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Optimization of Manufacturing Cost for Batch Production of Automobile Component Using Process Capability Study

[1]Dr. Harshal Rane, [2]Dr. Harjitkumar Pawar,
[3]Prof. Arvind Ghodake, [4]Prof. Gaurav Pathak, [5]Prof. Vishal Thakare

[1-5]*(Mechanical Engineering, SND COE & RC, Yeola, Maharashtra, India)*
(harshal17rane@gmail.com)

ABSTRACT

The paper presented here shows the development of manufacturing cost model for optimization of manufacturing cost by implementing the process capability study. The manufacturing cost is one of the important factors in industrial organizations, since the product cost is always dependent on the manufacturing cost. Recently, the management from automobile sector has the goal to minimize the manufacturing cost in available resources by changing various parameters including production parameters, design parameters and SPC (Statistical Process Control) parameters. The paper deals with the manufacturing and process capability analysis of automobile component by improving the production parameters. The production parameters were takes as spindle speed, feed and cutting depth. Three successive trials were taken by changing these parameters and process capability analysis were performed to justify the process is in control or not. A manufacturing cost model had been prepared based on the results observed and the manufacturing cost is optimized by reducing the defective parts.

Keywords - *Design Parameters, Manufacturing Cost, Process Capability Study, Production Parameters, SPC (Statistical Process Control) Parameters, etc.*

I. INTRODUCTION

The manufacturing cost has great importance in automobile as well as other sectors. The cost of finished product is strongly depends on the manufacturing cost. Many authors had said that the TQM will enable to reduce the manufacturing cost all through in association particularly in volume of defective parts, rework, etc. since these cost reduction will helpful to enhance the rate of productivity [1, 2]. The finished good cost can be considered as a assurance of the connection among activities and proportioned to included cost and also, it is significant source of information, in decision making in production organizations [3]. The customer's interest is called product yet according to another aspect, it defines the manufacturing platform and it is maintained by two important factors Quality and Cost. Manufacturing cost is the expenses of all the resources utilized through in the process of manufacturing a product [4, 5]. Three main ways to describe the manufacturing cost including direct materials cost, direct labor cost and other manufacturing overheads. A process capability study is the measure of all spread items as measured by evaluating the items under controlled circumstances [6]. The process capability is not relying upon the performance; however it is measured by as various situations of products. Like skill of labors requirements of tools, operation types and use of raw parts.

The process capability is defined as statistical measured of the inherent processes variability of the assigned characteristics. It is used to meet the design and manufactured specifications. Cp and Cpk are the indices of process capability shows the capability of the manufacturing process to meet the specification limits by using continuous data. The paper presents process capability analysis and its impact on manufacturing cost [7].

Now days, the developments are takes place rapidly in the field of total quality management, especially in SPC and SQC [8, 9]. The performance of quality has been done by various technology or tools like X-bar, Control Charts and Histogram. The manufacturing process performance is affected by various parameters including production parameters [10].

The approach presented in this paper states that the process performance can be enhanced by performing SPC analysis with change in production parameters. On that event, automobile component manufacturing process had been selected for enhancement. The main affecting parameters in automobile manufacturing process are Spindle Speed, Feed and Cutting Depth. By changing the stated production parameters, the one batch of production had been taken for the SPC analysis. The 120 samples were taken for the process capability analysis and the Cp and Cpk indices are observed. If the process is stable then the manufacturing cost were calculated by model explained as below.

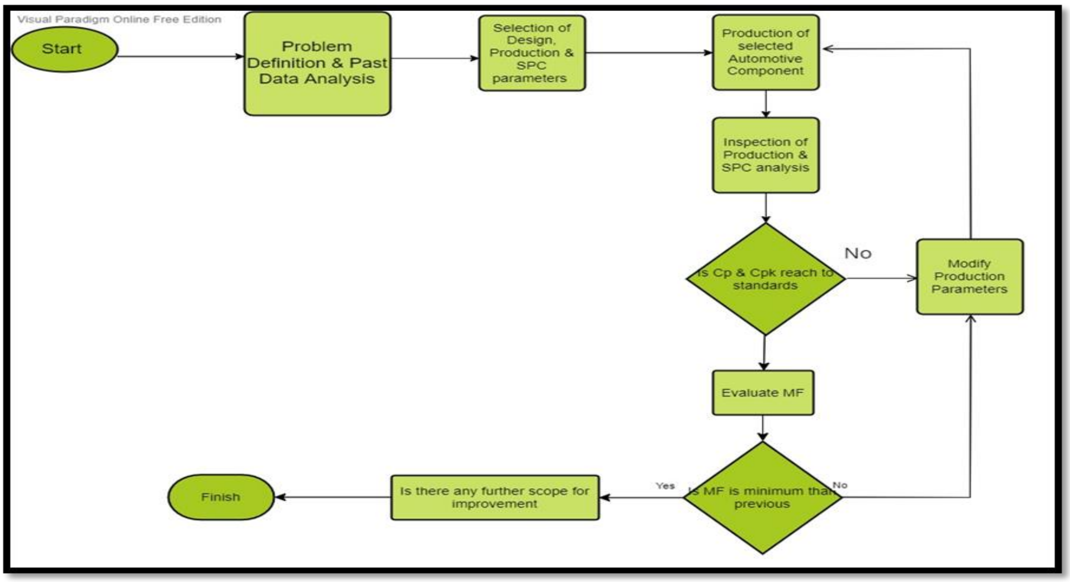

Fig. 1 Methodology

II. MATERIALS, METHODOLOGY AND PERFORMANCE

The manufacturing cost for defective parts can be represented by,

$$MFC = N_i(RMC + MC + TC + LC + IC + VC) \quad \text{..... (Eq. 1)}$$

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Where, RMC = Raw Material Cost, MC= Machine Cost, TC= Tool Cost, LC=Labor Cost, IC=Inspection Cost, VC= Variable Cost, N_i = No. of Defective parts per batch.

The objective function for optimization of manufacturing cost is given by,

Function = Min ($N_i(RMC + MC + TC + LC + IC + VC)$), ……………....………………………….... (Eq. 2)

Subjected to,

All Costs ≤ Assigned costs for selected manufacturing process, $N_i \geq 0$.. (Eq. 3)

Table 1 Evaluated Manufacturing Cost of Defectives in Successive Trials

Sr. No.	Costs	Description	Cost/ Job		
			Trial 1	Trial 2	Trial 3
1	RMC	Average Raw Material Cost	80.00	80.00	80.00
2	MC	Average Machine Cost	12.55	12.55	12.55
3	TC	Tool prize =14500, tool life = 1000 jobs	14.50	14.50	14.50
4	LC	Labor salary =433.33/day/(180 Jobs)	2.40	2.40	2.40
5	IC	IC = (Gauge Cost 3,11,000)/(300 day*Parts)	5.76	5.76	5.76
6	VC	Average Variable cost	24.50	24.50	24.50
7	Parts	No. of Parts defectives/ Batch	25.00	12.00	10.00
8	MFC	Manufacturing Cost (MFC) of Defectives = (sum(1-7)*8)	3493.00	1677.00	**1397.00**

The Fig. 1 represents the methodology used in the analysis. The work was started from the problem definition and past data analysis. The design parameter is selected as main bore for the analysis and the required production parameters are selected as Spindle Speed (600, 900, 1200 RPM), Feed (300, 400, 500 mm/min) and Cutting Depth (7, 7.5, 9 mm). The random 120 samples of four subgroups were inspected after the production of one batch. The SPC analysis was carried out to observe the CP and Cpk values reached to standards (1.67, by Six Sigma). If the results of inspection is negative then modify the production parameters and again take a batch of production. If the inspection of previous trial is positive then evaluate the MFC and inspect the MFC of defective parts which should be less than the previous successive results, otherwise modify the production parameters. By this way the MFC can be optimized with the help of SPC analysis. The manufacturing cost for the defectives had been tabulated in Table 1. For that purpose a process of manufacturing of automotive component is selected. Initial trial 1 has taken by considering speed as 600 RPM, feed as 300 mm/min and cutting depth as 7 mm. after production of one batch the 120 samples are tested for the design parameter reading and SPC analysis carried out to find Cp and Cpk indices and PPM defectives. The manufacturing cost is then evaluated as above stated Eq. 1. The Table 2 shows the observations for three successive trials. After trial 1, the trial 2 and trial 3 were taken by selecting spindle speed values as 900 and 1200 RPM, feed values as 400 and

500 mm/min, cutting depth values as 7.5 and 9 mm respectively. The samples were inspected during each trials and process capability was checked by the process capability indices (Cp and Cpk). The defective parts were evaluated and then manufacturing cost of defective parts is evaluated for optimization.

Table 2 Observations for Selected Manufacturing Process

Report No.:	2712								Date: 18.10.2017			
Component :	Y9T Calliper			Machine:	MCV 650 –F48		Operation:		R/M, L/M, M/B & Port holes			
Parameter:	Bore dia. 51 (+0.050, +0.100)		LSL 51.05	USL: 51.1	Production Parameters:		Speed = 600, 900, 1200 RPM Feed = 300, 400, 500 mm/min Cutting depth = 7, 7.5, 9 mm					
Sr. No	**Sub 1**	**Sub 2**	**Sub 3**	**Sub 4**	**Sub 1**	**Sub 2**	**Sub 3**	**Sub 4**	**Sub 1**	**Sub 2**	**Sub 3**	**Sub 4**
1	51.080	51.082	51.071	51.094	51.066	51.084	51.069	51.066	51.078	51.076	51.065	51.074
2	51.065	51.078	51.078	51.077	51.075	51.079	51.073	51.076	51.082	51.071	51.073	51.076
3	51.072	51.081	51.078	51.075	51.064	51.078	51.080	51.076	51.076	51.092	51.074	51.074
4	51.075	51.066	51.073	51.084	51.072	51.070	51.081	51.066	51.074	51.073	51.069	51.084
5	51.074	51.084	51.076	51.075	51.071	51.079	51.075	51.078	51.078	51.070	51.074	51.076
6	51.069	51.078	51.065	51.086	51.080	51.080	51.075	51.075	51.074	51.066	51.071	51.076
7	51.069	51.072	51.069	51.080	51.076	51.080	51.072	51.080	51.083	51.071	51.085	51.075
8	51.080	51.078	51.078	51.082	51.081	51.074	51.071	51.079	51.072	51.066	51.080	51.075
9	51.089	51.080	51.072	51.077	51.083	51.081	51.075	51.070	51.074	51.075	51.074	51.083
10	51.075	51.071	51.078	51.076	51.067	51.069	51.079	51.083	51.072	51.072	51.070	51.074
11	51.074	51.075	51.089	51.071	51.071	51.076	51.075	51.074	51.067	51.076	51.076	51.083
12	51.069	51.082	51.075	51.082	51.087	51.072	51.077	51.082	51.078	51.084	51.071	51.073
13	51.073	51.082	51.075	51.081	51.075	51.073	51.077	51.076	51.078	51.076	51.072	51.076
14	51.074	51.079	51.075	51.077	51.073	51.076	51.081	51.074	51.075	51.071	51.080	51.070
15	51.076	51.076	51.080	51.080	51.072	51.080	51.081	51.078	51.084	51.072	51.068	51.068
16	51.079	51.065	51.079	51.070	51.072	51.078	51.068	51.072	51.078	51.073	51.080	51.070
17	51.067	51.078	51.070	51.075	51.068	51.084	51.081	51.074	51.076	51.077	51.072	51.087
18	51.074	51.069	51.077	51.073	51.077	51.080	51.071	51.078	51.079	51.069	51.070	51.077
19	51.084	51.073	51.082	51.066	51.073	51.064	51.065	51.070	51.078	51.074	51.073	51.072
20	51.072	51.073	51.076	51.081	51.086	51.084	51.073	51.074	51.076	51.073	51.090	51.075
21	51.070	51.070	51.083	51.075	51.076	51.077	51.079	51.066	51.080	51.079	51.077	51.078
22	51.071	51.063	51.067	51.078	51.078	51.058	51.062	51.071	51.074	51.082	51.074	51.068
23	51.076	51.071	51.077	51.082	51.080	51.064	51.073	51.076	51.083	51.076	51.072	51.082
24	51.072	51.077	51.076	51.073	51.086	51.074	51.085	51.077	51.070	51.073	51.072	51.080
25	51.089	51.073	51.074	51.076	51.087	51.081	51.076	51.078	51.074	51.077	51.068	51.067
26	51.068	51.087	51.076	51.072	51.078	51.083	51.074	51.076	51.076	51.074	51.076	51.082
27	51.066	51.077	51.077	51.074	51.071	51.066	51.081	51.069	51.076	51.074	51.073	51.082
28	51.078	51.070	51.069	51.070	51.078	51.081	51.067	51.077	51.075	51.076	51.071	51.076
29	51.079	51.072	51.076	51.069	51.068	51.077	51.077	51.077	51.068	51.066	51.074	51.062
30	51.084	51.088	51.077	51.084	51.076	51.071	51.071	51.084	51.076	51.071	51.071	51.069

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Min	51.063	51.058	51.062
Max	51.094	51.087	51.092
Range	0.031	0.029	0.030
Average	51.076	51.075	51.074
Defectives	25	12	10
Cp	1.43	1.52	1.62
Cpk	1.38	1.50	1.62

III. CONCLUSION

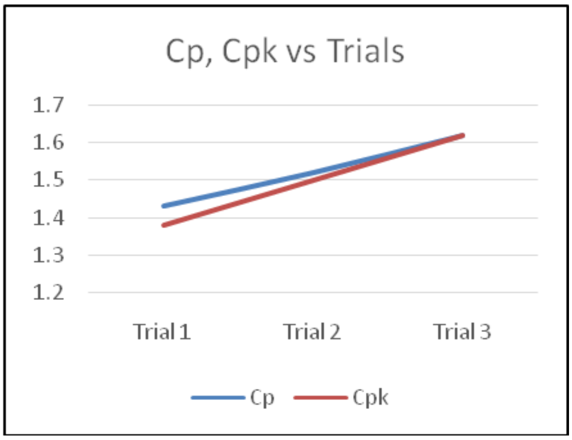

Fig. 2 Cp and Cpk vs Trials

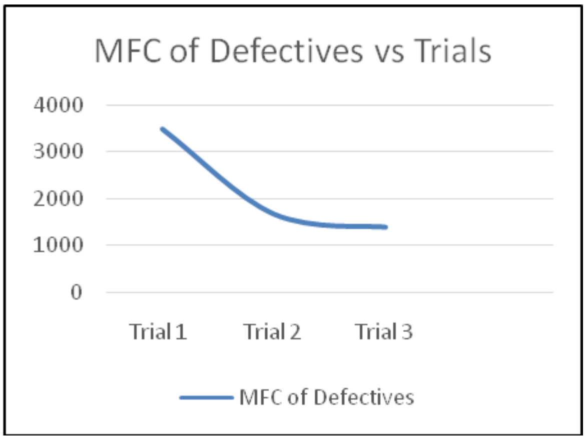

Fig. 3 MFC of Defectives vs Trials

The present investigation shows the optimization of manufacturing cost due to defective parts in the batch production of automobile component and draws following conclusions:

i) Three trials were taken successfully for the production of automobile component in batch production.

ii) The observed values of process capability indices Cp and Cpk in trial 3 are optimum and reached to standards (=1.67, according to six sigma level). The trial 3 is optimum among the trials 1 and 2 (Fig. 2).

iii) The manufacturing cost of defective parts has been observed to be reduced in trial 3 (Fig. 3).

iv) The manufacturing cost of defective parts has been reduced considerably from 3493 to 1397 in trial 3.

v) The trial 3 is the most optimum solution to implement, the production parameters as speed = 1200 RPM, feed = 500 mm/min and cutting depth = 9 mm respectively.

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