with the foreman and also according to the operation process chart, it was found that a new automation method is being proposed in the feed pump assembly section. Hence the assembly section was selected for time study and comparing. And also to find out the process capability of the center-less grinding machine in the assembly section. The importance of this work is directly related to the reduction of the inefficient time and increasing the productivity. The new approach of studying the operations by stop watch work study techniques. And also to determine if the process is stable and predictable, as well as to monitor the effects of process improvement theories by plotting p-chart. The advantage of this project lies in the improvement of the productivity by reducing cycle time, smooth flow of components of assembly, reducing the work fatigue, comparing of existing assembly to automation.

Index Terms **–Time study, Process capability, Cp, Cpk**

I. INTRODUCTION

Work study investigated the work done in an organization and aims at finding the best and the most efficient way to utilizing the available resources to achieve best possible quality of work in minimum possible time and cause least possible fatigue to the worker.

Work study succeeds because it is systematic both in the investigation of the problem being considered and in the development of its solution. It is only by continuous observation and study at the workplace or in the area where the activity is taking place that the facts can be obtained.

A p-chart is an attributes control chart used with data collected in subgroups of varying sizes. Because subgroup size can vary, it shows how the process change over time. P-chart are used to determine if the process is stable and predictable, as well as to monitor the effects of process improvement theories.

Process capability is the repeatability and consistency of a manufacturing process relative to the customer requirements in terms of specification limits of a product parameter. This measure is used to objectively measure the degree to which your process is or is not meeting the requirements. Capability indices have been developed to graphically portray that measure. Capability indices let you place the distribution of your process in relation to the product specification limits. Capability indices should be used to determine whether the process, given its natural variation, is capable of meeting established specifications. It is also a measure of the manufacturing ability of the product with the given processes. Capability indices can be used to compare the product/process matches and identify the poorest match (lowest capability). The poorest matches then can be targeted on a priority basis for improvement.

The paper explains about how the study has been made about the existing method for different work stations and comparing it with automation assembly for the same so as to reduce the cycle time and to improve productivity. The importance of this project work is directly related to reduction of the inefficient time and increasing

II. PROBLEM DEFINITION

"To study the existing method involved in assembly work station and comparing a new automation method using work study technique to reduce the cycle time and improve productivity."

III. OBJECTIVES

- To reduce the ineffective time associated with the operation
- To determine if the process is stable and predictable
- To compare the automation process with the existing method
- To find out the process capability and process capability index of center-less grinding process and characterize it.
- To alternate the already existing method in order to improve productivity.

IV. METHODOLOGY

Stop Watch Time Study:

Stop Watch Time Study is one of the equipment used for Time Study. It is employed for measuring the time taken by an operator to complete the work. Stop watch used for time study purpose should be very accurate and preferably be graduated in decimals so that it can recover even up to 0.01 minute.

A large hand in the stop watch is revolved at a speed of one revolution per minute. The dial of the stop watch is divided into 100 equal divisions. The small hand inside the stop watch revolves at a speed of one revolution in 30 minutes.

Procedure of Stop Watch Time Study:

- Analyse the job to establish the quality to be achieved in the job.
- Identify key operations to be timed in the job.
- Get improved procedure from the method study department.
- Organize resources and explain the objectives of time study to the worker and supervisor.
- Explain details to worker about improved working procedure.
- Break operation into elements to separate the constant elements from variable elements.
- Observe and record the time taken by an operator.
- Determine for number cycles to be timed and then the average time or representative time can be found out.
- Rate of performance of the worker during observation.
- Calculate normal time from observed time by using performance rating factor.

Process capability test and Process capability index:

The steps involved in this process are:

- To collect the already existing reading and information about the machine and component.
- To segregate the finished components (around 125 pieces)
- To check the allowances for each individual component by measuring it with standard gauge
- To note down the readings and formulate the Cp and Cpk (process capability and process capability index).

V. TIME STUDY AND READINGS

5.1 SPECIFICATION OF NUT AND BOLT ASSEMBLY MANUAL (Figure 1)

- Defect description: No damages on nut and screw thread
- Origin: MTM table, motor fixed
- Description: Visual
- Capacity: 8000 nut and bolt assembly per shift.
- Man power: One employee per shift

The time study was conducted on a nut and bolt assembly (manual) machine. The machine was operated by employees.

And the time study was conducted for the employees on different interval of time. There were many factors taken into consideration

Like time, date, shift and etc. To start the time study, the working pattern of the employees was recorded and analyzed. Then the work done by the employee was divided into small works.

- Picking the nut
- Picking the bolt
- Fixing the nut
- Screwing the bolt
- Inspection

The above are the steps involved in nut and bolt assembly (manual). And these steps were applied and the reading for each individual employee was recorded and the average was

Serial no	Employee	Date	Time	Average (in seconds)	Overall Average	Defects
1	Employee 1	13/02/2019	06:30	20.000	29.290	2
			10:15	32.086	29.290	2
			12:10	32.200	29.290	5
			13:30	32.900	29.290	5
2	Employee 2	15/02/2019	06:30	28.000	32.095	3
			10:15	34.110	32.095	3
			12:10	34.030	32.095	4
			13:30	32.240	32.095	3
3	Employee 3	14/02/2019	14:20	23.000	30.812	4
			15:15	33.000	30.812	6
			16:00	34.600	30.812	4
			16:45	32.650	30.812	4

Table 1 -Time study table

The above readings of time and defects were taken for an average of 100 nut and bolt assembly. The calculated average of all the three employees is **30.732 seconds.**

5.2 SPECIFICATION OF NUT AND BOLT ASSEMBLY AUTOMATION (Figure 2.1 and Figure 2.2)

Defect description: No damages on nut and screw thread

Origin: Automation

Description: Automatic

Man power: None (no employee required)

Machine company: Rexroth

The above readings of time were taken for an average of 100 nut and bolt assembly. The calculated average for the machine was **33.75 seconds.**

5.3 P-CHART

A P-chart is an attributes control used with data collected in subgroup of varying sizes. Because the subgroup size can vary, it shows a proportion on nonconforming items rather than the actual count. P-chart show how the process changes over time. The process attribute is always described in a yes/no, go/no go form. The chart for the above readings is tabulated and plotted as a graph.

Serial number	Defects	Sample limit	Proportion	P bar	UCL	LCL
1	2	100	0.02	0.0375	0.0944	0
2	2	100	0.02	0.0375	0.0944	0
3	5	100	0.05	0.0375	0.0944	0
4	5	100	0.05	0.0375	0.0944	0
5	3	100	0.03	0.0375	0.0944	0
6	3	100	0.03	0.0375	0.0944	0
7	4	100	0.04	0.0375	0.0944	0
8	3	100	0.03	0.0375	0.0944	0
9	4	100	0.04	0.0375	0.0944	0
10	6	100	0.06	0.0375	0.0944	0
11	4	100	0.04	0.0375	0.0944	0
12	4	100	0.04	0.0375	0.0944	0
	45	1200				

Table 2-P chart readings

Calculations for P chart p =0.037

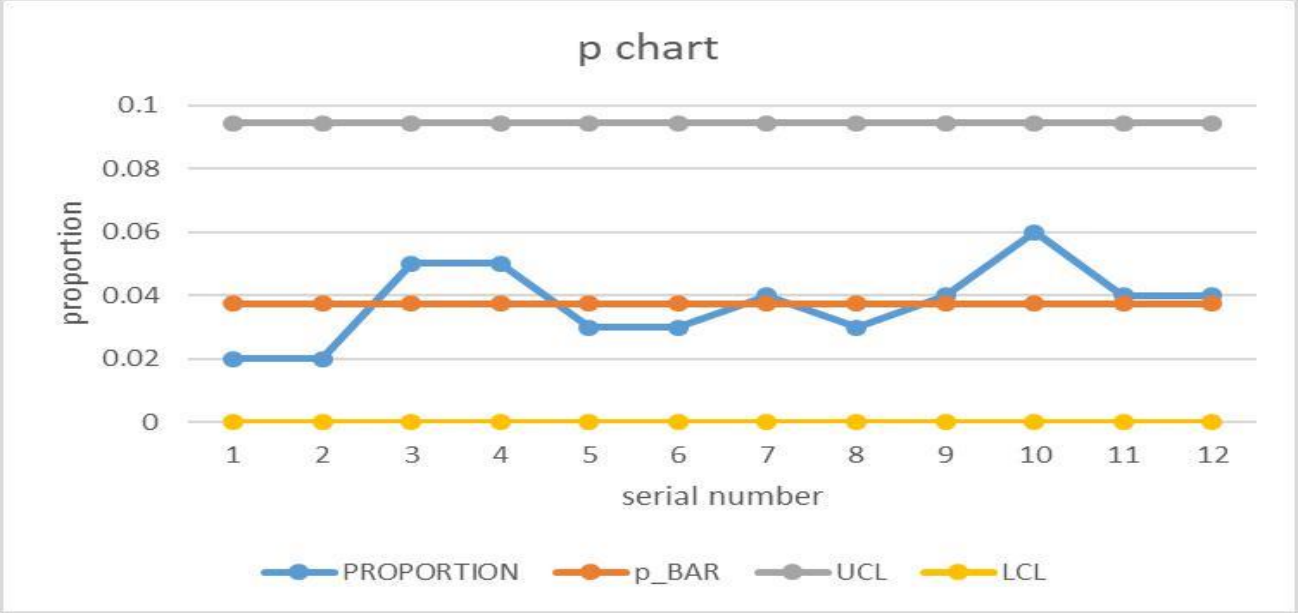
q=0.962 n=100

Formulas for p chart

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$LCL=\max[0,\bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}]$$

After calculating the readings from table 2,



Graph 1 Defect rate

From the above graph plotted we can come to a conclusion that the defects are well in limit and the nut and bolt assembly process is stable and predictable.

VI. PROCESS CAPABILITY AND PROCESS CAPABILITY INDEX

Process capability is the repeatability and consistency of a manufacturing process relative to the customer requirements in terms of specification limits of a product parameter. This measure is used to objectively measure the degree to which your process is or is not meeting the requirements. Cp and Cpk are measurements for the potential process capability. Obviously p stands for process, C stands for Capability index/ratio/factor. k represents a non-centering factor.

The process capability test was conducted to the center-less grinding process with 6 components. And the components that were taken for reading is:

Bearing pin

Sliding tappet

Plunger

Roller tappet

Control rod

Roller tappet body

The steps involved in this process are:

To collect the already existing reading and information about the machine and component.

To segregate the finished components (around 125 pieces)

To check the allowances for each individual component by measuring it with standard gauge

To note down the readings and formulate the Cp and Cpk (process capability and process capability index).

To plot the required graph and check whether the process is stable.

A Cpk that's less than 1.33 needs some action to make it higher, and a Cpk of less than 1.0 means that the process is not capable of meeting its requirement. If the mean of the process data is closer to the lower spec limit LSL and the standard deviation of the process data is Standard deviation, then Cpk = (Mean-LSL) / (3 Standard deviation).

The above Figure 3 showcase the result obtained for the bearing pin component. The graph was plotted and the Cp and Cpk was obtained for the process. The Cp is **2.04** and the Cpk is **1.92**. The process seems to be adequate and there the defect rate is stable for the process. The same procedure was carried out for the remaining components.

Serial number	Components	ensions in (mm)	Process capability(Cp)	Process capability index(Cpk)	Comments
1	Sliding tappet	10.99	2.04	1.92	Process is adequate
2	Sliding Tappet	7	1.68	1.40	Process is satisfactory
3	Bearing pin	12	2.77	2.11	Process is adequate
4	Roller tappet body	24	2.64	2.12	Process is adequate
5	Control rod	9.25	2.12	1.97	Process is adequate
6	Slider piece	4.5	2.10	2.07	Process is adequate
7	Plunger	22	2.66	2.32	Process is adequate
8	Roller tappet body	24	3.04	2.90	Process is adequate

Table 3-Process capability readings

The readings for all the components were taken and the Cp and Cpk were calculated.With proper comments, each results were obtained.And the graphs were plotted for the same and the defect rate is stable for all the components in this procedure.

VII. CALCULATIONS AND RESULTS

TIME STUDY

- For the nut and bolt manual assembly the average time taken for all the three employees to complete 10 assembly is **30.732 seconds.**
- And with that into consideration, 14,000 assembly are done per day.With Rs 20000 per month being the salary for one employee and for three of them it is Rs 90000 per month. And 10,80,000 per year is being awarded as salary for the employees.With average defect rate of 4 per 100 assembly.
- For the nut and bolt assembly (automation) the average time taken for 10 assembly is **33.75 seconds**.
- With that into consideration 12,800 assembly are done per day. And the cost of the automation machine is Rs 22,00,000 (twenty two lakh).With the defect rate of 3 per 100 assembly. Also, the human error rate is nil in automation
- Alternate method to improve the production rate in manual is we can use proper ergonomic chair with following specifications:

  The seat shall be 430*430 mm on 10 mm thick moulded plywood with 60mm thick high density moulded PU foam for minimum density. Back rest size shall be 430*300 mm on 10 mm thick moulded plywood with 40mm thick 32 density moulded PU foam covered with tapestry. The height of back rest shall be 900 and 500mm for bottom and top respectively.
- The assembly that's was done in early stage of the shift (6:30 am) were high comparatively.
- For the nut and bolt assembly the P chart was calculated and plotted.

PROCESS CAPABILITY AND PROCESS CAPABILITY INDEX

- The results for Cp and Cpk (process capability and process capability index) were calculated and all the components were in adequate process. To maintain adequate process in centre-less grinding machine, the machine should be handled properly by well experienced employee. And the Grinding wheel and regulatory wheel of the machine should be changed every 90 days in order to keep the process adequate.
- If the Cp and Cpk values are anyway near to 1.33 then the process might lose its adequate. And the Grinding wheel and regulatory wheel should be changed, this type of process is called to be satisfactory.

CONCLUSIONS

- The time study was conducted using time watch and video recording method on nut and bolt assembly manual and automation. The readings were taken in different interval of time, shift and employees.The average for for 10 assembly were calculated for both manual and automation. Both the methods were compared and the production rate is high in manual assembly than automation. But automation has zero human error and is cost efficient comparatively to manual assembly method. The assembly rate is high at the beginning of the shifts. To make the working environment more comfortable the ergonomic chair was proposed.With proper international specifications.The defect rate of the process was stable and predictable which proved by plotting the P chart.
- The process capability and process capability index for the centre-less grinding process was calculated for different components and the graphs were plotted for the same.The process for all the components are adequate except for one, which satisfactory.

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