Design and Manufacturing of 5 Cylinder Hydraulic Fixture for Machining Case on VMC EZ5

[1]Niraj J. Sanghani, [2]Dr. Nirav P. Maniar, [3]Prof. Hardik Khunt and [4]Prof. Pankit Kondhiya

[1]Student, Masters of Engineering, [2]Associate Professor, 3 Assistant Professor, [4]Assistant Professor
Mechanical Engineering Department, V. V. P. Engineering College, Rajkot – 360 005, Gujarat, INDIA

Abstract

Various areas related to design of fixture are already been very well described by various renowned authors, but there is a need to couple and apply all these research works to an industrial application. The present volume of this research work integrates all these aspects and the evolutionary functional approach is proved from the fact that real industrial component is considered for fixture designing. The component is case of motor body widely used in automobile industry, made up of aluminum ADC12. The major operations to be performed are drilling and grooving. The research includes design and manufacturing of a fixture, which provides location and clamping arrangement for machining 5 operations on various faces of component in one setup on VMC EZ5 of pallet size 600 mm x 400 mm. Application of hydraulic systems till now was limited to machine tools, material handling devices, transport and other mobile equipment, in aviation systems, etc. but very few applications and research work is carried out on hydraulic fixture. This paper includes the unique aspect of designing and manufacturing 5-cylinder hydraulic fixture for machining case on VMC. While designing this research, a good number of literature and titles written on the subject by renowned authors are referred. The important details of the part and fixture are included in each fixture design section along with component drawing, fixture drawing, 3D view of component & fixture using AutoCAD 2017. Fixture is not only designed but manufactured also, it sets the classical example of design for manufacturing.

Keywords: Hydraulic Fixture, Case, VMC, Automobile, Drilling, Boring, Grooving, Design for Manufacturing.

1. INTRODUCTION

A revolutionary change has taken place in the field of fluid power technology due to the integration of electronics as a control medium for hydraulic components and systems. Due to increased sophistication of hydraulics and allied fields of engineering, the hydraulically driven machines are now able to generate more power and higher accuracy in speed, force and position control. In the recent past there has been a significant increase in the use of hydraulics in our industries. The use of oil hydraulic system as a means of power transmission in modern machines evolved a few decades earlier in the western world. But its application in Indian industries is of comparatively recent choice and hence, there is a great deal of urgency and importance to master the art of its application and maintenance.

Application of hydraulic systems till now was limited to machine tools, material handling devices, transport and other mobile equipment, in aviation systems, etc. but very few applications and research work is carried out on hydraulic fixture. This paper includes the unique aspect of designing and manufacturing 5-cylinder hydraulic fixture for machining case of motor body on VMC EZ5 of pallet size 600 mm x 400 mm.

The fixture designing and manufacturing is considered as a complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes. While designing this work, a good number of literature and titles written on the subject by renowned authors are referred.

If a small number of components are to be produced, then steps are marking, setting on a machine, clamping to a machine table. But it is not economical for producing a large number of components. Developing a device on which components can be quickly positioned in the correct relationship to the cutting tool and quickly clamped for machining results into a faster, convenient and more economical method. Fixtures are such devices which are designed to hold, support and locate every part to ensure that the part is machined within the specified limits. A fixture is used to hold a workpiece and locate it correctly with respect to the tool.

It was in the 1940's, when studies in fixturing began. Several manuals on jig and fixture design were developed such as Houghton (1956) and Wilson (1962) [1-2]. Many aspects of fixture design were considered by Henriksen (1973) [3], and a handbook that contained a set of guidelines for fixture design was developed by Boyes (1989) [4].

All findings and conclusions obtained from the literature review and the interaction with fixture designers are used as a guide to develop the present research work.

As stated by Koji Teramoto, Masahiko Anasoto and Kazuaki Iwata (1998) [5]; Fixturing Plan (FP) and Machining Plan (MP) are mutually dependent. Implicit to this conclusion, paper coordinates MP and FP by coupling a fixture design with manufacturing.

A relevant issue when considering requirements, taking this as a general concept, is to make explicit meaning of two main terms: Functional Requirement (FR) and Constraint (C). Functional Requirement (FR), as stated by Hunter, R., Rios, J., Perez J. M., Vizan, A. (2006) [6], 'represents what the product has to or must do independently of any possible solution'. Constraint (C) can be defined as 'a restriction that in general affects some kind of requirement, and it limits the range of possible solutions while satisfying the requirements'. Adapting to this functional approach, the functional requirement is design and manufacturing of hydraulic fixture to increase productivity.

According to Hunter, R., Rios, J., Perez J. M., Vizan, A. (2006), work holding is a key aspect in machining and fixtures are the elements responsible to satisfy this general goal. Usually, a fixture solution is made of one or several physical elements, as a whole the entire FRs and the associated Cs must be satisfied by the designed fixture solution.

The functional requirements of fixtures include centering, locating, orientating, clamping and supporting. There are many factors to be considered in terms of constraints, mainly dealing with shape and dimensions of the part to be machined, tolerances, sequence of operations, machining strategies, cutting forces, number of set-ups, set-up times, volume of material to be removed, batch size, production rate, machine morphology, machine capacity, cost, etc. At the end, the solution can be characterized by its: simplicity, rigidity, accuracy, reliability, and economy.

The following section presents the real-time research work of designing and manufacturing 5-cylinder hydraulic fixture for machining rear flange on VMC EZ5 of pallet size 600 mm x 400 mm. The important details of the part and fixture are included in each section along with component drawing & fixture drawing, 3D view of finished component & 3D assembled view of fixture using AutoCAD 2017.

2. DESIGN AND MANUFACTURING OF HYDRAULIC FIXTURE

2.1 Statement of Problem

"Design and manufacturing of hydraulic fixture for machining case of motor body on VMC EZ5 of pallet size 600 mm x 400 mm. The major operations to be performed are drilling, boring and grooving."

2.2 Component Details

The methodology proposed for design of a fixture includes the realization of two stages. The first stage represents the knowledge of the objects like part geometry, machining process, functional and detailed fixture design and fixture resources. The second stage describes the inference process (design and interpretation rules) needed to obtain a first solution for the machining fixture [7]. As a part of first stage, component geometry is discussed here [Fig. 1,2].

The component is case of motor body widely used in automobile industry, made up of aluminum ADC12 and overall dimensions are 231mm diameter and 31.5 mm height weighing 700 gram. The raw component is made by High pressure die casting process and then turning of all required faces are performed. Machining operations are to be performed on 3 faces – 2 sides from top and bottom face.

The list of operations to be performed are as under:

1. Drilling 6 holes, ϕ 7 mm
2. Drilling 6 holes, ϕ 6 mm
3. Drilling 1 holes, ϕ 2 mm
4. Boring, ϕ 81.3 mm
5. ID Grooving (2.6 mm)

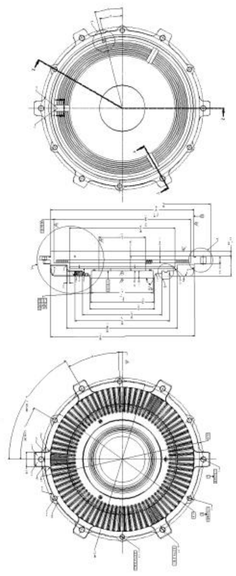

Fig. 1. 2D drawing of finished component

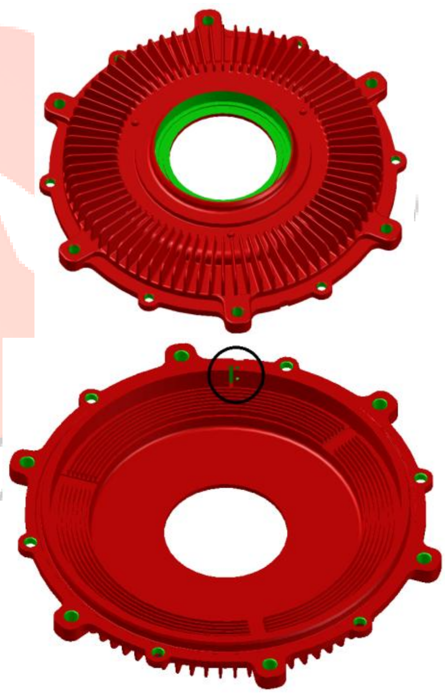

Fig. 2. 3D view of finished component

2.3 Design of fixture

According to design specifications (Nee and Kumar, 1991) [8], the basic function of a fixture is to locate and secure the workpiece in the correct orientation and relationship so that manufacturing can be carried out. A typical fixture consists of three components: locators, clamps and supporters.

Locators are used to locate the workpiece in static equilibrium. Clamps are used to hold the workpiece firmly against the locators during machining for rigidity. Cutting forces and tool direction are major considerations. Additional hydraulic work supports are used to reinforce the stability of the workpiece. The use of these fixturing elements can be determined manually or analytically. The three fixture elements must assure that the workpiece is rigid, positively located and assures repeatability, since the external cutting forces acts on workpiece during machining.

All these states of the art guidelines are used to design the present research work. According to very basic principle of location suggesting that machined surface should be used for location, bottom face of the component is used for machining as it is received finished by turning process after casting. The complete location is achieved using base plate, one rest pad, one retractable orientation pin and four poka-yoke nylon pins. Base plate provides the support to all components of fixture as well as piping for hydraulic fluid to operate hydraulic clamps as well as retractable orientation pin. Using principle of mutually perpendicular planes, a rest pads and orientation pin are used to locate the component. Orientation pin locates in a hole where drilling process is occurred. So, a push-pull cylinder is provided to retract orientation pin after clamping. Four hydraulic clamps are used to clamp the component. Total 5 cylinders are required to operate 4 hydraulic clamps and one orientation pin. Front and Top view are shown in fig. 3. Isometric 3D view of fixture assembly without rotary table and workpiece as well as with workpiece and rotary table are shown in fig. 4 and 5 respectively. Figure 4 presents the fixture assembly for one component with locating and clamping devices. Photograph of manufactured fixture is shown in fig 6.

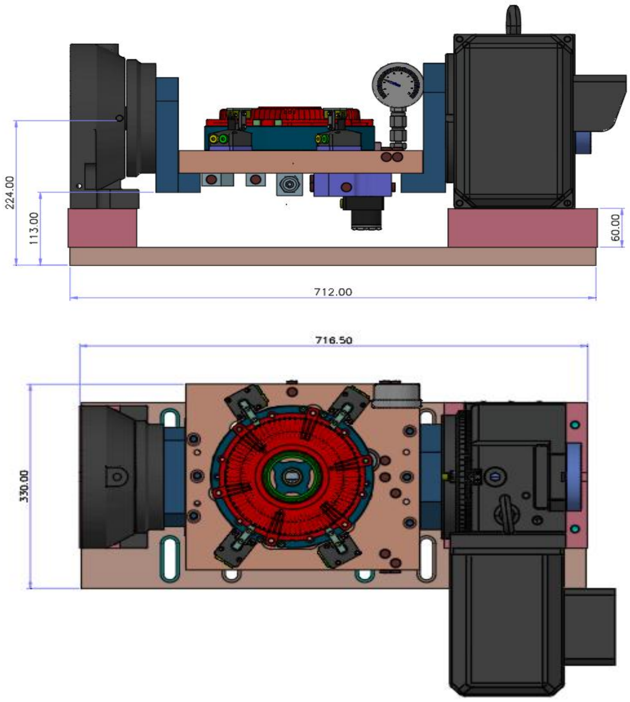

Fig. 3. Front and top view of fixture assembly

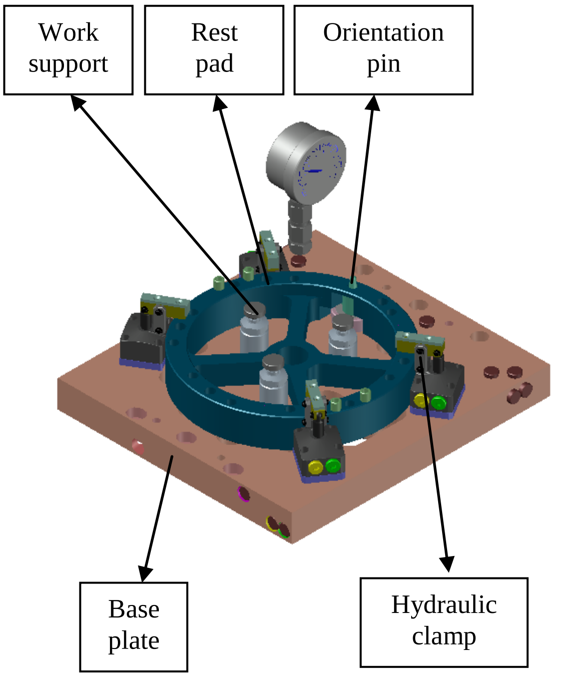

Fig. 4. Isometric 3D view of fixture assembly without workpiece and rotary table

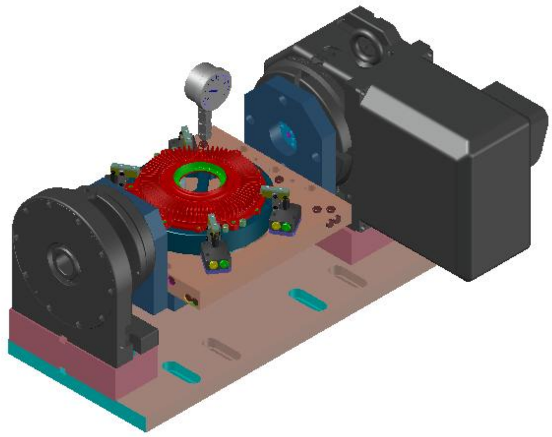

Fig. 5. Isometric 3D view of fixture assembly with workpiece and rotary table

Fig. 6. Photograph of manufactured fixture

3 RESULTS AND DISCUSSIONS

Unique approach of hydraulic fixture is used in the present research work, which results into following advantages:

i. Saves Time

Manual clamping and declamping requires 15 to 20 seconds per clamp. For a fixture with multiple clamping points, the total time for clamping will be more than one minute. For uniform clamping, this time will be still more. This time can be saved by automatic clamping. The payback period for the cost of automation can be estimated considering the net saving per job. (Time saved x Machine hour rate). Advantage of time saving is increase in production capacity of bottle neck machines.

ii. Reduces operator fatigue

In manual clamping, the efficiency of the operator decreases due to fatigue. This may result in less clamping torque at the end of the shift, specifically for the elderly operators, causing reduction in safety. A humane approach is more important than the clamping efficiency. By introducing automatic clamping system, one operator can handle two or more machines simultaneously.

iii. Improves quality of clamping

Only one point can be clamped at a time during manual clamping. To achieve uniform clamping, initially all the bolts are clamped with a light clamping force and then with a heavy clamping force. Clamping force at each bolt may vary. However, following are the advantages of hydraulic automation clamping.

a) All clamps can be operated at the same time. There is no need of a light and heavy clamping force.
b) Clamping force can be controlled as per the requirement, to control dimensional accuracy.
c) Clamping force is consistent.

4 CONCLUSIONS AND FUTURE SCOPE

It is apparent that almost all the literature is focused on principles and theoretic aspects of fixture design. This puts a question of the practical value of fixture research. There is a clear demand for designing & manufacturing fixture for real industrial component and more research in computerized fixture design in such fields. The present research work satisfies this demand by deploying the fixture design task into an overall manufacturing process to obtain best fixture design solution for real industrial component.

The present research work formalizes the use of hydraulics in fixture and reduces non-productive time for performing machining operations on 4 components in one cycle. Hydraulic fixture favors automated clamping, provides uniform clamping force with high operational efficiency. Future scope exists in the present research work, in which two orientation cylinders can be hydraulically operated to improve location accuracy. Fixture is not only designed but manufactured also, it sets the classical example of design for manufacturing.

5 ACKNOWLEDGEMENT

The authors wish to acknowledge the support of Mr. Sudhir Thakar and Mr. Pradeep Thanki, Supra Technology, Rajkot, Gujarat, India for the present research work.

References

[1] D Houghton, P., 1956, “Jigs and Fixture Design”, *Chapman & Hall*.

[2] Wilson F. W., 1962, “Handbook of Fixture Design”, *New York: McGraw-Hill*.

[3] Henriksen, E., 1973, “Jig and Fixture Design Manual”, *New York: Industrial Press*.

[4] Boyes, W. E.,1989, “Handbook of Jig and Fixture Design”, *Dearborn, MI: Society of Manufacturing Engineers*.

[5] Koji Teramoto, Masahiko Anasoto and Kazuaki Iwata, 1998, “Coordinative Generation of Machining and Fixturing Plans by a Modularized Problem Solver”, *CIRP Annuals, Manufacturing Technology*, **47** 437-440.

[6] Hunter, R., Rios, J., Perez J. M. and Vizan, A., 2006, “A functional approach for the formalization of the fixture design process”, *International Journal of machine tools and manufacture*, **46** 683-697.

[7] Hunter, R., Vizan, A., Perez, J. and Rios J., 2006, “Knowledge model as an integral way to reuse the knowledge for fixture design process”, *Journal of material processing technology*, **164 – 165** 1510-1518.

[8] Nee, A. Y. C, and Kumar, A. S., 1991, “A framework for an object/rule-based automated fixture design system”, *Annals of the CIRP*, **40** 147-151.