ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 3, May 2015

Study of Supply Chain Flow of Integral Fuel Floor Component of LCA and Improving Its Machining Process (A case study at Hindustan Aeronautics Limited (HAL), Bangalore)

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ABSTRACT---Airline Industry is one of the biggest industry employing vast aspects of supply chain management and thus makes it more important to study the supply chain and its machining process within airline industry. . The paper aims at studying, identifying and eliminating the problems observed during the existing supply chain flow and machining process of critical class-1 component (Integral fuel floor) at HAL (Hindustan Aeronautics Limited) Bangalore. Manufacturing of Integral fuel floor longitudinal structural member takes place in multi axes machining center (CNC). It was observed that major problems were due to improper co-ordination in supply chain flow and in machining centre. Thus Major attention was focused on proper co-ordination during the supply chain flow and to analyze the cause of warpage, dimensional deviation, dig marks, chattering marks, improper machining setup, improper selection of cutter approach and not considering the proper reference during machining processes. Methodologies adopted are selecting and studying all the process involved in the existing manufacturing process and recording the facts in each process activities using different charts. Recorded data were examined to find the root causes of the problem by developing flow chart and the control chart.. And developing a new /improved method for the existing process and implementing the same results in elimination of manufacturing problems/rework of integral fuel floor. From the trial run, the data is collected & analyzed; it infers that the implementation of the suggested new method will reduce the problems/rework of the integral fuel floor component which in-turn reduces the cost of production and time.

Keywords: **Supply chain Management, IFF, CNC, machining process, process charts etc.**

I. INTRODUCTION

Aircraft Research & Design centre a division of H.A.L has taken the responsibility of developing L.C.A. It consists of many critical components out of which Integral fuel floor is an important component in wing structure in naval version of L C A. The Integral fuel floor is a longitudinal structural member in the centre fuselage of the LCA NAVY aircraft. Naval landing gears are designed to take high landing load due to deck landing. There is a need for very strong back up structure in the fuselage to take these high landing loads.
Part nomenclature:

Part name:	INTEGRAL FUEL FLOOR.
Material used:	Aluminum-copper alloy, (2124-T851),
Calculated weight:	32.421Kgs,

Supply Chain Management in Aerospace Industries

Airline Industry is one of the biggest industry employing vast aspects of supply chain management and thus makes it more important to study the supply chain within airline industry. The supply chain project is designed to study supply chain management at aerospace industry. This would be done by studying leading aerospace companies to ascertain what specific supply chain practices are being followed by the companies that make them a leader. Fig 1 shows the 3D model of the Integral Fuel Floor component and supply chain flow IFF is shown in the Fig 2

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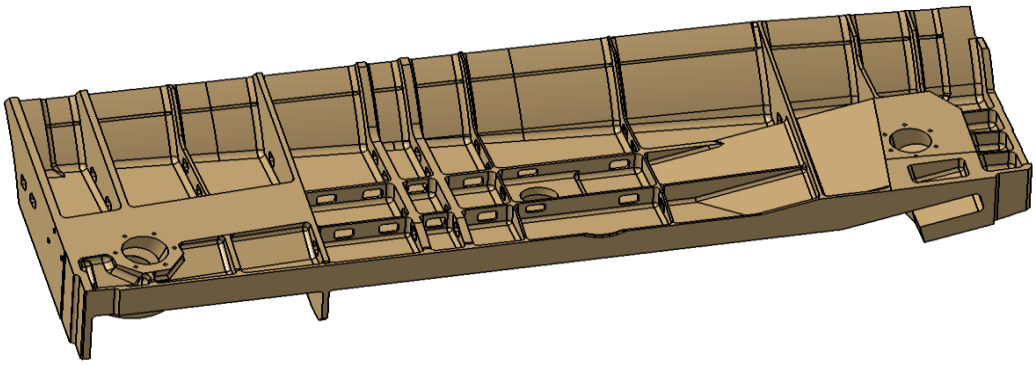

Fig 1:3D model of integral fuel floor component

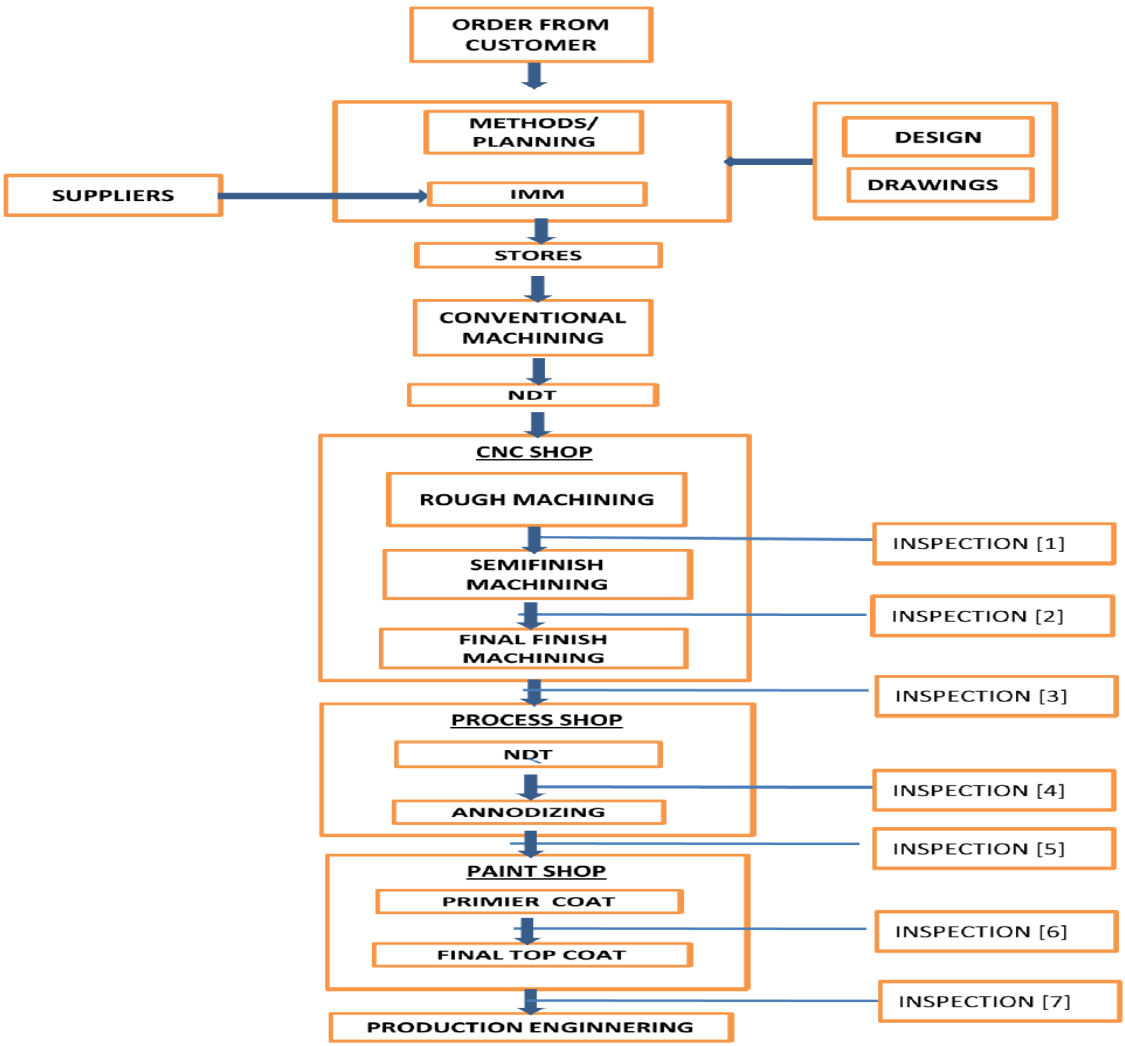

Fig 2: Detailed flow of the component at different stages of supply chain

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ISO 9001:2008 Certified
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II. METHODOLOGY

The following methodologies are used to solve the problem identification and for achieving the objectives

1. Studying the supply chain flow and all the manufacturing process involved in the machinery of Integral fuel floor.
2. Recording the observed data in each process.
3. Examining the recorded data.
4. Finding the root cause of the problem by analyzing the collected data.
5. Developing a new method or improving the existing process using some of the quality tools and techniques.
6. Evaluating the modified process or new process.
7. Installing/Implementing the new method/improved methods.

III. DATA COLLECTION

Data for the present manufacturing process has been collected by the following three techniques

Technique no.1: Data collected from the existing method of manufacturing is tabulated in the table 1.
Technique no.2: Data collected from observation is tabulated in table 2.
Technique no.3: Data collected by interviewing is tabulated in table 3.

Table No. 1: Data collected from the existing method

Sl. no	**Source**	**Findings on part Quality**
1	CMM Report,	Un even contour surface shown, thickness varies at different zones.
2	Component Dimensional reports	Deviations in the final dimensions of the component after trimming.ICY not maintained as per the drawing.
3	Visual inspection	Dig marks noticed at corner areas, chattering marks noticed on rib walls where multax programs used to run, and warpage observed.

Table No. 2: Data collected from Observation

Sl.no	**Operation description**	**Observation**
1	Contour surfaces and ribs.	Difficulty in rectification of any type of shift, mismatch of contour in between machining process.
2	Reworks of any snags after trimming	Very laborious and time consuming operations.
3	Post processing of programmes	Extra care is needed while in putting the values of cutter length during multax programmes.
4	Cutting speed of cutters	Cutting speed should be reduced at corner areas during radius reduction operation.
5	Finishing programmes	Some dig marks are observed during approach and depart of finishing cutters while running finishing programmes on contour surfaces.
6	Cutting tools,(specified end mills)	Surface finish of the component depended on the type of cutter used, sharp and new cutter gives good surface finish, and smoothly removes the material where as blunt and used cutter forms bad surface finish and creates vibration, noise and chattering.

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Table No. 3: Data collected by Interviewing shop employee

Sl. no.	Source	Problems
1.	Shop employees	Difficulty in loading and unloading the billet, as the size of the raw material is big. Difficulty in viewing the cutter position while running multi-axis programmes. Poor house-keeping. Fatigue to the operator during loading the part on the machine bed and preparation of tools, holders, clamping and finding exact tool length values of multi axis cutters for post processing. Single man has to concentrate on all areas. Difficulty in avoiding communication gap between all 3 shift operators.

IV. PROBLEMS IDENTIFIED

During the study of existing sc flow and machining process of the component the following defects were observed which increases cost of production and time.

1. Physical defects
2. Manual defects
3. Lack of Co-ordination

Physical defects

The physical defects which are observed in the existing process are part undergoing war page, shifting of contour wall, not maintaining the wall thickness as per drawing, tearing of wall at cut out area, deep tool dig marks at the corner, chattering marks on deep pockets, not maintaining the inter changeable point[icy] dimension.

The above defects were observed due to improper maintenance of the tools and machines. The extensive use of the machines with the same set of tools has resulted to the above defects.

Manual defect

These errors are not the result of the machine but are the result of the carelessness of the human element in the manufacturing floor. The defects are incorrect comprehension of the reading, incorrect part of operations, complexity in programming, lack of inspection at every step, selecting incorrect tool length, typing error while inputting the program.

The element of the manual defect can't be ignored and can't be removed completely from the manufacturing process. But the percentage of the error can be reducing drastically with better caution and inspection.

Lack of Co-ordination

Co-ordination is the major problem in complex manufacturing process carried out at various departments Since manufacturing of the Integral fuel floor unit requires the combined efforts of different departments like CNC programming, planning, CNC machining, store, process shop and designing departments. Hence co-ordination among these departments is very much essential, which is lagging in the present method.

V. ANALYSIS

From the analysis of collected data, it was noticed that all the parameters with respect to other departments were well within the controlled limits and as per the specified process. And majority of the problems were found during running 5axis programs, and final finishing operations, major attention was to analyze the cause of errors due to manual and physical defects. Such as improper tooling, improper co-ordination, improper maintenance of cutter, considering of the wrong reference during machining process etc. Manufacturing of complicated aircraft components in R&D centers is costly and time consuming process and any rework/rejection of parts causes heavy loss to the company. Hence it is concluded that the standard procedure / process should be adopted for complicated components like integral fuel floor.

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Proposed improved method of manufacturing process

Solution for physical defects

War page: Uneven twisting of material is called as war page. Here war page occurs due to heavy metal removal in CNC machine.

SOLUTION: Remove the war pages at roughing stage by keeping proportionate stock on all sides of the component.

Contour wall shift: Contour is geometrical model (shape) of detailed component created in design with the help of design software. The root causes for contour wall shift are Misalignments in machining setups, Errors in post processing of CNC program files by entering exact cutter length. . The selection of wrong tool length is due to inadequate knowledge about tool setter and at last lack of training caused the above problem.

SOLUTION: Advised for proper training in post processing procedures with advanced equipments.

Tearing of wall at cut out area: when Cutters cutting edges are not maintained well, it leads to improper material removal and need to depend on new cutters

SOLUTION: Advised for in- time procurement of special tools from market.

Deep tool dig marks at corner: this is caused due to cutter deflection. Occurs when selection of tool path is not correct, lack of machining knowledge and improper interaction with operator.

SOLUTION: Arranged for discussion and exchange of technical issues between OPERATOR and programmer and program modified and standardized.

Chattering marks at deep pockets: this is due to cutter deflection. Occurs when Lack of machining knowledge and experience in special components.

SOLUTION: Special attention and care to be taken while machining by controlling feed rates.

ICY Dimension not maintained: the above said over all effects, results in improper maintenance of icy dimension. It is mainly due to war page while removing of bulk material during rough machining.

SOLUTION: Advised to remove the war page and the boring operation has to be carried out at final finishing operation with minimum stock in single setup.

Solution for the Manual defect

To cope with these manual processes, it's important for managers not to become overwhelmed on the employees, as there are several reliable steps to mitigate errors—and stress. CNC shops must not only focus on standardization and accountability, but also on creating a quiet, calm work environment, this leads to the employees to have a correct reading, making correct part operations and selecting the correct tool length. Rather than making ten thousand lines of programmes for particular operation, it should be split to some thousand lines so that complexity in programme is reduced and inspection can be followed at every step. Finally, shops should consider redundant data entry. Also called double entry, redundant data entry involves two separate people entering the data, with data only flowing forward if the two independent entries match. It adds time to data entry, but it dramatically reduces data entry errors when computer interfaces are not an option.

Achieving Co-ordination

The Co-ordination is the most important aspect among various departments. Co-ordination can be improved by the following methods:-

1. There should be a clear understanding throughout the organization.
2. The interface between the maintenance and operating departments also needs to be clearly defined and accepted, together with any maintenance responsibilities for the operations department.
3. Maintenance frequently involves activities that need to be co-ordinate and aligned with operational demands. When maintenance accidents are analyzed, poor communication is often identified as a contributory cause. Therefore, formal communications should be an essential part of maintenance management
4. Weaknesses in communication systems can cause a lack of co-ordination between different departments. They can also cause problems if the roles and responsibilities of managers, staff and contractors are not properly defined.

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5. Reliable communication is best achieved by providing a range of communication methods. These need to provide staff with task-specific information and background information about the overall system status. Approaches available include team briefings, notice boards, face-to-face conversations, telephones, radios or pagers, permit systems, logs, procedural documents, work orders and checklists.
6. All organizations undergo change, e.g. in response to competitive pressures. It is therefore important to ensure that the impact of change on maintenance is not ignored and, where possible, allow for the opportunity for introducing improvements in maintenance performance. Any changes have to be properly considered and managed to ensure the desired benefits are achieved.

V. RESULTS AND DISCUSSIONS

Fig 3 showing the flow diagram for manufacturing integral fuel floor of existing method

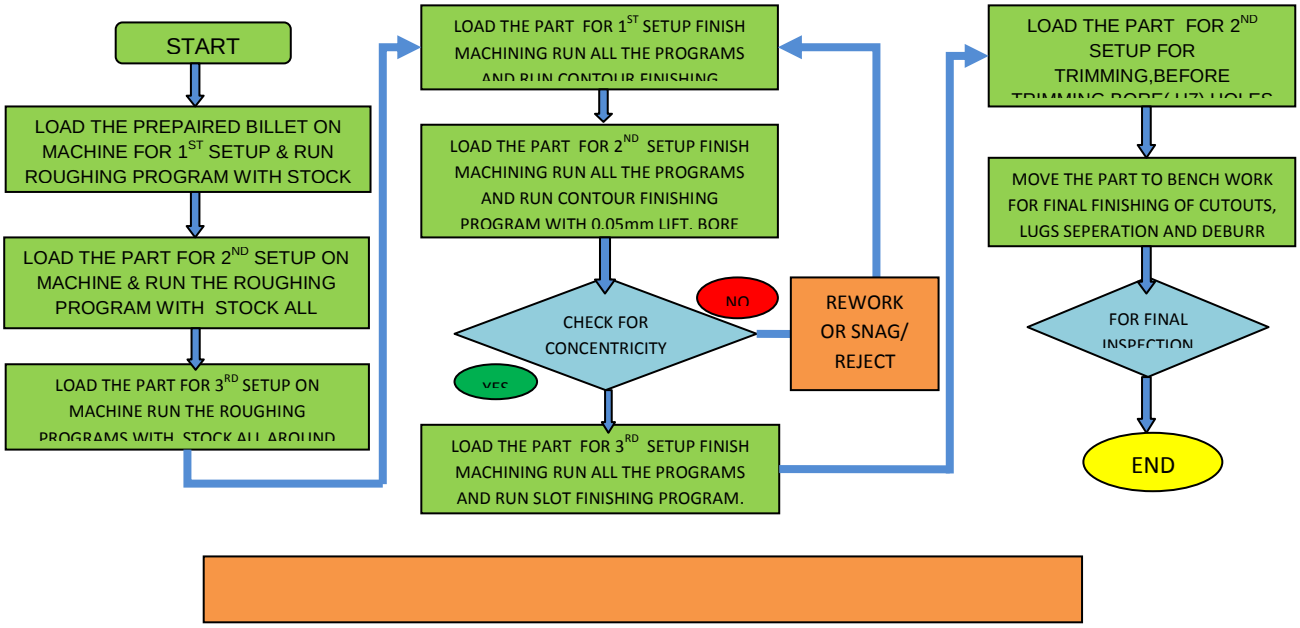
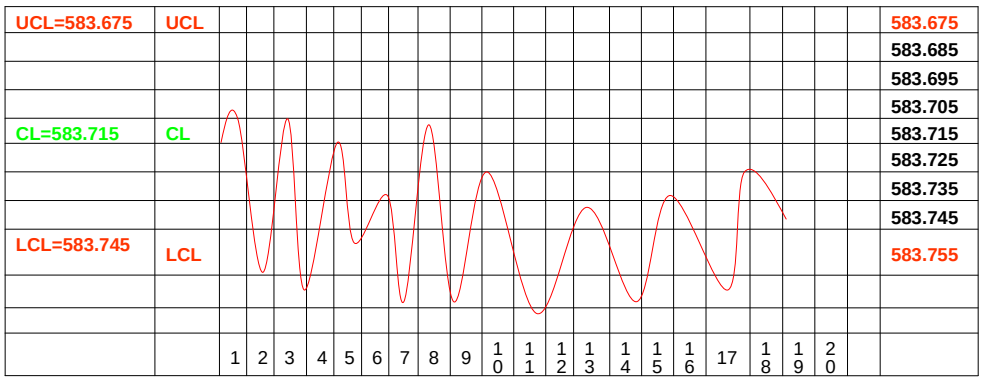


Fig 3 Flow diagram for manufacturing INTEGRAL FUEL FLOOR (Existing Method)

Fig 4 showing the CMM report for contour measurement of existing component where the Control limits are out of limits



Note: Values are with respect to flight reference Line (FRL)

Fig 4 CONTROL CHART SHOWING THE C.M.M REPORT FOR CONTOUR MEASURMENT (Existing method)

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Fig 5 showing the Flow diagram for manufacturing INTEGRAL FUEL FLOOR. Of proposed/improved method

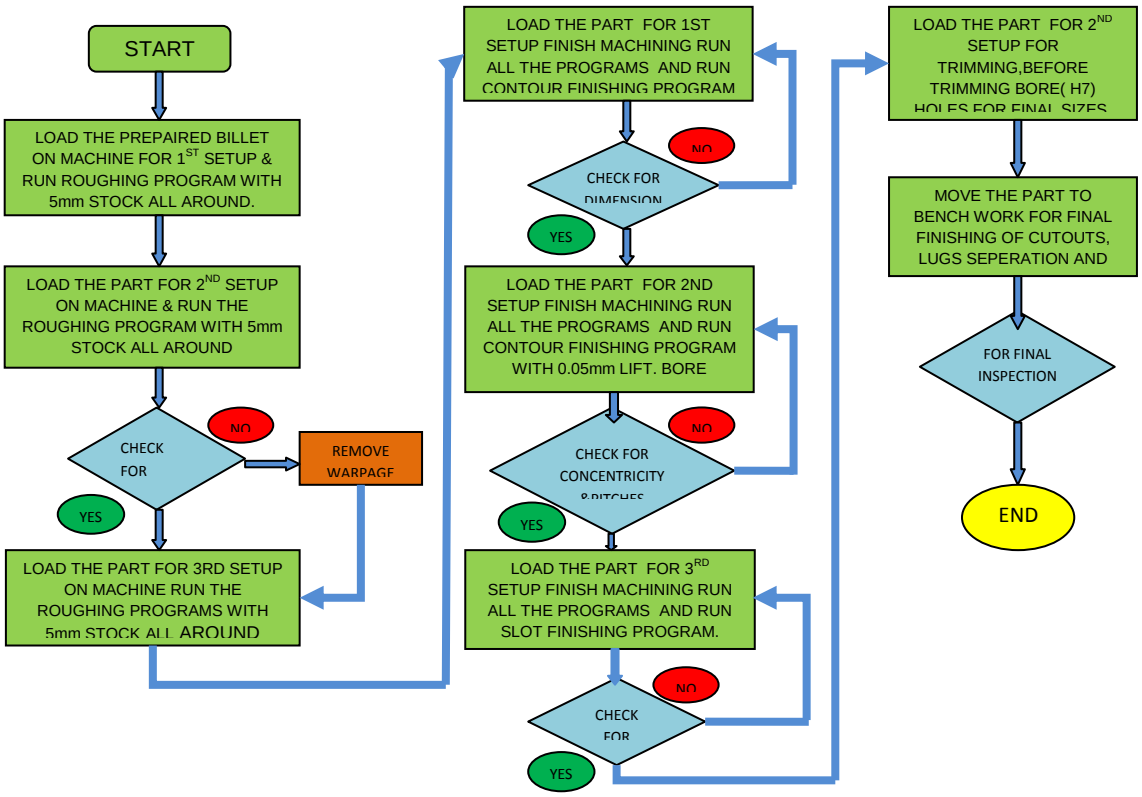

Fig 5 Flow diagram for manufacturing INTEGRAL FUEL FLOOR (Improved Method)

Fig 6 showing the CMM report for contour measurement of improved method of component where the control limits are within the controlled limits

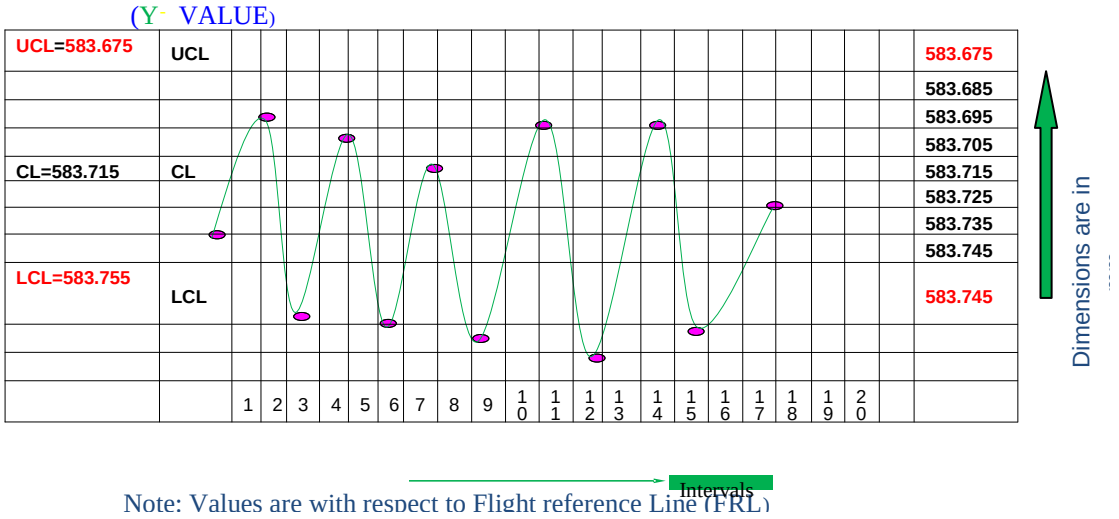

Fig 6 CONTROL CHART SHOWING THE C.M.M REPORT FOR CONTOUR MEASURMENT (Existing method)

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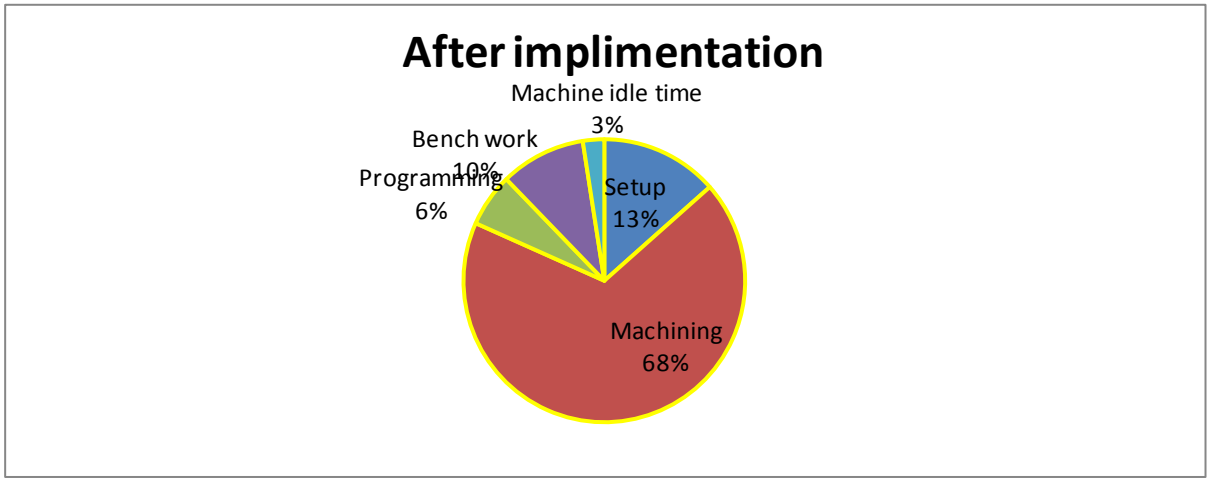
Table 4 showing the total no. of hours saved at different level of operations when new proposed method is implemented

Sl no.	Operation	Hours taken Before Modification	Hours taken After Modification	Hour's Saved
1	Set -up	60	44	16
2	Machining	250	224	26
3	Programming	30	20	10
4	Bench	45	32	13
5	Break idle time	15	8	7
6	Total	400	328	72

Table 5 showing the total no. of cost saved at different level of operations when new proposed method is implemented

Sl no.	Operation	Before Modification Hrs x Rs	After Modification Hrs x Rs	Saved
1	Set -up	60*100	44*100	4.0%
2	Machining	250*1200	224*1200	6.5%
3	Programming	30*500	20*500	2.5%
4	Bench work	45*100	32*100	3.25%
5	Break idle time	15*1200	8*1200	1.75%
6	Total amount	3, 43,500	2, 96,000	47,500

Graph 1 shows the percentage of time utilized in the existing process



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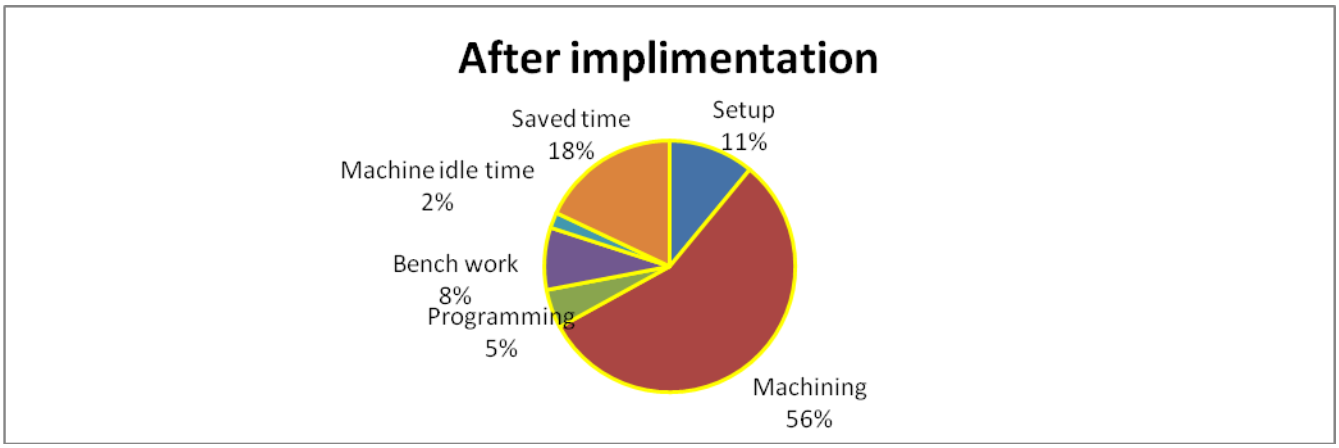
Graph 2 shows that overall 18% percentage of time saved when improved method is implemented.



VI. CONCLUSION

This paper studied, identified and eliminated the problems observed during the existing supply chain flow and machining process of critical class-1integral fuel floor component. From the data collection & analysis it can be inferred that the implementation of the suggested/improved method of technique will reduce the problems of the integral fuel floor. The obtained results proven that implementation of new method leads to reduce in production time and cost. The proposed improved method can be planned in the machining process duly prepared by methods planning department and approved by the design department to incorporate same in the regular production of integral fuel floor.

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