Optimization In Machining Process Of Aircaft Actuator Beam Component

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Abstract- *Product development is focused on machining complex Implemented lean manufacturing to AIRCRAFT components manufacturing machining processes. In this project, we optimized Actuator Beam Components manufacturing machining processes. ACTUATOR BEAM used to assemble component of aircraft landing gear retraction assembly and also used to aerospace / aircraft vehicle retraction assembled areas. This component manufacturing machining processes programmed in CAM (COMPUTER AIDED MANUFACTURING) software. CAD/CAM designed parts were used to assess cycle times and surface quality of machined sculptured surfaces with NC-files generated by CAM, respectively. The generated NC-files were fed into a 3-axis CNC Vertical Machining Centre (VMC) for SSM. In that we changed Numerical codes using of 3D pocket and contour programming. For that we reduced the machining lead time. When mass production work carried out in machining, component taken more time for settling in bed . For that we have done fixture design to optimized setting time for Actuator beam multiple machining setups. To get the Finial product of machining in same Quality with optimized machining processes for that we reduced the lead time of machining , reduced setting time and also increased the quality , productivity , profitability for the industry.*

Keywords- Actuator Beam machining process optimization, CAM programming for VMC, Fixture Design, Reduction of setting time and machining time.

I. INTRODUCTION

Lean manufacturing is bundle of various methodologies and various tools. Lean aim is to reduce all types of waste and construct process defect free and waste free. The main objectives of lean manufacturing are reduce cycle time, lead time, inventory, and transportation, defects etc.

Defects and wastage – Lean manufacturing is helps to reduce defects in product and generate defect free product. It also reduces extra use of raw materials, and hence reduces scrap. By lean we produce products which are requirements of all the customers. Lean concept is preferable for reducing defects andwastage.

Cycle Times – Lean have aim of reducing cycle time as well as process lead time. Lean reduces waiting at process level. It also reduces process setup time and reduces changeover time of product.

Inventory levels – More inventories is waste which occur in the every industry. Lean tools which are very helpful to reduce inventory level like KANBAN, Supermarket, etc.

When aerospace manufactruring company implemented lean manufacturing, they observed various improvements at various levels of company. In their medium sized production system they noticed following improvement

1. Spaceutilization
2. Defect freeproduct
3. Processing time or cycle time isreduced
4. Production lead time is alsoreduced.

II. LITERATURE REVIEW

Yang and Chen demonstrated a systematic procedure of using Taguchi parameter design in process control of individual milling machines. The Taguchi parameter design had been done in order to identify the optimum surface roughness performance with a particular combination of cutting parameters in an end-milling operation. Ghani *et al.* applied Taguchi optimization methodology to optimize cutting parameters in end milling while machining hardened steel with TiN coated carbide insert tool under semi-finishing and finishing conditions of high speed cutting considering the milling parameters - cutting speed, feed rate and depth of cut. Oktem *et al.* had focused on the developed a methodology with a genetic algorithm (GA).

Kopac and Krajnik presented the robust design of flank milling parameters, milled surface roughness and the for injection mold Al-Alloy has been machined as per material removal rate. Grey-Taguchi method combined the orthogonal array (OA) design of experiments (DOE) with grey-relational analysis (GRA), which enabled the determination of the optimal combination of milling parameters for multiple process responses. Previous researchers have studied various aspects of process optimization of milling. It has been found that in most of the cases, Taguchi method along with grey relation analysis or RSM has been largely recommended. However, these approaches are based on the assumption that individual quality attributes are uncorrelated i.e. they have been treated as independent. But in practical case the reverse situation mayarise.

The present study proposes application of Principal Component analysis (PCA) coupled with Taguchi method to solve such correlated multi-attribute optimization of CNC end milling operation. PCA has been proposed to eliminate correlation between the responses and to estimate uncorrelated quality indices called principal components; Datta et al. (2009a). The quality index (principal component) having highest accountability proportion has been treated as equivalent single objective function; which has been finally optimized by Taguchimethod.

III. METHODOLOGY AND OBJECTIVES

End milling is the most important milling operation has a capability of producing complex geometric surfaces with reasonable accuracy and surface finish. However, with the inventions of CNC milling machine, the flexibility has been adopted along with versatility in end milling process. It is found that many research works have been done so far on continuous improvement of the performance of end milling process. In end milling, surface finish and material removal rate are two important aspects, which require attention both from industry personnel as well as in Research & Development, because these two factors greatly influence machining performances. In modern industry, one of the trends is to manufacture low cost, high quality products in short time. Automated and flexible manufacturing systems are employed for that purpose. CNC machines are considered most suitable in flexible manufacturing system. Above all, CNC milling machine is very useful for both its flexibility and versatility. These machines are capable of achieving reasonable accuracy and surface finish. Processing time is also very low as compared to some of the conventional machining process.

In this case, we following methodology is lean manufacturing based machining processes. For that, Existing Component Manufacturing process study taken. Analysis of present state process. Design required fixtures for holding the component on machining and Implementation. Generate the (Numerical codes) NC-files programming codes for **3 axis VMC** using the CAM software with optimized tool path sequence based on the **lean manufacturing** concepts. Raw material settled on machine bed is common. Multiple setups of machining process, must we need the required fixtures for holding the component on machine bed. From the raw material maximum of wastages removal using perfect roughing tool in single machining operation. That optimum of material removal operation is called 3D pocket mill operation. Up to tolerance all the waste material removed from the raw material. Tolerance stock wastes removal using perfect finishing tool. That operation called as finishing. Each particular surface has to remove the wastes. For that we using 2D contour operations. To optimized the manufacuturing machining processes of Aircraft Components. To Design required fixtures for holding the component in machining setup for avoiding the vibrations, mismatched positioning and comfortable machining. To Optimized the lead timing of machining when reduces the operations in required manner. To get the Finial product of machining with same Quality with optimized machining processes.

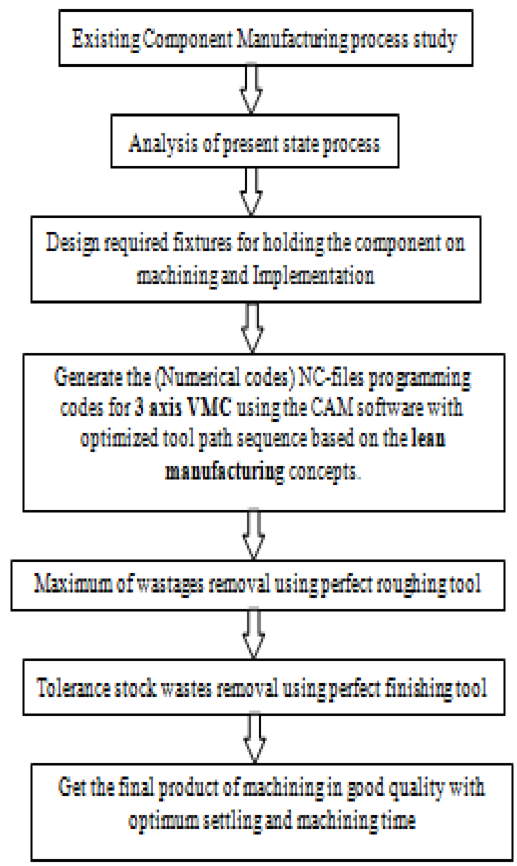

Figure 1-Methodology flowchart

IV. ACTUATOR BEAM

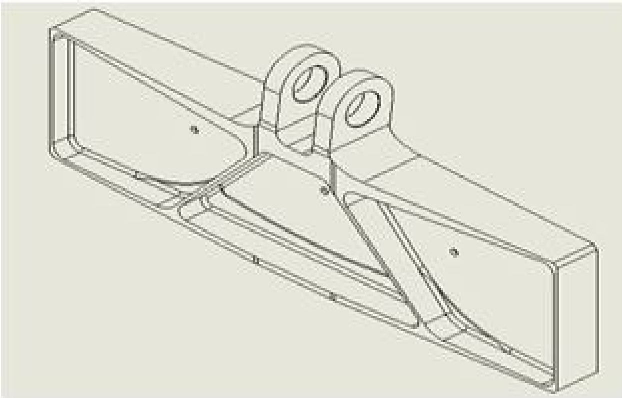

Figure 2-Actuator Beam

Actuator Beam is an aircraft component. It is used in aircraft landing gear assembly and also aircraft all retractive mechanism assembly parts used in this actuator beams.

V. MACHINING CHALLENGES & SOLUTIONS

Actuator Beams are manufactured by the CNC Vertical Milling Centre. This component has both side pocketed critical structure. Middle portion had 0.5 mm thickness. 3 setups of machining operation to be needed for completed this product.

When mass production time industries faced high machining complexity of the product like that component setting work on machine bed, production time and quality.

Individual fixtures needed for multiple setups machining, in that we reduced the settling time. NC-Files sequence a change is the way of reduced the production lead time machining.

VI. FIXTURE FOR ACTUATOR BEAM

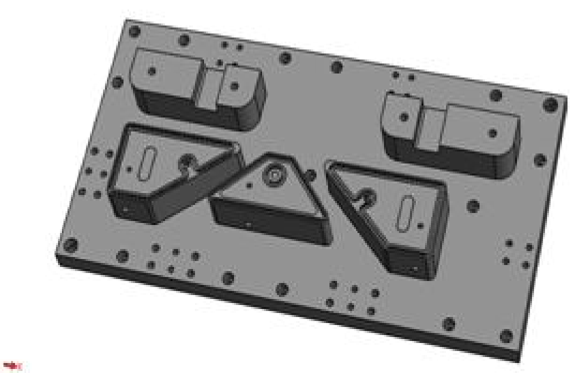

Figure-3 Fixture for Actuator Beam

Two and more setups of machining settling time optimized some more minutes. Air lock, nut and bold kind of things to be used for holding the component.

Small scale industries can be used this fixture for increasing the production, in 3 axis Vertical Milling Center (VMC) itself.

VII. MACHINING OPERATIONS INVOLVED SETUP 1&2

1. 3D Pocket (Open)
2. Contour (2D)
3. Pocket (Open)
4. Pocket (Open)
5. Pocket (Open)
6. Pocket (Standard)
7. Pocket (Standard)
8. Pocket (Standard)
9. Contour(2D)
10. Contour (2D)
11. Contour (2D)
12. Contour (2D)
13. Contour (2D)
14. Contour (2D)
15. Contour (2D)
16. Contour (2D)
17. Contour (2D)
18. Contour (2D)
19. Contour (2D)
20. Contour (2D)
21. Contour (2D)
22. Contour (2D)
23. Contour (2D)
24. Contour (2D)
25. Contour (2D)
26. Contour (2D)
27. Contour (2D)
28. Pocket (Standard)
29. Pocket (Standard)
30. Surface Finish Parallel
31. Surface Finish Parallel
32. Chip Break

VIII. TOOLS REQUIRED FOR SETUP 1 & 2

Table 1- Tools parameter for setup 1& 2

S.NO	Tool Name	Diameter (mm)	Corner Rad (mm)	Length (mm)	Flute
1.	Drill	8.5	0	14	2
2.	Drill	11	0	40	2
3.	Ball Endmill	6	3	6.5	1
4.	Ball Endmill	12	6	25	3
5.	Bull Endmill	20	0.2	42	4
6.	Bull Endmill	16	4	24	3
7.	Bull Endmill	50	0.8	10	3
8.	Bull Endmill	32	4	15	3

IX. MACHINING OPERATIONS INVOLVED IN SETUP 3

1. Drill / Counter bore
2. Drill / Counter bore
3. Drill / Counter bore
4. Drill / Counter bore
5. Standard Finishing (pocket)

X. TOOLS REQUIRED FOR SETUP 3

Table 2- Tools parameter for setup 3

S.NO	Tools Name	Diameter (mm)	Length (mm)	Flute
1	Drill bit	40	120.0	2
2	Drill bit	40	115.0	2
3	Drill bit	3	40.5	2
4	Drill bit	3.5	40.75	2
5	Flat Endmill	32.8	11.4	4

XI. ROUGHING OPERATION IN 3D POCKET

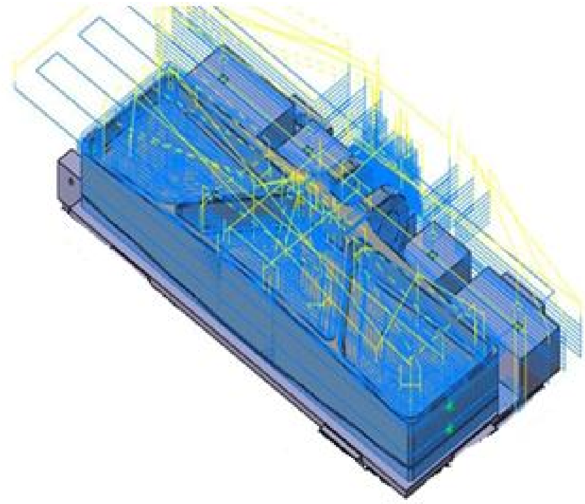

Figure-4 3D POCKET OPERATION

A way of eliminate the waste from the raw material based on lean method. In this 3D Pocket operation maximum of wastes reduced from the raw material.

XII. FINISHING OPERATIONS 2D CONTOUR

Finishing operation taken major role of the product quality. Smaller or required tools to be used for perfect finishing on component .The 2D contour operation generated by using the CAM software. That controls has to calculate by the VC calculation formulae.

XIII. FORMULAE USED

Cutting Speed (Vc) $= \frac{\pi X D X n}{1000}$

Spindle Speed (n) = V_c x π x D x 1000

Feed (V_f)= n x f_z x z

Feed per Tooth (f_z) = $\frac{Vf}{nXz}$

In that ,

V_c = Cutting Speed (m/min)
π = 3.14 [The Circular Constant]
D = Diameter (mm)
n = Spindle Speed (min $^{-1}$)
Vf = Feed (mm/min)
f_z = Feed per Toooth (mm/min)
z = Number of Flutes

Above the formules used to control the machining tool path cycle time. In multi axis CNC machines , multi axis programming CNC NC-Code files only can be fed .Horizontalmilling machine is similar to a vertical mill, except that the spindle is oriented horizontally instead of vertically.
A horizontal machining center (HMC) is a machining center with its spindle in a horizontal orientation. This machining center design favors uninterrupted production work. To reduce time, work can be loaded on one pallet of an horizontal machining center while machining occurs on the other pallet.

But Vertical Milling Center (VMC) 3-axis milling machine consists of a table, which acts as a work surface, which the spindle is attached, below an arm. VMC stands for vertical milling center and refers to a particular type of milling machine where the spindle runs in a **vertical axis** known as the "z" axis. So critical designed components machining processes facing difficulties of machining . CAM programming method easy to generated 3D Component machining NC-files for 3 axis VMC and also small scall industries can be used in this method of machining.

XIV. TIME VARIATIONS CHARTS

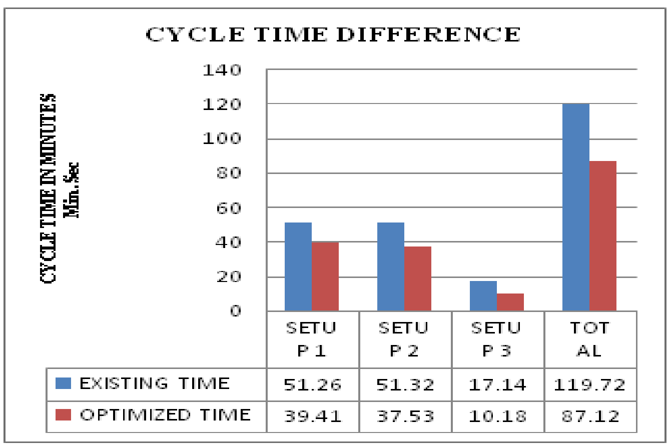

Figure-5 Bar chart Time difference

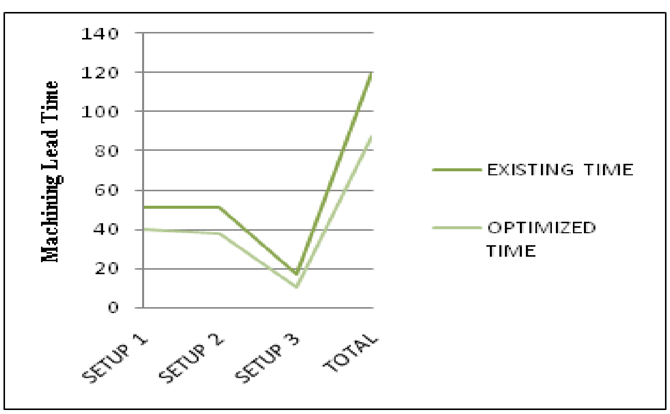

Figure-6 line chart Machining lead Time difference

Above the charts said that after changing the machining sequence time devations difference comparision of existing one .

Unnecessarly spindle movement areas controlled by the CAM Numerical code algorithm. Totally machining time reduced 32.6 minutes per one part with in this totally 8 minutes of settling time also reduced per one part to using the fixtures.

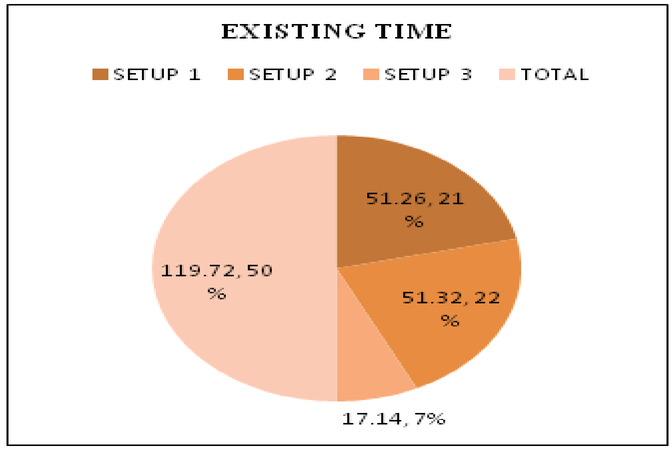

Figure-7 Pie chart Existing Time % difference

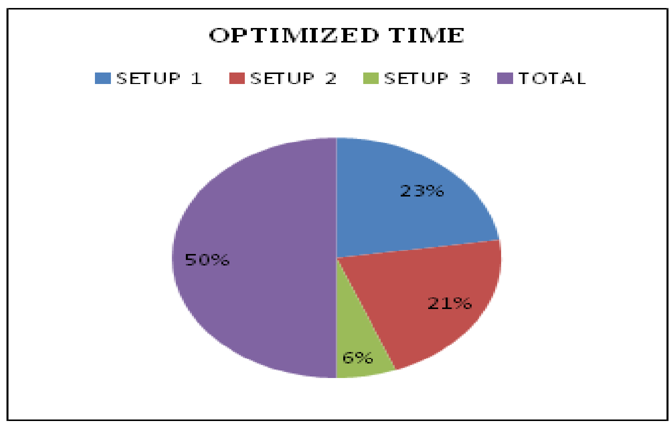

Figure-8 Pie chart Optimized Time % difference

As per the pie chart values , we reduced the 2% of cycle lead time in setup 1 , and 1% of cycle lead time reduced in setup 2 and also 1 % time reduced in setup 3. Tottaly 4% of machining lead time reduced as per one part production

XV. QUALITY INSPECTION

A Quality control is a process by which the entitles review the quality of all factors involved in the production.

The inspection refers to the activity of checking products whereas audit applies to analyzing manufacturing processes and/or systems. The quality inspections usually follows the results with the a checklist that is based on the product specifications, Inspected products can be the components used for production, semi-finished goods, or (most often) finished goods before shiping to a customer.

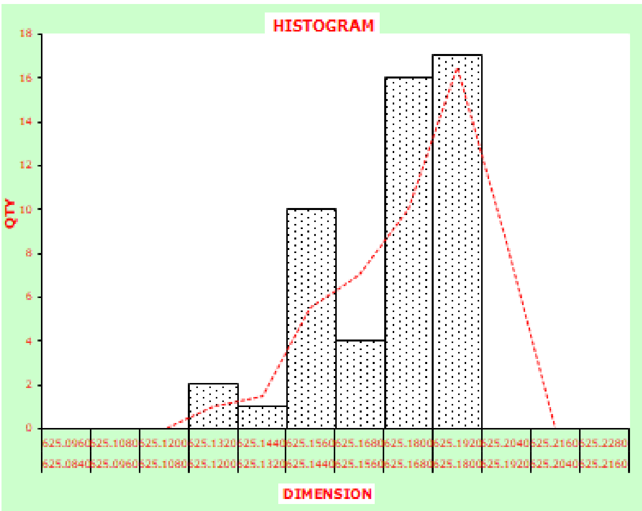

Figure-9 Quality and Dimension Histogram Chart

Actuator Beam part quality inspection histogram chart is in above. A Histogram is a graphical tool used to visualize data that can be produced with histogram software such as Quality SPC programs (STATISTICAL **PROCESS CONTROL**). The width of each bar is calculated by dividing the range of the data (the maximum value minus the minimum value) by the number of bars.

In statistical process monitoring , the X and R chart is a type of scheme , popularly known as control chart , used to monitor the mean and range of a normally distributed variables simultaneously , when samples are collected at regular intervals from a business or industrial process. In this control chart analysis give the result of process capable or not. Actuator Beam component process capable result came excellent in Statistical Process Control (SPC) chart. Optimized machined component is there in good quality , process capable in quality control chart .

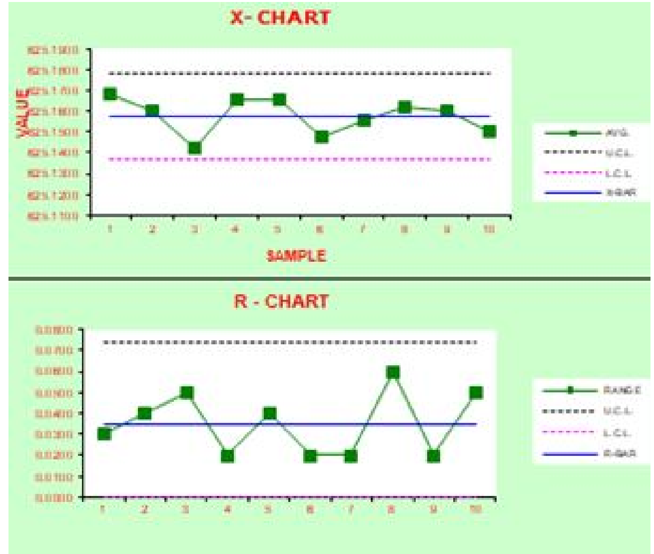

Figure-10 Control and Range Quality X-R-Chart

XVI. CONCLUSION

The application of lean tools in machining tool path sequence was studied and analyzed. The objective was to identify and remove the wastes in any activities that do not value added to the final product in the manufacturing process and also to reduce the overall lead time. Based on the study and analysis the following conclusions werearrived.

- Designed required fixtures for holding the component in machining setup for avoiding the vibrations, mismatched positioning and comfortable machining.
- Optimized the lead timing of machining get, when reducing the operations in CAM programs.
- Get the Finial product of machining in same Quality with optimized machining processes.
- Optimized the manufacuturing machining processes of Aircraft Actuator Beam Component.
- We reduced total process of machining time (included settling time & machine lead time) **40 minutes per one part**. So increased the quality, productivity, profitability for the industry.

This research was focused based on lean manufacturing production in effective manner. This could be more extended in the operations of parallel manufacturing parts with additional lean tools like TPM, SMEDetc.

XVII. ACKNOWLEDGMENT

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