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Modification in Fixture by Computer-Aided-Fixture-Design (CAFD) in Manufacturing Process of Steering Nut to Reduce Defects

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Abstract - The study was done on the defects of the steering nut which was rejected due to incorrect setting up of machine tool on special purpose machine and mishandling of component during heat treatment stage. To eliminate the problem, the threading and grooving is done after the heat treatment on CNC. If threading operation is done after the heat treatment process then the clamping of the component should be changed from the previous clamping method which was held through threaded mandrel. The manufacturing processes such as boring, back boring, threading and grooving are done after the heat treatment which resulted in 60% reduction of machining time and modification in manufacturing process and fixture resulted in decrease in defective components from 15.18% to 1.00%.

Keywords – Steering nut, CNC, boring, back boring, grooving, defects

I. INTRODUCTION

In India, most of the small and medium enterprises are an unorganized sector because of investment, manpower, organizational sector, space, plant and machinery etc. are limited, whereas this sector fulfills the need of many large scale units by supplying low cost components as per their specifications and their requirements (within finished as well as semi-finished). In the era of globalization, more and more competition has to face by this sector. At present, micro small and medium enterprises are facing difficulties because input cost (like raw material cost, electricity cost, fuel cost and transportation cost) has increased but final product price are not increasing accordingly. There is no space for rejection/reworking because it is a non value added activity of the company. No customer will pay cost for this. So customer wants defect free product with economical price.

II. LITERATURE

A. Y. C. Nee and A. Senthil Kumar [1] determined that automation of the fixture design process can be accomplished with the use of solid modeler, an object/ rule based expert system and a feature recognizer coupled with external analysis routines. Although the proposed framework was only capable of solving relative simple cases based on fixture elements, it has excellent application potential in flexible manufacturing system. The final output can be in the form of robotic assembly sequence or a series of “assembly slides” to be sent to the loading stations where the operator can manually build up the fixture based on pictorial instructions. **X Dong et al. [2]** investigated the use of features in the domain of fixture design. They developed a method to describe a machined part, intermediate workpiece geometry and material properties, machined features and their intermediate states. The information represented about the intermediate workpiece and features enables a fixture design program to determine the surfaces available for locating and supporting and will facilitates the detection of interference between the workpiece, the cutting tool and the fixture. The representation of machining processes described the operation between intermediate workpiece states and provided the process information that allowed the generation of such information as cutting force directions. A sample part has been used to demonstrate the use of features in two fixture design tasks. It has been shown that feature information was very useful for the selection of locating elements and surfaces. **Hiroshi Sakural [3]** developed an automatic setup planning and fixture design system. Algorithmic and heuristic methods were developed to synthesize and analyze setup plan and fixture configurations. Based on the study, the task of setup planning and fixture design was structured into a setup planning and fixture design plan. The plan was implemented as a system that automatically plans the setup sequence and design fixture configurations from the tolerance solid model of the finished component. He described the result of the study of the requirements, the setup planning and fixture design plan and the result of the implementation. **E.C. DeMeter [4]** used total restraint analysis to evaluate the ability of a machining fixture to restrain workpiece motion. He explained how to apply restrain analysis to a fixture which relies on frictionless or frictional surface contact. Presented model of the wrench systems defined by frictionless and frictional planar, spherical and cylindrical contact as well as hard point contact. These models were applicable to the restrain analysis of other work holding devices such as gripper and assembly fixtures. In addition, they were the basis for other types of fixture analysis. He also presented a linear program which uses static equilibrium constraints to directly prove the existence of total restraint. Both the models and the linear program are applied to the analysis of the fixture. **Shyr-Long Jeng et al**. **[5]** described the minimum clamping forces that keep the workpiece stable during the metal cutting process. However, previous search algorithms for the instant centre of motion either lack theoretical sufficiency or computational efficiency. They presented a new method derived from the correlation between cutting force and clamping moment. This method increases the search efficiency by proving inadequate search directions. In addition, examples are provided to illustrate minimum clamping force analysis under different fixturing conditions. **Ajay Joneja and Tien-Chien Chang [6]** developed a system that attempted to perform setup planning, fixture planning, unit design and verification. Verification is limited to ensuring that stability of the workpiece is achieved. Fixture planning is performed by a planner that exhibits preferences for a particular solution strategy. The system inputs are the workpiece geometry and machining forces. Outputs are a setup plan, fixture plan and unit designs for the locating and clamping units and the base plate. **Y.F. Wang et al. [7]** developed an intelligent fixturing system (IFS) for machining. They presented the concept, architecture, control scheme, models and methodologies for IFS. Using off-line simulations and on-line experimental verification, the performance of the proposed IFS is evaluated and verified. As adaptive clamping forces appropriate to the dynamic machining environment are employed, the IFS offer higher quality of machined parts and greater robustness to disturbance. This system is suitable for application in high-precision machining environment as well as flexible manufacturing system (FMS).

III. STUDY OF EXISTING FIXTURE

The company was using indexing fixture. This fixture was very simple and any lay man can operate this fixture. Also the repair was very less. Only disadvantage of this fixture for nut steering knuckle was that the clamping of the component on this fixture was through threading i.e. threaded mandrel was used to hold the component and then slotting was done. It was a time consumable process as it took more time for loading and unloading through threading. Figure 3.15 shows assembly of indexing fixture with nut steering knuckle.

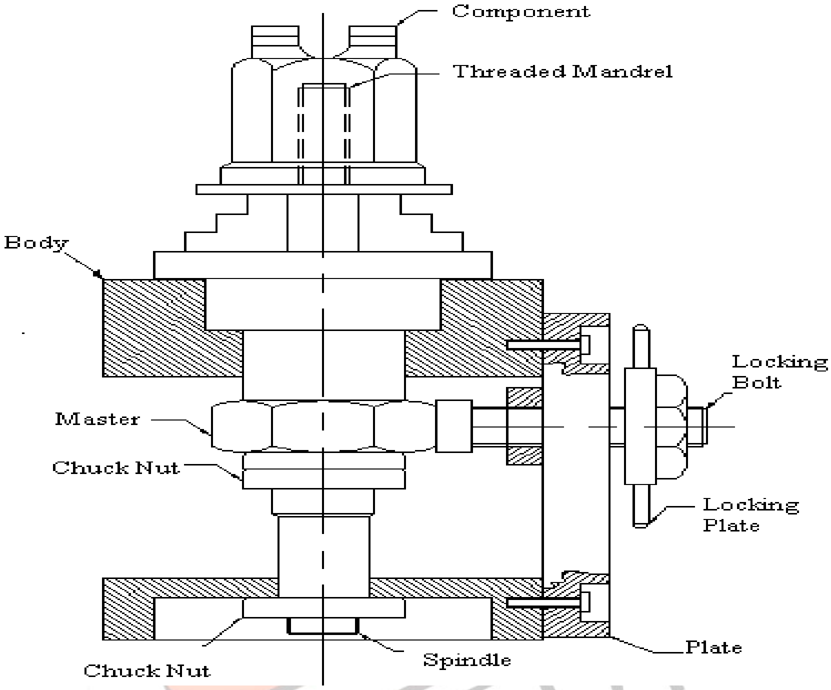

Figure 3.15: Existing Assembly of Indexing Fixture with Component

Different parts used in existing fixture, their material and bill of material are given in Table 3.4.

Table 3.4: Parts Used in Indexing Fixture with Component

Sr. No.	Nomenclature	Material	No.
1	Body	C-20	1
2	Spindle	C-55	1
3	Chuck Nut	C-45	1
4	Master	C-55	1
5	Chuck Nut	C-45	2
6	Plate	C-20	1
7	Locking Bolt	C-55	1
8	Locking Plate	C-55	1
9	Threaded Mandrel	C-45 (Soft)	1
10	Component	C-45 (Forged)	1

IV. FIXTURE MODIFICATION

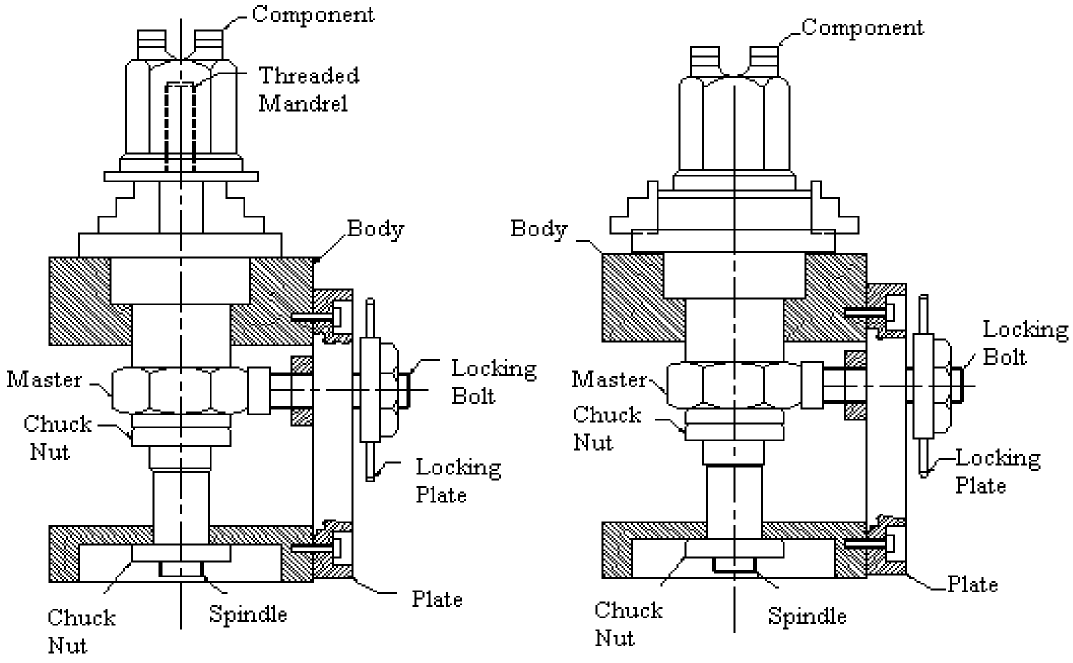

Figure 4.14: Comparison of Existing and Modified Fixture

A careful study of cause and effect diagram reveals that the main cause of rejections was incorrect setting up of machine tool on special purpose machine and mishandling of component during heat treatment stage. If the threading and grooving is done after the heat treatment, then rejection can be eliminated or minimized, whereas threading can be done on CNC after heat treatment, because inserts are available for hard part machining up to 60HRC. But for this, slot milling operation must be completed before heat treatment. After discussion with the management, it was decided to revise the manufacturing process. If threading operation is done after the heat treatment process then the clamping of the component should be changed from the previous clamping method where it was held through threaded mandrel as depicted in Figure 3.15. Hence a need of fixture modification is required in existing fixture.

V. MODIFIED MANUFACTURING PROCESS

In the modified process, boring, back boring, threading and grooving is done after the heat treatment i.e. the component is sent for heat treatment without threading and grooving. Boring, back boring, threading and grooving operation is carried out on CNC turning centre.

Figure 4.6 shows the comparison between existing manufacturing process and the modified manufacturing process of nut steering knuckle. Figure 4.6(b) shows the operations which have been modified by dotted lines. The operations 7 and 8 have been proposed to be carried out on CNC machines. Moreover, the heat treatment process which was earlier performed after threading operation is now performed before boring and threading operation.

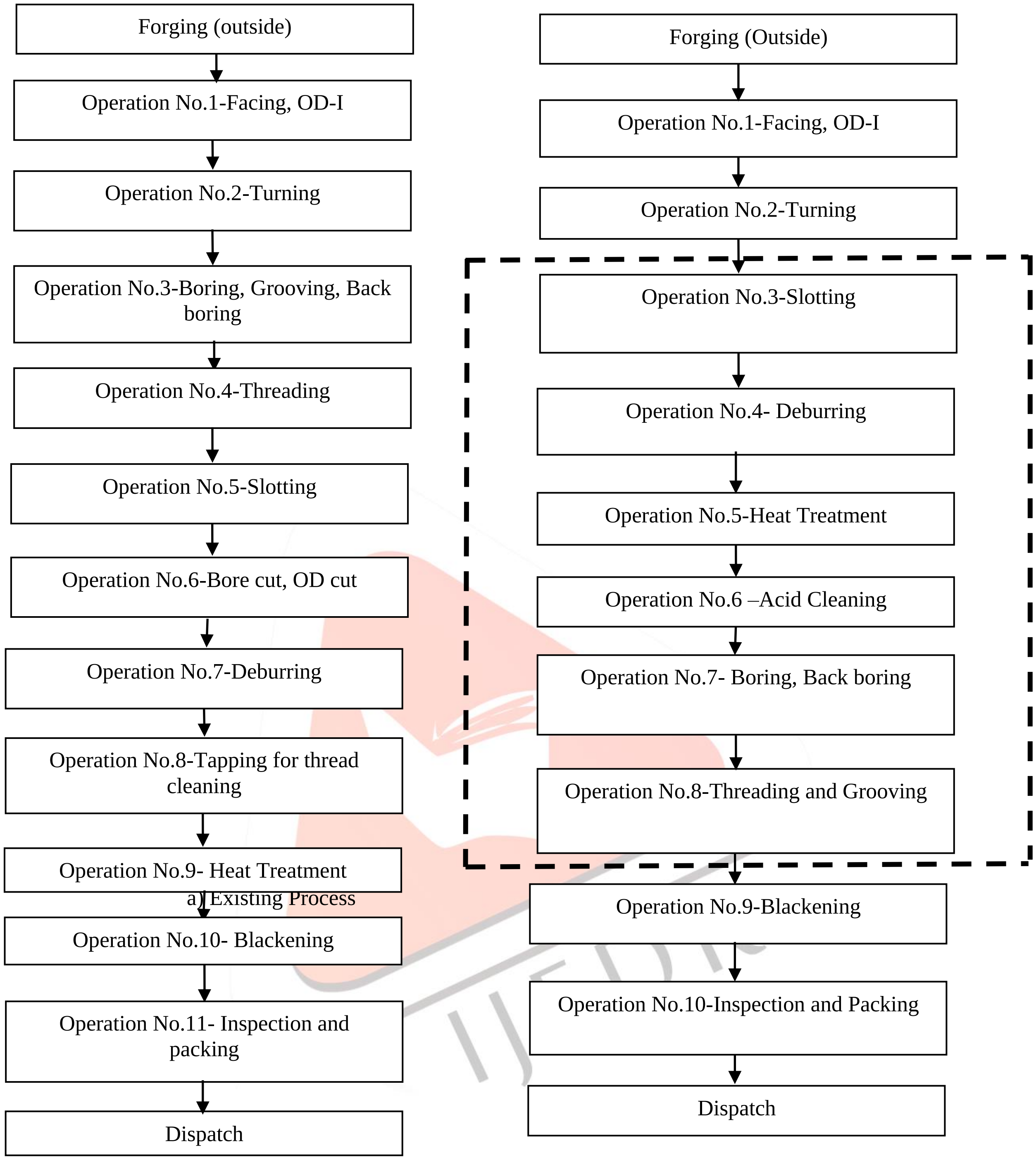

Figure 4.6: Comparison of Manufacturing Processes

VI. CONCLUSION

1. In the modified process, boring, back boring, threading and grooving is done after the heat treatment i.e. the component is sent for heat treatment without threading and grooving. Boring, back boring, threading and grooving operation is carried out on CNC turning centre.
2. Cycle time of boring operation on conventional lathe machine was 50 sec and on CNC machine this cycle time was reduced to 20 sec. This resulted in 60% reduction of machining time. For back boring, cycle time was 110 sec and on CNC machine total cycle time was 30 sec. Similarly, for grooving and threading, the cycle time was reduced to 30 sec and 35 sec respectively.
3. Reduction in labour by using modified process as boring, back boring and grooving was done on conventional lathe machine and then threading was done on special purpose machine. So these operations were done by two workers but now boring, back boring, grooving and threading was done on CNC machine so only one worker is required to carry out these operations.

4. The modified clamping method of the component for slot milling helps the company to perform the threading operation after heat treatment.
5. Modification in manufacturing process and fixture resulted in decrease in defective components from 15.18% to 1.00%.

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