Investigation on the Influence of Geometrical Deviation of Rack in the Assembly Process and Development of the Fixture

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Abstract - Fixtures have a direct impact on the productivity and the quality of the product, so the design of the fixture for the respective production process is important. This paper deals with the design and fabrication of the assembly fixture to mount the subassembly parts of the MultiTherm^{Pro} plasma cutting machine. In the existing method, the rack and pinion concept is used for the horizontal movement of the plasma torch and the alignment of the rack in the groove (horizontal column) is done manually. Considering the process quality, manually aligning the rack leads to a deviation or error in rack assembly. Also, the technique suggested in this paper helps in reducing the cycle time of the production process. The fixture was designed with the CAD software and the fixture was developed based on the requirement.

Keywords - Fixture, Rack Deviation, Productivity, Quality, Cycle Time.

I. INTRODUCTION

The motive of every production based industry is to deliver a quality product within the stipulated time. The demand from a customer gets increasing day by day so the manufacturing sectors were also adopting new technologies and tooling for faster, more economical, and reliable ways of production [1]. For this companies going for newer types of fixturing. Fixture has its own advantages like accuracy, skill reduction, time-consuming, etc. Fixtures are of two types, one is a dedicated fixture and the other is a modular fixture [2].

Inside the manufacturing unit fixture plays a variety of roles in machining, assembly, inspection, etc. As said earlier fixture tooling aims at a high degree of accuracy and interchangeability and it is one of the important ways to reduce the cycle time of the entire production process. But there is difficulty in developing fixture tooling due to design constraints since every time developing a prototype increases the overall cost of the production. So demand for developing the fixture without generating the prototype has arrived which was overcome by computer-aided designing (CAD) using various software. The real-time fixture can be visualized through cad models and any changes can be made easily [3, 4].

The Fraunhofer IWU developed a fixture for clamping the robot in the assembly section. The fixture has a specialized clamping facility to accompany the assembly robot, since the Fraunhofer IWU have different car models, they cannot develop individual fixture for each assembly robot, which reduces the production cost, and cycle time [5]. The fixture for engine door assembly was developed by Aphale S, et. al., [6]. The author analyzed the existing problem and the same was eliminated by the trial and error method using CAD software. The author claims that, after implementing the fixture, the cycle time in the assembly unit has reduced to 40%. A prototype model was developed using CAD software for modular fixtures for the designing and developing of any type of fixture in order to reduce the designing time [7]. Computer-aided designing will help us to develop large-scale mechanical products, in which fixture design is not a problem [8]. The author developed a fixture to reduce the cycle time in the assembly of adaptors for gas equipment [1].

Plasma cutting is a process that cuts electrically conductive material through accelerated jet plasma. The rack and pinion mechanism on the horizontal column is used in the movement of the torch assembly setup. So alignment between the rack and pinion must be perfect because if there is any deviation in the alignment of the rack it may result in a dimensional error in the cutting process.

A groove provided on the horizontal column which is shown in **Fig 1** is used to align the rack. The groove will be present for the overall length of the horizontal column of the machine having a tolerance limit from 30mm to 30.5mm in width and 2mm to 2.5mm in depth. During the machining of the groove, there is a possibility of an error occurring while machining the groove using a milling machine. The groove will be in the permitted tolerance, but at one place it will be 30mm and at the next place it will be 30.2mm. Even though it is inside the permitted deviation, the deviation will reflect back in the assembly of the rack. While taking the rack into consideration, the rack will be in the given dimension with zero-dimensional error. The rack will be mounted within the groove located on the horizontal column. A drilling operation is done for the rack and the groove, to lock the movement of the rack. Drilling of the rack and groove has a tolerance limit of 59.9mm to 60.1mm, the difference in tolerance say 50 microns will also reflect in the alignment of the rack.

The main objective of this work is to design and develop a fixture to support the production process for aligning the rack perfectly and to minimize the deviation or error in the production process i.e., improving the accuracy of the plasma cutting process. Another benefit of developing this fixture increases the production cycle by easier alignment of the rack on the column

Fig 1. Horizontal Column of The Plasma Machine.

II. METHODOLOGY OF THE WORK

The work has been experimented in MultiTherm Pro–Plasma Cutting Machine at MESSER Cutting Systems located in Coimbatore district, Tamil Nadu. Assembly of parts in the plasma cutting machine is performed by manual method. Likewise, the assembly of plasma arc torch in the crosshead of the horizontal column is also assembled by human hands. The movement of the torch is controlled by the stepper motor and it is moved by rack and pinion setup in the horizontal column. The rack is aligned and assembled by human resources, which takes a lot of time and needs higher accuracy while assembling the rack. So in order to improve product quality and reduction in process timing a fixture was designed to hold the entire rack for mounting it on the crosshead horizontal column. **Fig 2** shows the steps involved in the development process of rack fixture for the plasma cutting machine.

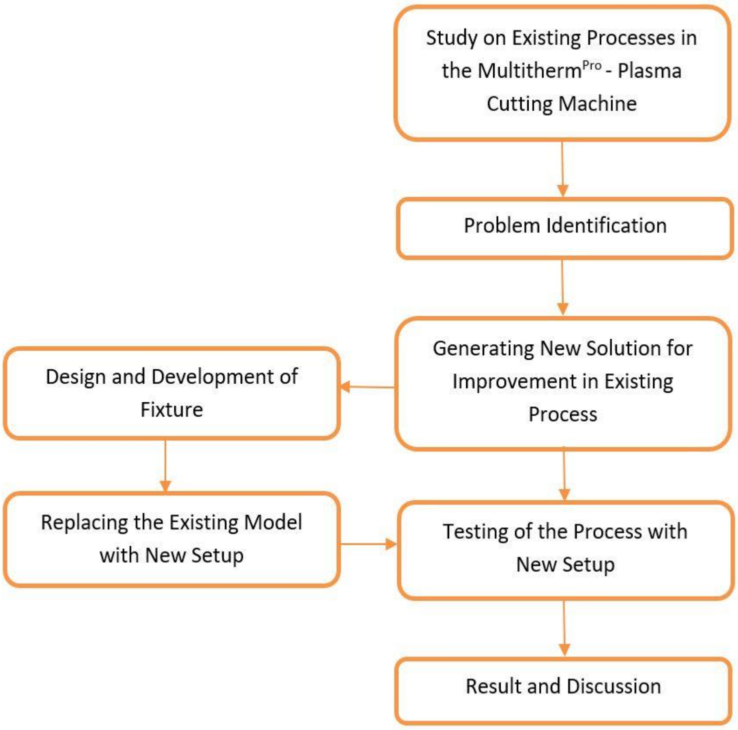

Fig 2. Methodology of The Workflow.

III. EXPERIMENTAL STUDY

Dimensional Errors

At first, the existing work process was studied by taking the readings, to find how much deviations (dimensional errors)are taking place in the assembly process. During the assembly of the rack, there are several machining operations were carried out like milling the groove, aligning the rack in the groove, and drilling the rack with the groove.

Groove Deviation Measurement

The plasma cutting machine has two different lengths of cross beam i.e., 6 meters and 4 meters. The groove is made for the entire length of the beam. The vernier caliper is used for measuring the depth and width of the groove. Randomly ten various points were selected in the overall lengthbeam and it is observed that it is not the same in all the measured points. The deviation was measured and tabulated in **Table 1**. The deviation that occurs will also reflect back in the rack alignment process [9, 10].

Rack Deviation Measurement

After machining the groove, the rack was assembled inside the groove on the beam. The deviation in the rack alignment was noted down using the dial indicator which can be seen in **Fig 3**. The deviation varies from one point to another point. If the variation is greater than 50 microns from the given tolerance values, it will have an effect on the alignment process.

Fig 3. Rack Alignment Using Dial Indicator.

Time Study for Rack Alignment

The time study indicates how much amount of time is taken to align the rack in the groove. Time study is confronted with the following considerations, length of the beam (whether it is a six-meter beam orfour-meter beam), the type of person who is assembling the rack (whether the person is an experienced person or a new person) [11, 12].So these are the criteria prescribing the time taken for assembling the rack in the beam groove and the time study was tabulated in **Table 1.**

Table 1. Time Study on Rack Alignment

Length of the beam	Experienced employee	New employee
6-meter beam	3 hours	3.5 hours
4-meter beam	2 hours	2.5 hours

The errors or deviations which are in the groove, rack, and drilling process are not taken into consideration because the same type of part is being given to both the new employee and the experienced employee.

IV. DESIGN AND DEVELOPMENT OF FIXTURE ASSEMBLY

Based on the real-time study of the rack assembly process some disadvantages in the assembly process were observed and to improve the assembly process a fixture was designed and developed, which definitely improve the assembly process, production time, and accuracy of the plasma cutting torch.

Cad Modelling

Solidworks 2018 was used for the development of the CAD design. The fixture was designed by trial and error method based on fulfilling the requirements like the length of the beam, fixture setting time, the weight of the fixture, mechanism of the fixture, and the number of labor power required [13, 14, 15]. Finally, an assembly fixture was designed by satisfying all the requirements which is shown in **Fig 4**.

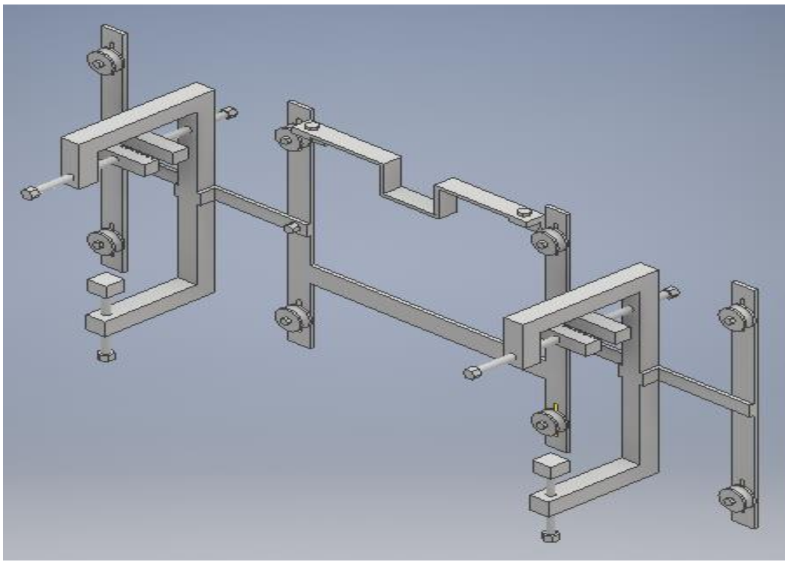

Fig 4. CAD Model of The Fixture.

Fabrication

Considering the weight and built quality of the fixture, mild steel was selected for fabricating the frames and the rollers were made using stainless steel 310 grade for easy maintenance. The slots are provided in the clamp as well as in the roller mounting area for the purpose of adjustment and to fix or hold at required places.The guiding wheels are to be seated in the aluminum chamber near the rack. The bolts and nuts which are used are mainly stainless steel and mild steel of the size M10 and M6, the reason for choosing M10 is to withstand the load which is given by the worker during the alignment process [16, 17].

Fig 5. Fabricated Fixture.

The rack in the fixture clamp and the rack to be assembled in the groove have similar pitches for the proper alignment of the rack in the beam groove [18]. The bottom of the clamp is fixed with the rubber bush to prevent scratches in the machine (horizontal column). Finally, the weight of the assembly fixture was calculated which is around 7.23 kilograms. The carriage beam is capable of carrying tons of load, so the weight of the fixture will not play a negative role during the assembly process. The fabricated assembly fixture was shown in **Fig 5, 6** and the sub-parts like fixture rack, tightening bolt or clamps were shown in **Fig 7, 8** and **9**.

Fig 6. Side View of The Assembly Fixture.

Fig 7. Rack with Tightening Bolt.

Fig 8. Fixture Rack.

Fig 9. Bolt with Rubber Stopper.

V. CONCLUSION

The works aim to develop an assembly fixture for the improvement in process quality and product quality. The work was conducted in a MultiTherm Pro Plasma Cutting machine. At first, the workflow and the assembly process were studied. A fixture was created by trial and error method by satisfying all the requirements in the assembly process. Solidworks 2018 software was used for developing the CAD model of the fixture and the same was fabricated. For fabrication, proper material was selected for each component or part of the fixture and finally, a complete setup was made. Fabricated assembly fixture is implemented and tested in the industry. It can be observed that the time taken for assembling the rack is reduced from three hours to two and a half hours. Then the quality of the work is also improved by the reduction of deviation in rack alignment.

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