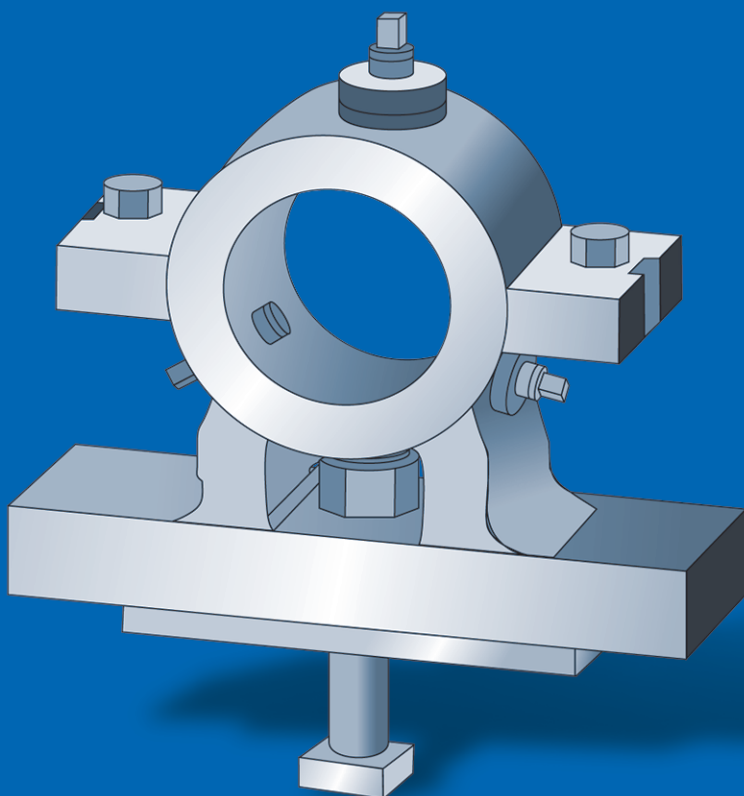


# Design of Jigs, Fixtures and Press Tools



**K. Venkataraman**

  
**Athena**  
ACADEMIC

**WILEY**



# **Design of Jigs, Fixtures and Press Tools**



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**K. Venkataraman**

*External Faculty  
Mechanical Engineering Department  
Anna University,  
Chennai, India*

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**K. Venkataraman**

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*To*  
*My Dear Parents*  
*Late V. Kalyanaraman*  
*and*  
*Mrs. Rajalakshmi Kalyanaraman*



# Preface

The subject 'Tooling' encompasses areas such as (i) Cutting Tools (ii) Gauges, (iii) Jigs and Fixtures, and (iv) Press Tools. Each of these fields is very vast. To become a successful professional, be it a designer or a production or manufacturing engineer, the student needs to have an in-depth knowledge of all the above topics. In addition to the expertise needed in such specific areas, knowledge of Materials Science, Costing and Economics and Computer Modeling of components and sub-systems is also essential.

The present book, Design of Jigs, Fixtures and Press Tools, is aimed at providing the introductory knowledge on the subject to the undergraduate students of mechanical and manufacturing engineering of Anna University. Many of the universities in India prescribe a syllabus that contains both Design of Jigs and Fixtures, and Design of Press Tools in a single semester course. Keeping the above in mind, this book is designed in two parts. Part I deals with Jigs and Fixtures and Part II is earmarked exclusively for the study of Press Tools. Both these subjects are built progressively in successive chapters. A separate appendix in each part, provides short answer questions with answers, which will help the students in clarifying doubts and strengthen their knowledge base. The explanatory notes and illustrations provided in the book will serve the purpose of awakening the interest of the students and invoking in them the passion for tooling in their study of mechanical, manufacturing, or production engineering.

Finally, I wish to express my gratitude to the Anna University for providing support in my endeavour to write a book on the subject.

**K. Venkataraman**



# Foreword

The book, Design of Jigs, Fixtures and Press Tools by K. Venkataraman, is intended for undergraduate students in Mechanical Engineering and Production/Manufacturing Engineering students. It is a treatise on two major topics in 'Tooling', viz. (a) Jigs and Fixtures and (b) Press Tools and thus makes it comprehensive for undergraduate students of Mechanical Engineering and allied branches. The book covers all the major topics in the subject. Some of the salient features of the book are as follows:

- Exhaustive illustrations covering almost all variants in the subject of Jigs, Fixtures and Press Tools.
- An appendix at the end of Part I of the book dealing with the mechanics of cutting tool operation and the forces involved in various tools such as turning, milling, drilling and broaching.
- An appendix on worked examples for the first part showing the 2-D drawings of the typical jigs/fixtures as well as a 3-D model of a jig will be very useful for the beginner.
- 3-D models of fixtures such as (a) a common vise used in milling operations, (b) Three-jaw chuck and in the field of press tools a model of a progressive die with associated components for making the students understand the concepts better.
- The final chapter in Part II showing typical worked examples of drawing dies.
- Separate appendices giving suggested questions and answers in both the parts to facilitate review of the subject by the students.

I am sure that this book will go a long way in filling the long-felt gap by covering both the topics of tooling under one cover. I congratulate the author for this effort and hope the students make full use of it.

**Dr. K. Srinivasan**

Director

AU-FRG Institute for CAD/CAM

Anna University



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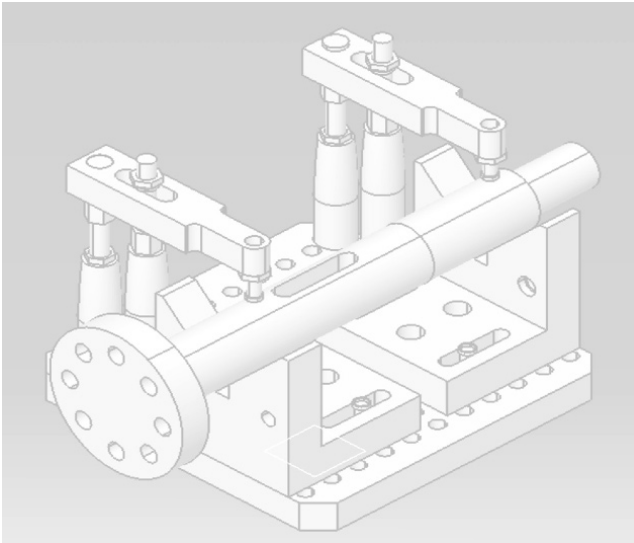
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# PART-I



## IN THIS PART

1. Introduction to Jigs and Fixtures
2. Design of Locators
3. Design of Clamps
4. Drilling Jigs
5. Design of Milling Fixtures
6. Other Types of Fixtures

*Design Exercises*

*Worked Examples*

**Appendix A:** Metal Cutting Tools

**Appendix B:** Fits and Tolerances

**Appendix C:** Suggested Questions and Answers



# Introduction to Jigs and Fixtures

## 1.1 INTRODUCTION TO MODERN DAY PRODUCTION

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The advent of industrialisation in the early decades of the 20th century has ushered in the concept of providing goods and services to the common man, like the motorcar, electric motors, ceiling fans, etc. This enabled the government as well as the leaders in industry to provide affordable goods to the consumers. By improving the production techniques and by providing specialized tooling equipments, such as jigs, fixtures, special tools, and gauges, the production cost have reduced considerably without sacrificing the accuracy and interchangeability of parts and components. To achieve the desired quality and quantity of production, the concept of accuracy and interchangeability go hand in hand. They play a major role in meeting the present day classes of engineering production, namely, “flow production” and “batch production”.

To necessitate the need of jigs, fixtures and special tools, the four main engineering classes of production are as follows:

**1. Job Production:** This involves the manufacture of specialized components or systems to meet the specific needs of the customers. Examples of job production are the manufacture of jigs, fixtures and press tools.

**2. Batch Production:** Some of the examples of batch production are the manufacture of aeroplanes, aero-engines, battle tanks, etc., that use the concept of intermittent manufacture of large range of products, produced in batches. Some brands of motorcars like “Benz” and “BMW” may be classified under “batch production” as they are required to meet specific requirements.

**3. Flow Production:** In flow production, the standardised finished products are produced in plants, specifically laid out for this purpose. Examples of flow production are the modern motorcar plants.

**4. Mass Production:** In this type of plants, the products are produced in mass quantities by specialised and repetitive methods, without requiring specialised layouts as in the case of flow production. Examples are mass production of screws, pins, hand tools, like chisels, spanners, hammers, etc.

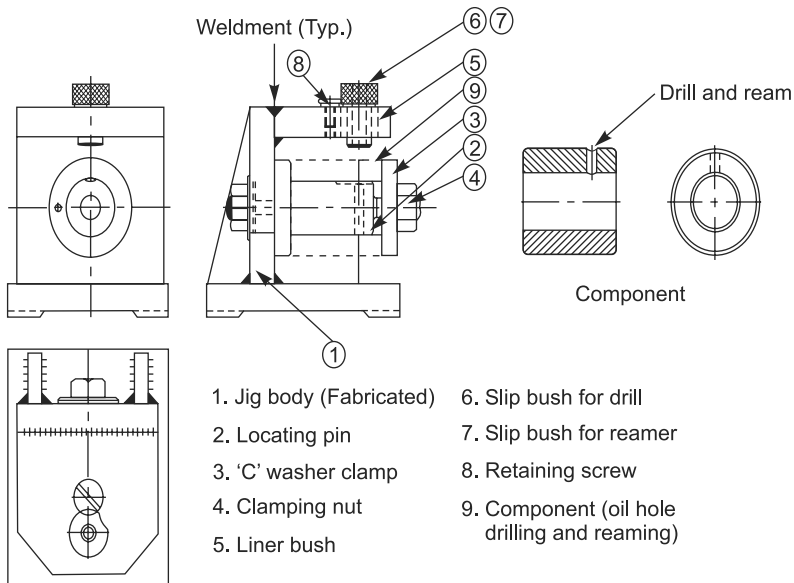
## 1.2 DEFINITION OF JIGS, FIXTURES AND TOOLING

As explained earlier the present day trend is to produce components and systems to meet the basic specifications of:

- (i) Accuracy
- (ii) Interchangeability
- (iii) Economic production rate.

In order to achieve the above objectives the following tooling equipments are deployed:

- (i) Jigs
- (ii) Fixtures
- (iii) Special tools like broaching tool, gear shaping tools, special class of taps and reamers
- (iv) Gauges to verify if dimensions are within the limits.



**Fig. 1.1** Example of a Drilling Jig

A jig is a device, in which the component is clamped in a specific location so that cutting tools are guided to perform one or more operations. Jigs, which are independent devices, are fastened to the table of a machine tool. They are so designed to facilitate loading and unloading of components with ease. The third feature of a jig is that it has locating devices to position a component in a unique way. The fourth aspect of a jig specification is the gripping of the workpiece through a clamping device. There are elaborate methods to clamp, namely, (a) threaded fasteners, (b) cam clamps, (c) 'V' type sliding clamps, (d) pneumatic clamps, (e) hydraulic clamps, etc. An exclusive chapter is earmarked in later part of this book, which deals with various clamping techniques. The fifth aspect of the specification of a jig, which distinguishes the same from a fixture, is the guiding

bushes which are fixed/fastened to the jig body or frame and act as guides to the tools, especially drilling, reaming or face milling cutters. They enable the tool to be positioned exactly with respect to the component and more precisely in relation to the location of the hole to be drilled, or the hole to be reamed. A later chapter deals with various types of bushes employed, such as plain bush, collared bush and renewable bush. Figure 1.1 gives a specific example of a drilling jig.

A fixture is also a device, which is fastened to the table of a machine tool, such as milling machine, and in the case of turning operation in a lathe, the fixture is fastened to the chuck or a faceplate. The device also enables loading and unloading of components with ease. The third aspect of unique location of workpiece in relation to the fixture also holds good as in the case of a jig. The fourth aspect of clamping is given more emphasis in fixture design as the clamping force should be able to withstand the cutting force which may not be along with the direction of gravity, and hence needs to be analysed more closely. At the same time, the clamping force should not be excessive, as it may cause damage to the part. The final aspect, which distinguishes a fixture from a jig, is the absence of bushes to guide the tools. In lieu of the guiding bush, the fixture deploys setting blocks to locate the cutter properly in relation to the fixture or the components *per se*. However, the requirement of setting blocks may not be always necessary as in the case of turning or welding fixtures. The requirement is more pronounced in the case of milling fixtures while cutting slots, keyways, side milling of fastener heads, etc. Figure 1.2 shows a specific example of gang milling fixture.

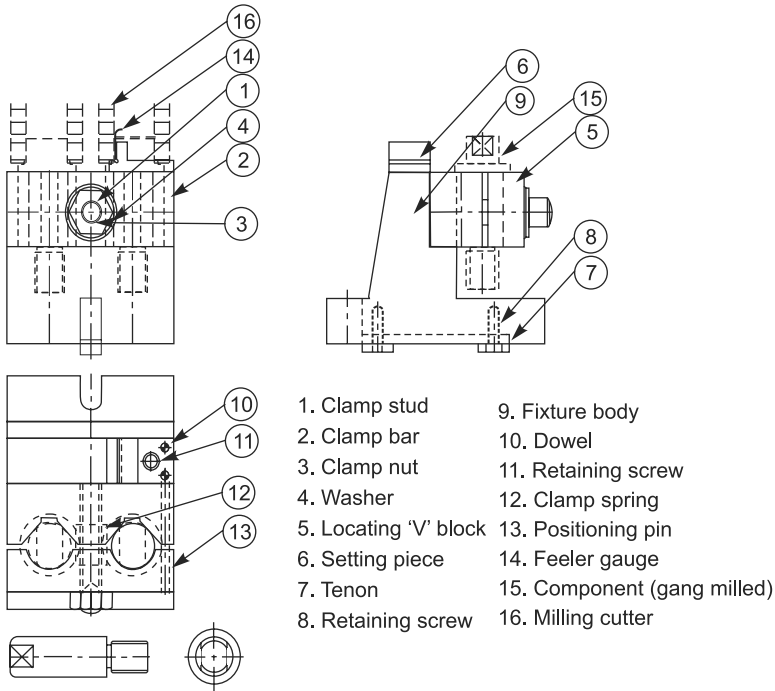


Fig. 1.2 Example of Gang Milling Fixture

### 1.3 FUNDAMENTAL CONCEPTS IN THE DESIGN OF JIGS AND FIXTURES

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The basic difference between the design of “Jigs and Fixtures” and that of machine tool components is that the designing of jigs and fixtures calls for extreme accuracy followed by rigidity, whereas in the case of various machine elements, the concept of stress analysis plays a vital role. Therefore, the design of such special devices calls for in-depth knowledge on material specifications, mechanics of metal cutting, concepts of accuracy, simplicity, strength, safety and economy.

Hence, the designer of these special tools should be capable of preparing manufacturing drawings to meet the specific requirements of each job, its production scheme, rate of production, and the level of dynamic forces involved. As indicated earlier, the design of jig has the following aspects or elements:

- (i) Unique location of components with respect to the jig
- (ii) Ease of loading and unloading the components
- (iii) Clamping of the components so as to impart adequate clamping force and also to have ease in operation
- (iv) Guiding the cutting tools
- (v) Provision for swarf removal
- (vi) Proper fastening methods to hold the jig to the table (in the case of radial drilling machines)
- (vii) Holding the assembly together so as to withstand the cutting forces which occur at frequent intervals causing static and dynamic forces
- (viii) Provision for replacement of bushes, in case different tools like reaming subsequent to drilling are used for drilling different diameter holes in the same location.

Following are the major elements in the design of fixtures:

- (i) Unique location of components with respect to the fixture
- (ii) Clamping techniques to be adopted to deploy adequate forces without damaging the component; ingenious techniques to be adopted for the ease of clamping like quick acting screws, cam clamps, hydraulic clamps, etc.
- (iii) Provision for easy loading and unloading of components
- (iv) To hold the assembly together to withstand the cutting forces
- (v) To design the location, size and material of the setting block to enable the cutter to be set in relation to the fixture and to be precise in relation to the component to be machined this is applicable only for milling fixtures
- (vi) Provision for swarf removal

- (vii) Fastening of fixture to the machine table or chuck or collet
- (viii) Proper design of tenons at the bottom of the fixture so as to properly locate the fixture with respect to the machine table.

In addition to the above said points, the following aspects should also be taken into account in the design of jigs and fixtures:

- (i) Consideration of sequence of operation given in the operation chart with particular reference to the operation to be performed
- (ii) Study of the detailed drawing of the component critically, especially the dimensions which are provided with tolerances
- (iii) Consideration of the manufacturing defects such as (a) shrinkages (b) blow holes, (c) inclusions as in the cast bodies of jigs, (d) distortions as in the case of welding and fabricating jig body or frame.

### SUMMARY

In this chapter, a brief outline has been provided on the tooling involved in the manufacture of components to meet the requirements of accuracy and interchangeability with low cost of production. Various classes of engineering production, such as job, batch, flow and mass production are elaborated. The use of tooling, particularly in the “batch” and “flow” production models, is further explained. Definition of jigs and fixtures and their distinguishing characteristics are explained.

Various points on the design of jigs which need to be focused are: (i) location of components, (ii) clamping, (iii) guiding the tool in the case of jigs/setting the cutter in the case of milling, and (iv) loading/unloading of the components. Lastly, additional design features such as (i) focus on the tolerance dimensions of the component, (ii) study of the sequence of operations relating to the operation in question, and (iii) design for manufacturing are also listed.

### REVIEW QUESTIONS

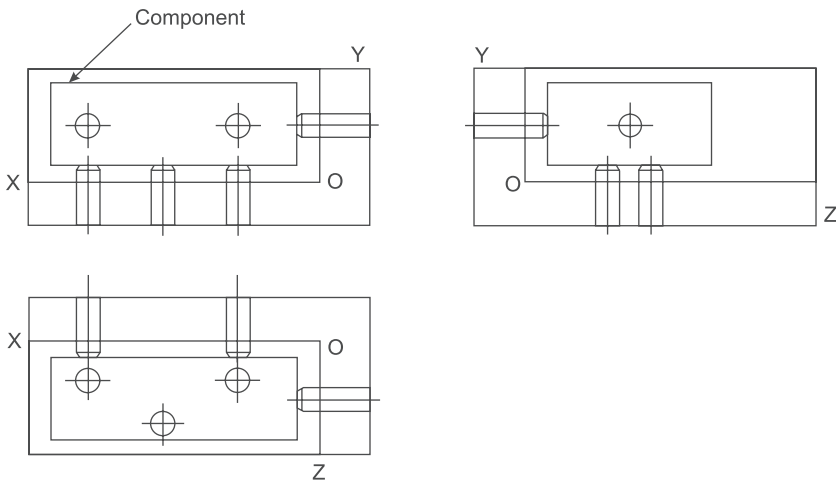
1. Draw a flow chart of the activities that follow while using a jig or a fixture when machining a component.
2. Distinguish between job, batch and mass production in manufacturing. Explain the functions of jigs/fixtures in each of the above types of production.
3. What will be the extent of increase in productivity by using a jig or a fixture? Explain with a specific example.

## Design of Locators

### 2.1 GENERAL PRINCIPLES OF DEGREES OF FREEDOM AND CONSTRAINTS

A parallelepiped shown in Fig. 2.1 has six degrees of freedom in space, namely, three translations along X-X, Y-Y and Z-Z axes and three rotational movements about the three axes. In order to provide constraints to the body, which has parallel and right-angled plane faces, six pegs are provided, three pegs in the X-Z plane, two pegs in the X-Y plane, and one peg in the Y-Z plane. These pegs provide the required constraints in six degrees of freedom. This is further explained below.

The three pegs provide a constraint in movement along the vertical direction parallel to O-Y. Similarly, the two pegs provided along the X-O-Y plane and the one provided along the Z-O-Y plane provide constraints in translation movements along the axes parallel to O-Z and O-X respectively.



**Fig. 2.1** Six Point Location Principle