Design and Fabrication of Special Purpose Tool Fixture for CNC Turrets

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Abstract

Manufacturing industries in India have brought lot of radical changes in the manufacturing technology, because of which several improvements like CNC machine centers, flexible manufacturing systems, fabrication center, robotics etc. took place. There is a continued use of fixtures in spite of so many advancements in the manufacturing industries and the use of such special fixtures continues either in combination with other systems or autonomously. Various aspects related to the design of tool fixtures have already been well described by various eminent authors, but there has always been the need to apply all these research work in to a manufacturing industrial application. This paper unifies all the aspects and the functional approach to the designed, manufactured tool fixture. This is justified by taking a real component from an industry for our analysis.The component is cylindrical body of Automobile industry. The operations to be performed are outside diameter turning, boring and drilling, inner chamfers. The research work of this paper turned out to prove that a lot of rupees where saved in installation costas now these operations can be performed on CNC centre instead of complicated procedures using the designed tool fixture. The paper presents the integrated approach of design for manufacturing. This research work includes the 3D assembled view of tool fixture using Solid works 2014 and also reports generated from ANSYS. The present contentsof the paper are a deuce of the research work, Process planning and manufacturing. The application is real time and the tool fixture is not only designed but tested with various materials and manufactured.

Index Terms: *CNC (Computerized numeric control), Fixture, CNC machining tools, Special purpose tools, Process planning, andspecial purpose tool holder.*

I. INTRODUCTION

The manufacturing industry has undergone lot of changes in order to meet the custom engineered systems and parts. Initially it was basic manufacturing process with general tools and tool fixtures. Most of these machines were offering manufacturing flexibility but lacked mass production standardsattributing to a lot of machine adjustments and adjustments in tools which consume lot of time and require skilled operators.

With increasing competition from various regions for low labor costs and fast manufacturing techniques, this specialized tool fixture was designed. This tool fixture in the CNC enabled good amount of success for mass production and was flexible. This in turn led to reduced machining times and brought down the labor costs. Because of its flexibility this fixture could also accommodate smaller lot and piece production.

Considering the need in manufacturing industries, these specialized tool fixtures could flexible and inflexible production. And this leading to the research work on the specialized tool fixture for the CNC turret [1]. This paper elaborates and explains the design, manufacturing of the special purpose tool fixture used in the CNC turret especially with the tool fixture being economical for mass production as well as piece production and this without any alteration to the existing CNC system [2].

II. STATEMENT OF PROBLEM

"Design & fabrication of special purpose tool fixture for CNC turrets. The operations which are to be performed are drilling, front facing, outside diameter turning, inner and outer chamfers. The work piece is held to its fixture and the tool fixture is not stationary. Lackof process planning which aides in consuming manufacturing time and labor costs."

III. COMPONENT DETAILS

The methodology proposed for the design and fabrication of the tool fixture includes a two stage realization. The first stage presents the component details like its geometry, analysis of various forces and machining process. The second stage presents design of the tool fixture along with its assembly. As part of the first stage, the component geometry is expressed in here [Figure 1]. The component is hallow cylindrical part made of mild steel, weighing 0.898 Kg and is one of the parts used in automobile engines. The component is used as a coupler or as a joint with shafts in the engine the holes on the cylinder help the lubricants and other oils to pass through. The component in raw material form is proof machined with 2mm machining allowance on the CNC. The operations to be performed on component are facing, drilling, turning on both outside and inside diameter, creating chamfers on both ends along with the various holes drilled on the cylindrical component and some other basic machining operations. The front view of the component is expressed here [Figure 2].

The component here is understood as work piece. The work piece is also considered in various other materials such as Aluminum, Copper, Stainless steel, higher grade of plastic and grey cast iron.

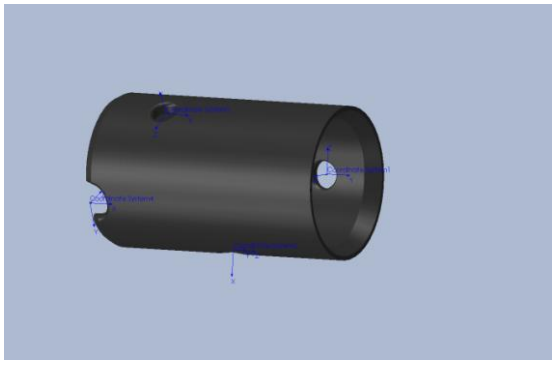

Figure 1. 3D View of the Finished Part.

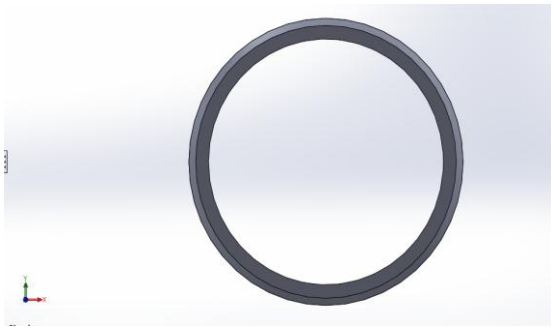

Figure 2. 3D Front View of the Finished Part.

IV. DESIGN OF SPECIAL PURPOSE TOOL FIXTURE

The location of the work piece is essentially noted as it has various deformations caused due to the clamping and other forces [3]. The tool fixture is designed considering the size and position of the work piece. Any vibrations caused might affect the cutting force on the work piece and hence rigidity is the key in controlling such effects [4]. The tool fixture solution has several physical elements such as gears to transmit power from one drive to another, shafts, and certain parts which assist in making the fixture hold together as shown here [Figure 3].The parts fabricated where hardened considering their size and the strength required by them to withstand the forces acting on the fixture during the machining [5]. The inner and outer chamfers created on the work piece are of priority as they have been the most time and cost consuming machining process. Considering all the above the complete tool fixture is designed and fabricated which is shown here [Figure 4] [6].

The tool fixture is designed in a manner that it can travel inside the work piece for machining the inner chamfers and can also machine outer chamfers as shown here [Figure 5] [7]. The work piece is held firmly by the fixture in the CNC, but the contact complication by the friction persists and can experience tension or slipping depending on the magnitude of machining. [8]

The CNC tool holder is attached with the specialized tool fixture. Once connected to the CNC spindle drive the gears in the specialized tool fixture transmit the force to the tool and hence machining the work piece. The total weight the CNC tool holder can hold is 28 Kg and the weight of the complete specialized tool fixture along with the tool is 19.80 Kg which rotates at the speed of 300 rpm while performing the machining operation. The speed is variable by controlling or setting the spindle speed of the CNC.

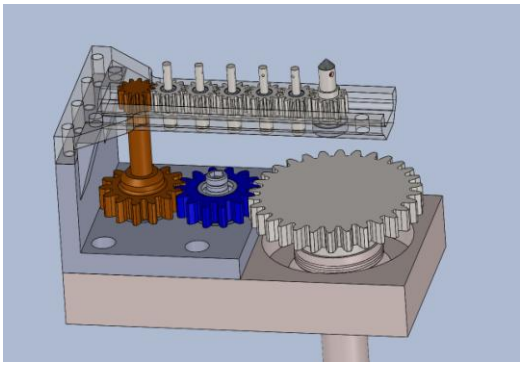

Figure 3. 3D View Tool Fixture.

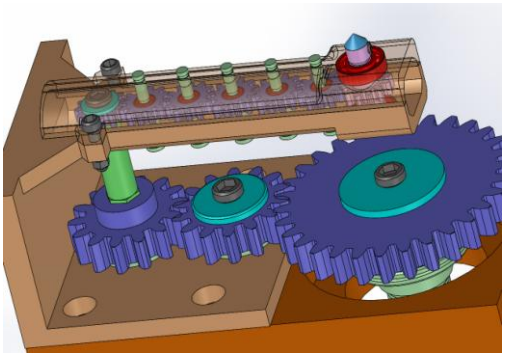

Figure 4. 3D View of the Tool Fixture Assembly Without The Work Piece.

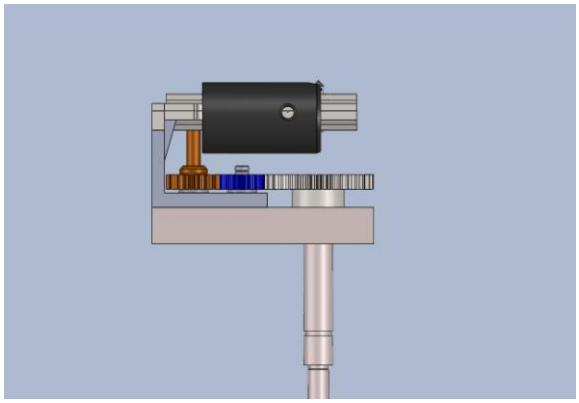

Figure 5. 3D View of the Tool Fixture Assembly with the Work Piece.

V. STRESS ANALYSIS

Stress analysis is carried out on the tool fixture using ANSYS. In the analysis shown below is the result that the machining is been successfully carried out [9]. There are five materials taken in this analysis. Various forces like the cutting force and moments are taken in to consideration for the analysis [10]. The stress analysis is carried out considering various materials such as Aluminum, Copper, Stainless steel, higher grade of plastic and grey cast iron. The [Figure 6 and 6A] explains the work piece and the stress calculated for Aluminum is 1.6869e-6 m Max. This is the metal deformation during the machining for creating the chamfers inside out [11]. The stress calculated for Stainless steel is 0.00014804 m Max and shown here [Figure 7 and 7A]. The stress calculated for high grade plastic is 2.9636e-6 m Max and is shown here [Figure 8 and 8A]

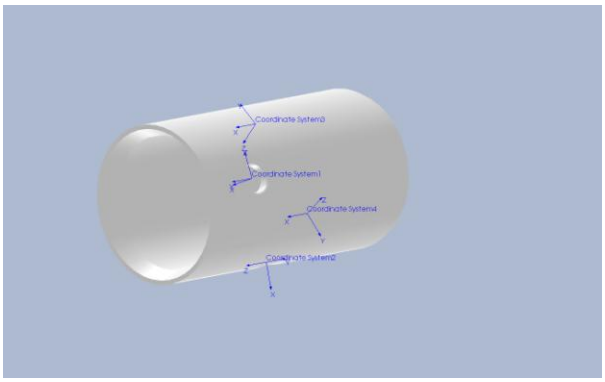

Figure 6. 3D View Of The Work Piece - Aluminum.

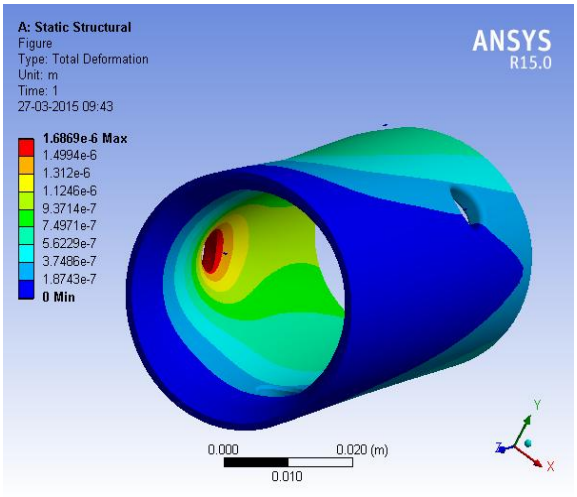

Figure 6A. Stress Analysis of the Work Piece - Aluminum.

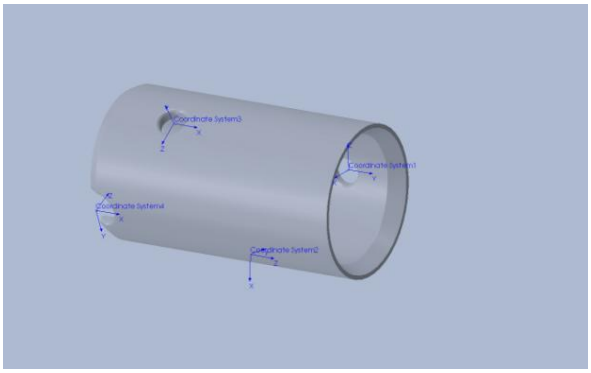

Figure 7. 3D View of the Work Piece – Stainless Steel.

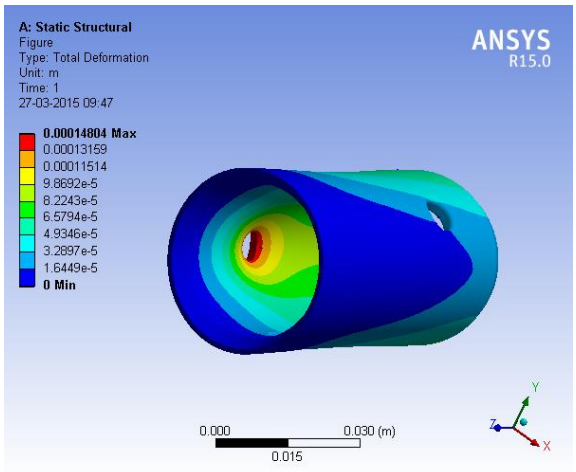

Figure 7A. Stress Analysis of the Work Piece – Stainless Steel.

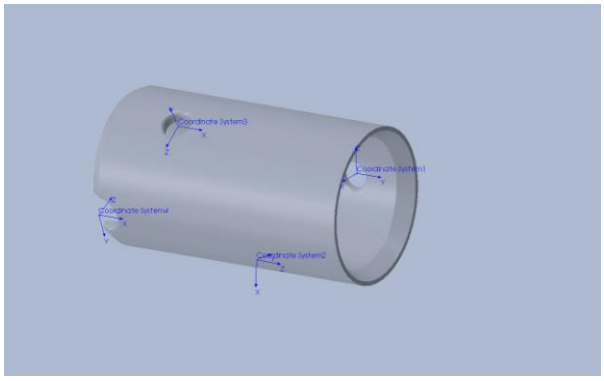

Figure 8. 3D View of the Work Piece – High Grade Plastic.

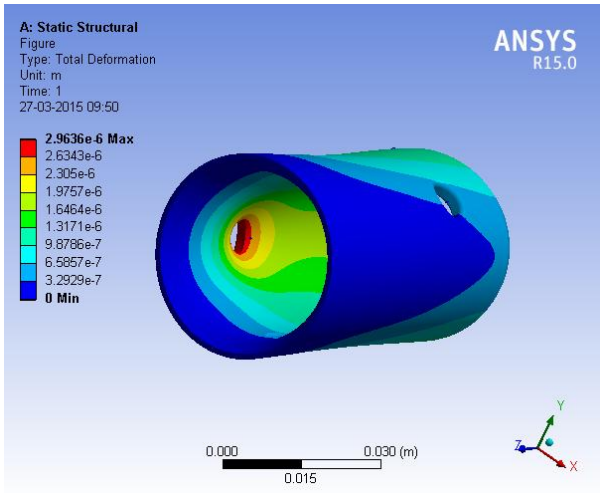

Figure 8A. Stress Analysis of the Work Piece – High Grade Plastic.

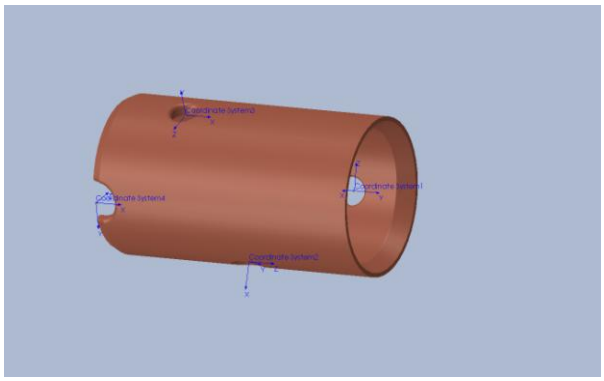

Figure 9. 3D View of the Work Piece - Copper.

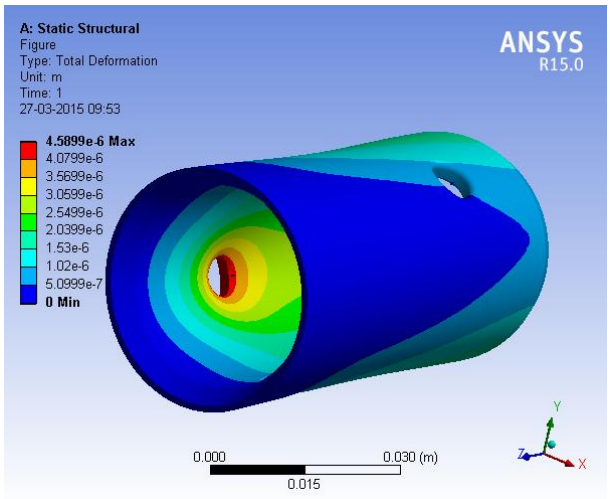

Figure 9A. Stress Analysis of the Work Piece - Copper.

The stress analyzed for Copper is 4.5899e-6 m Max and is shown here [Figure 9 and 9A]. The stress analyzed for Grey cast iron is 1.2923e7 m Max and is shown here [Figure 10 and 10 A].

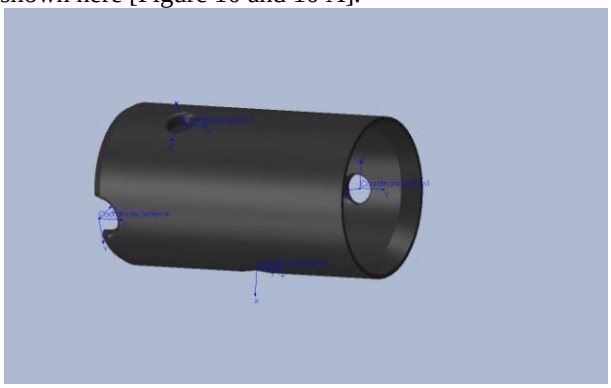

Figure 10. 3D View of the Work Piece – Grey Cast Iron.

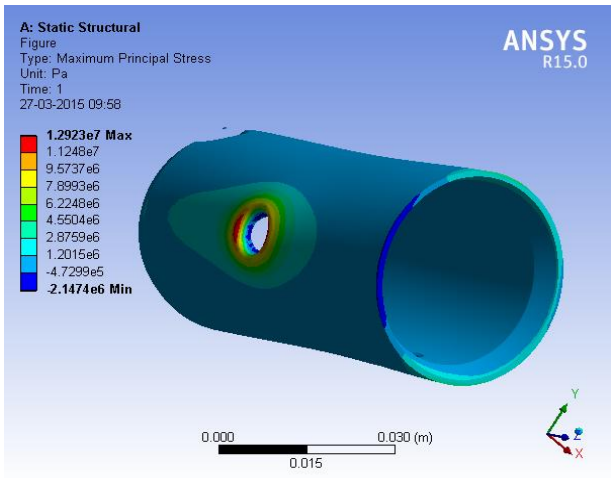

Figure 10A. Stress Analysis of the Work Piece – Grey Cast Iron.

VI. CONCLUSION

This paper provides an integrated approach to manufacturing, designing a special purpose tool fixture and stress analysis of the work piece considering the cutting force. This approach has been crucial for manufacturing industries in real time by understanding the real challenges they face during the various operations they perform. The total cost of the special purpose tool fixture summed up to Rs 12,000 which is very moderate considering the machining time and the discomforts faced by a labor. Here the research work is proved as 5 million rupees are straight away saved by installing the special purpose tool fixture in the CNC turret.

The analysis of stress is essential to understand the properties of the work piece such as deformation. The validity of the model has been checked by conducting conformity analysis in ANSYS.

VII. FUTURE SCOPE

The second set of specialized tool fixture can be designed and fabricated for the same work piece comprising of multiple operations which could save further labor cost and time for the operation.

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