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Design and manufacturing of 8 cylinder hydraulic fixture for boring yoke on VMC - 1050

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Abstract

Jigs and fixtures are the special production tools which make the standard machine tool, more versatile to work as specialized machine tools. They are normally used in large scale production by semi-skilled operators; however they are also used in small scale production by when interchangeability is important. 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. This paper on “Design and manufacturing of 8 cylinder hydraulic fixture for boring YOKE on VMC – 1050” which integrates all these aspects and the evolutionary functional approach of designed fixture is proved from the fact that a real industrial component is considered for fixture designing. In addition of the fixture being hydraulic type, it is also collet type and has expanding customized collet as its main fixturing element. The fixture shows great time saving in the production.

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Keywords: Hydraulic fixture; Expanding Collet

1. Introduction

There is an increasing need for improved methods of determining the reliability and predicting the lifetime of machines and production systems more accurately. The paper presents unique design of & manufacturing of 8 cylinder hydraulic fixture for boring YOKE on VMC – 1050 with expanding customised collet.

The important details of the part and fixture are included in each fixture design section for clarifying doubts in addition to component drawing & fixture drawing. The research work includes the 3D assembled & exploded view of fixture using Creo Elements/Pro 5.0. Fixture is not only designed but manufactured also, the present research work sets the classical example of design for manufacturing.

2. Related Work

The fixture designing and manufacturing is considered as complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes. The specifications & limitations of the machine limit the ideas of designing. To design a fixture and collet, a designer must know manufacturing procedures. He must be able to visualize exactly how the workpiece is to be made. He should be competent to judge the merits of different methods. He must have knowledge of standards and procedures. He must be inventive and original. He must be able to incorporate his ideas in design layouts. He must understand how tools perform their function. He needs a good background in mechanics and mathematics. He should also know how the physical properties of materials used in making tools. A mastery of drafting techniques is an essential to the tool designer as ability to read and write.

While designing this work, a good number of literature and titles written on the subject by renowned authors are referred. All findings and conclusions obtained from the literature review and the interaction with fixture designers are used as guide to design the present research work. The design of machining fixtures and collet relies on designer experience and his/her implicit knowledge to achieve a good design. In order to facilitate its application, the explicit definition of the collet design process and the knowledge involved is a prior and a fundamental task to undertake. Additionally, a fundamental and well-known engineering principle should be considered: the functional requirements and their associated constraints should be the first input to any design process. A relevant issue when considering requirements, taking this as a general concept, is to make explicit the meaning of two main terms: Functional Requirement (FR) and Constraint (C). Functional Requirement (FR), as it stated by different authors, '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' [2]. Various areas related to design of fixture like machining fixture knowledge, optimizing workpiece setups, modeling of forces, improving workpiece location and high efficiency tools [3-7] are already been very well described by various renowned authors.

Hunter, R., Vizan, A., Perez, J., Rios J Proposed the methodology for design of a fixture which includes the realization of two stages[3]. An important characteristic of a workpiece-fixture system is that locators are passive elements and can only react to clamping forces and external loads, whereas clamps are active elements and apply a predetermined normal load to the surface of workpiece to prevent it from losing contact with the locators[4]. X.P Li, A.Y.C Nee, Y.S Wong, H.Q Zheng developed a theoretical model for forces in milling based on a predictive machining theory and the mechanics of milling[5]. In the model, the action of a milling cutter is considered as the simultaneous work of a number of single-point cutting tools, and milling forces are predicted from input data of the workpiece material properties, the cutter parameters and tooth geometry, the cutting condition, and the types of milling.

3. Statement of Problem

"Design and manufacturing of 8 cylinder hydraulic fixture for boring YOKE on VMC – 1050. The operations to be performed are drilling and boring. Reliability is to be improved and loss of energy is to be reduced through reduction in non-productive time."

4. 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 [3]. As a part of first stage, component geometry is discussed here [Fig. 1-2]. The component is YOKE, made up of material Cast Iron, weighing 1.9 kg. The operations to be performed on component, using designed fixture set up, are drilling and boring. Figure 1(a) is the casting drawing. This is the part to be machined and clamped in the fixture. Figure 1(b) shows 3D view of finished component. Drilling and boring operations are performed on both sides one by one after rotating by 180°.

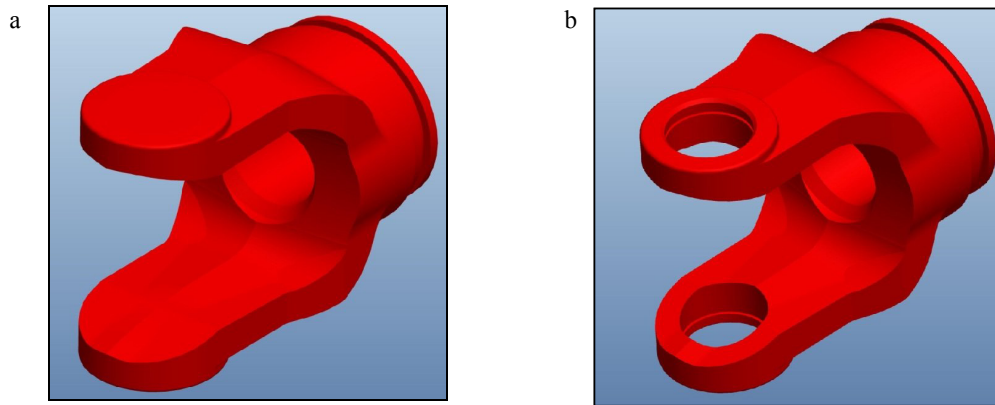


Fig 1 (a) 3D view of Raw Component (b) 3D view of finished Part

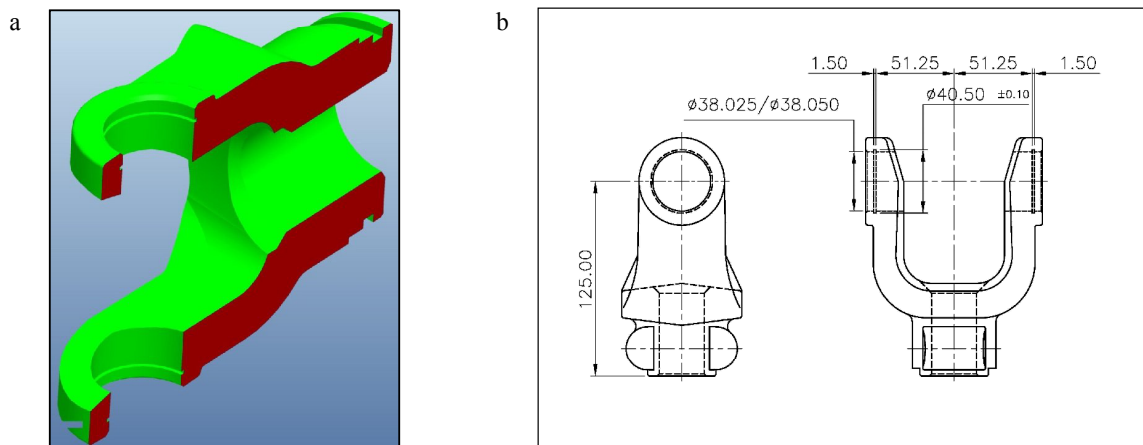


Fig 2 (a) 3D cross-sectional view of finished part (b) 2D Drawing of finished Component

5. Design of fixture – location and clamping considerations

In machining, work holding is a key aspect, 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 designed fixture solution must satisfy the entire FRs and the associated Cs. Centering, locating, orientating, clamping, and supporting, can be considered the functional requirements of fixtures. In terms of constraints, there are many factors to be considered, 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 [4].

S. K. Hargrove and A. Kusiak [5] recognize four general requirements of a fixture: (i) Accurate location of the workpiece, (ii) Total restraint of the workpiece during machining, (iii) Limited deformation of the workpiece, (iv) No machining interference. In addition, as set forth by R. T. Meyer and F. W. Liou [6], dynamic machining conditions occur when a workpart is subject to machining forces that move through the work part or along its surface. A viable fixture designed for a workpart experiencing dynamic machining must ensure: the workpart is

restrained for all time, the clamping forces are not too large or small, deterministic positioning, accessibility, stability of the workpart in the fixture while under no external forces, and a positive clamping sequence.

Considering all above mentioned facts, the complete locating & clamping is accomplished by using collet, stopper and V – block [Fig. 3-7]. 4 work-stations with 8 cylinders are used for complete hydraulic fixture assembly. To start with, component is loaded keeping it in horizontal position into collet side manually. After loading, component is located using stopper, clamped by activating collet side cylinder and aligned by using V-block cylinders. As V-block cylinders are bigger than collet side cylinders, the job is pushed from V-block side and maintains the central axis to be perfectly aligned with respect to the collet axis.

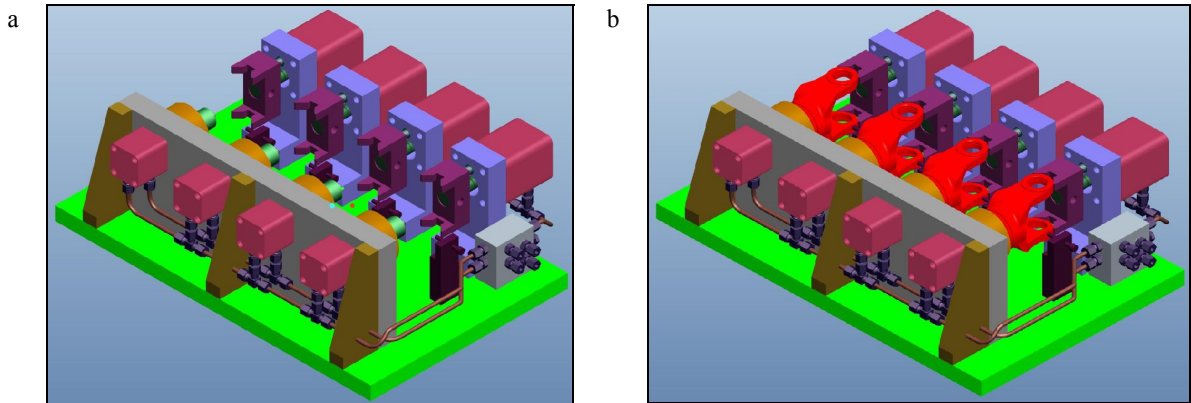


Fig 3 (a) 3D view of Fixture without Component (b) 3D view of Fixture with Component

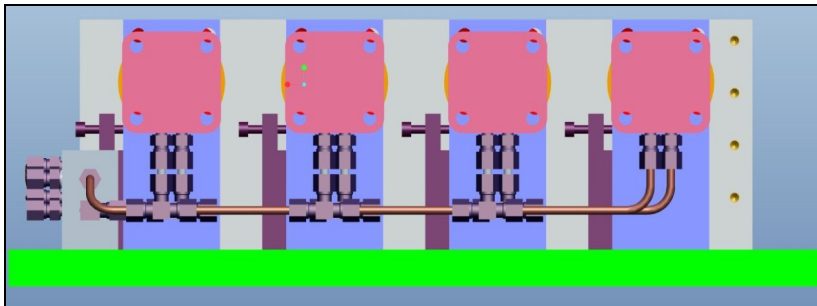


Fig 4 3D rear view of Fixture

Distinguished feature of fixture design –collet and manufacturing of fixture. In addition to the hydraulic nature of fixture, another exclusive feature of the fixture is design of collet [Fig. 7]. It works in the following manner: When the piston rod is retracted, puller rod and expander along with collet will also move from right to left as a single unit. As mandrel is fixed with the rest pad, the collet must have to expand which will fix the job resting over it firmly.

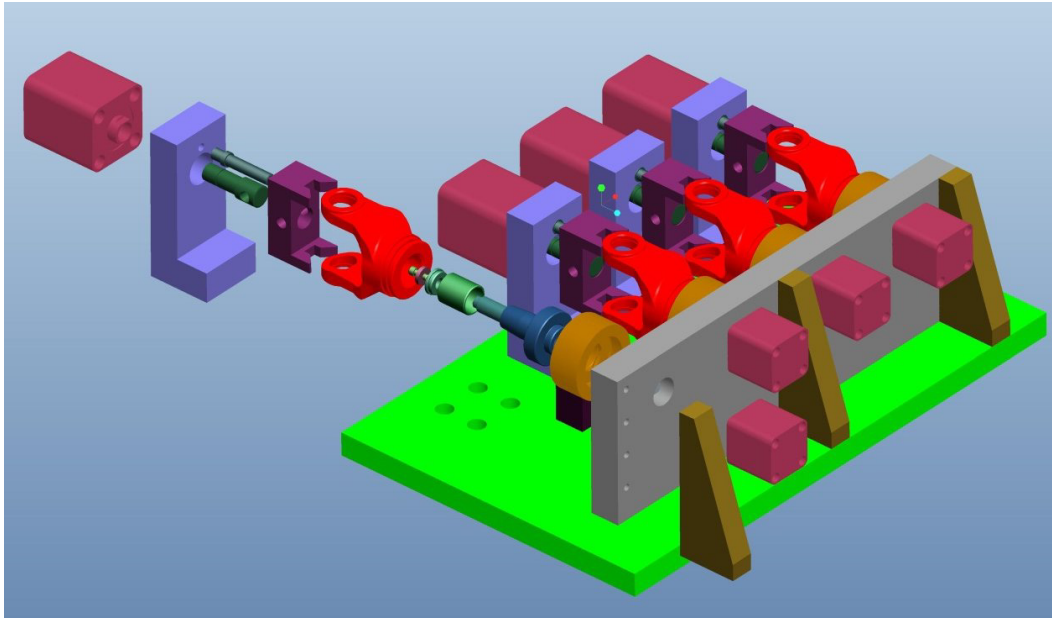


Fig 5 3D Exploded view of fixture assembly

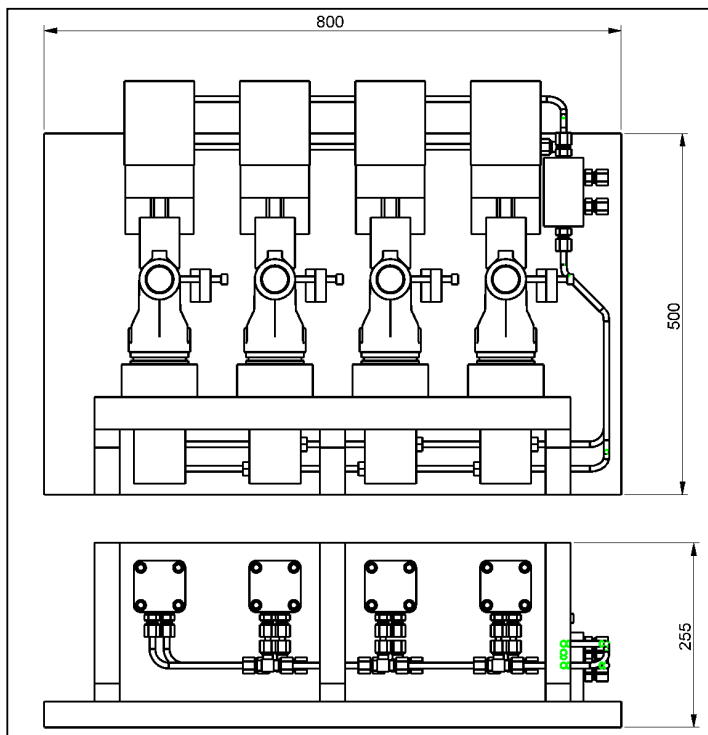


Fig. 6 2D Drawing of Fixture

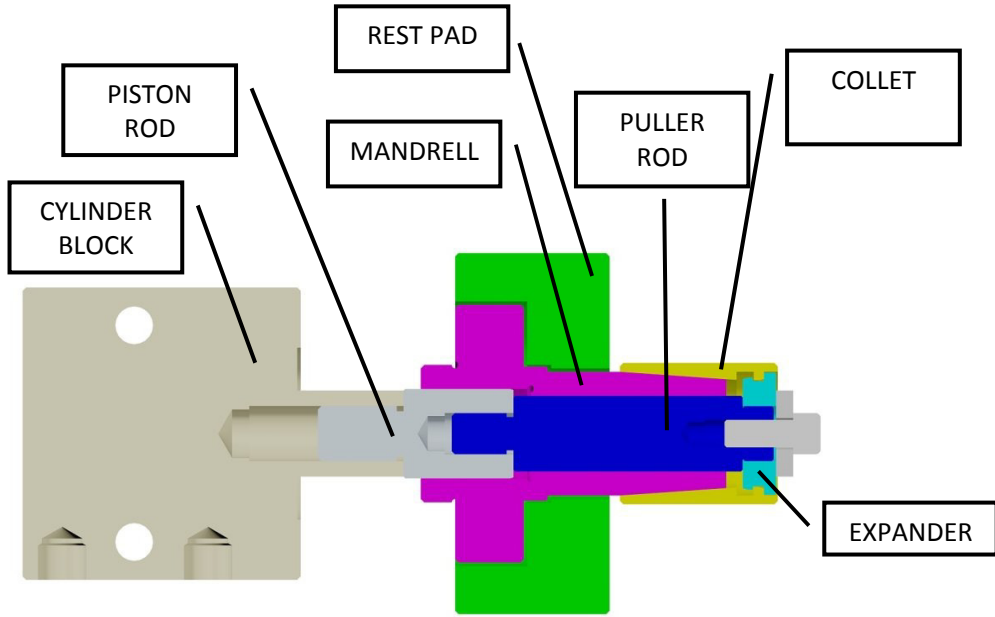


Fig 7 Working of Collet

6. Hydraulic Circuit

Figure 8 shows simplified hydraulic circuit for this fixture.

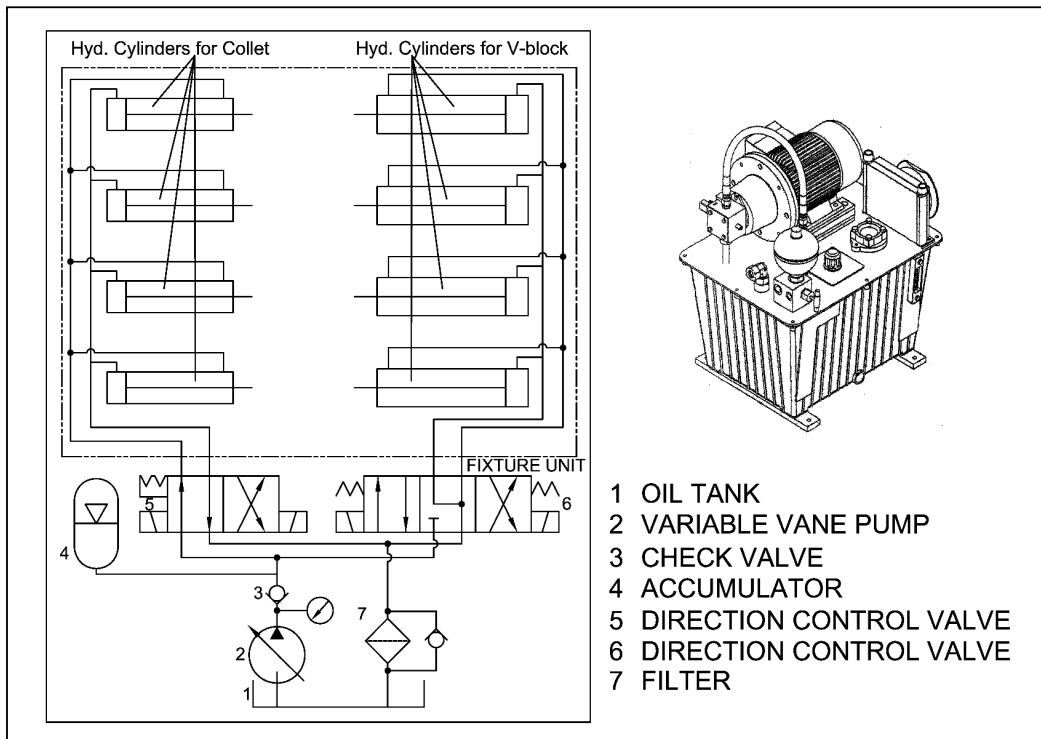


Fig. 8 Hydraulic Circuit with Power Pack

Small variable volume vane pump (Capacity : 8 cm³/rev, Discharge rate : 15 litre/min and Pressure : 7 MPa – Nachi) is used to maintain required pressure of 35 kg/cm² in the circuit. Volume of Diaphragm type Accumulator is 0.75 litres. Direction control valves are solenoid actuated which has pressure capacity up to 35 MPa.

Fixture is not only designed but manufactured also as shown in Fig 9

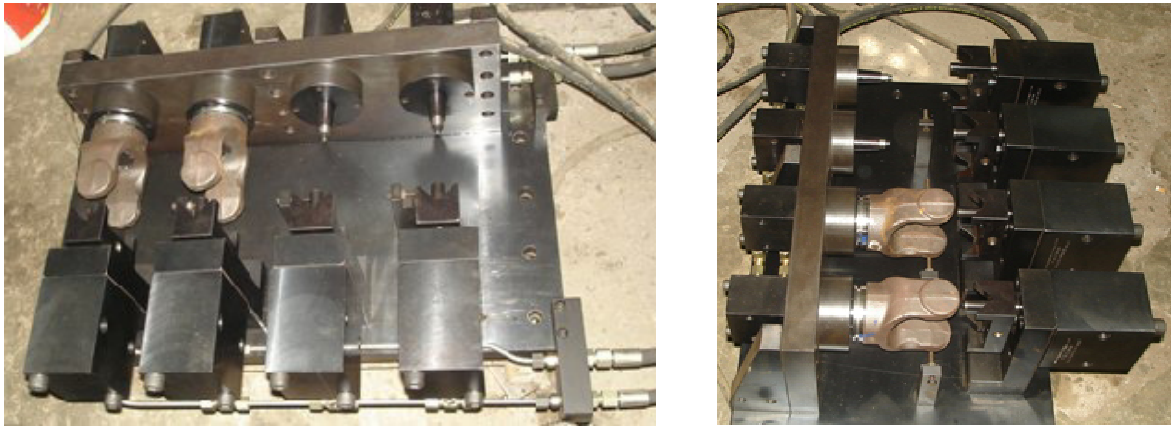


Fig. 9 Photographs of manufactured fixture

7. Conclusion

Paper proves utility of hydraulics in fixture design in three different ways: (i) reduces cycle time, (ii) reduces operator fatigue and increases productivity and (iii) reduces wear and tear of fixture components.

(i) Reduction in cycle 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 and to achieve uniform clamping, this time will be still more, which 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) Reduction in operator fatigue and increase in productivity

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 elder 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) Reduction in wear and tear of fixture components

Only one point can be clamped at a time during manual clamping. To reduce wear and tear of fixture components, uniform clamping must be assured by clamping all the bolts with a light clamping force initially and then with a heavy clamping force. But in this case, clamping force at each bolt may vary. However with use of hydraulic, all clamps can be operated at the same time, there is no need of a light and heavy clamping force and also clamping force can be controlled as per the requirement, altogether these result into consistent clamping force, better dimensional accuracy, reduction in wear and tear of fixture components.

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