DESIGN AND ANALYSIS OF MACHINING FIXTURE FOR S.R.E. BRACKET IN VERTICAL MACHINING CENTER

A PROJECT REPORT 2001-2002

Submitted in partial fulfillment of the requirements
for the award of the degree of

**BACHELOR OF ENGINEERING IN MECHANICAL ENGINEERING
OF BHARATHIAR UNIVERSITY**

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During the year 2001-2002

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[illegible] Mar [illegible]

PROJECT WORK CERTIFICATE

This is to certify that **Mr.M.Ramprabhu, Mr.M.Nateshkumar, Mr.S.Suresh & Mr.P.Yoganandan** Final year B.E. (Mechanical Engg) students of [illegible] College of [illegible], Coimbatore have done a project with us "**Design and Analysis of Machining Fixture for SRE Bracket in Vertical Machining Centre**" from Aug-2001 to Mar-2002

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DEDICATED

TO

OUR BELOVED PARENTS

ACKNOWLEDGEMENT

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SYNOPSIS

SYNOPSIS

Our project deals with design and analysis of machining fixture for S.R.E BRACKET in Vertical Machining Center sponsored by **ROOTS INDUSTRIES LIMITED,** coimbatore-6, who are the leading manufacturers of horns.

We have designed and analyzed the machining fixture to meet the required specifications of drilling ,tapping , reaming , facing , and boring with maximum accuracy and repeatability and economy in mass production.

In addition , these fixtures are used to hold, support and locate the component to ensure that each part is machined within the specified limits.

Design calculations and principles to be followed in the design of fixture are taken into consideration. We had analyzed the clamps using ANSYS software. Thus with the help of this fixture production rate is increased and time delay is considerably reduced.

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INTRODUCTION

1. INTRODUCTION

Engineering and technology is playing a vital role in the development of any nation. The technology is improving day by day and it is used to produce goods of high quality. The world's demand for manufactured goods is growing at a staggering rate. Industry has responded to this demand with many new and sometimes, radical ways of producing products.

The competition between the manufactures has made it necessary to reduce the price of their goods than their competitors, so that they can have a very good demand for their products in the market. For this, production of goods is done in mass production method. Because of this, the machining cost of the product becomes less and in turn the price of the product also.

In machining cost, the set up cost is the main part, which has to be reduced as much as possible, since, this is much more than the processing cost.

Despite changes in cutting tools, machine tools and production methods, there are something that never seems to change. Every part being produced must be held while it is being machined, whether on a simple drill press or a multiple axis CNC machining tool. The part is the primary consideration in the work holding, but not the process. For this fixtures are used.

JIGS AND FIXTURES

2. JIGS AND FIXTURES

2.1 DEFINITION :

JIGS :

A jig is a special device which holds supports, or is placed on a part to be machined. It is a production tool made so that not only locate and holds the workpiece, but also guides the cutting tool as the operation is performed. Jigs are usually fitted with hardened steel bushings for guiding drills or other cutting tools.

FIXTURES :

The fixtures may be defined as a device which holds and locates a workpiece during an inspection or for a manufacturing operation. The fixture does not guide the tool.

In construction, the fixtures comprise different standard or specially designed work-holding devices which are clamped on the machine table to hold the work in position. The tools are set at the required positions on the work by using gauges or by manual adjustments. The fixtures are generally heavier in construction and are bolted rigidly on the machine table.

2.2 CLASSIFICATION :

Fixtures are normally classified by the type of machine on which they are used. Fixtures can be also be identified by a sub classification. For example, if a fixture is designed to be used on a milling machine, it is called as milling fixtures.

If the task it is intended to perform is straddle milling, it is called a straddle-milling fixture. The sample principle applies to a lathe fixture which is designed to machine radii. It is called a lathe-radius fixture.

The following is a partial list of production that uses fixtures.

a) Shaping.
b) Boring.
c) Drilling.
d) Grinding.
e) Milling.
f) Tapping.
g) Turning.
h) Assembling.

2.3 PRINCIPELS:

2.3.1 DESIGN OF FIXTURE :

The successful designing of fixtures depends upon the analysis of several factors which must be carefully studied before the actual work is taken in hand.

The following are the essential factors which must be considered in designing fixtures:

1) Study of the component.
2) Study of the type and capacity of the machine.
3) Study of the locating elements.
4) Study of the clamping arrangements.
5) Study of the clearance required between the fixture and the component.
6) Study of the degrees of freedoms arrested.
7) Study of the rigidity and vibration problem.

8) Study of the table fixing arrangement.

9) Study of safety devices.

10) Study of the methods of manufacture of the fixture base, body or frame.

2.4 MATERIALS USED :

Material selection is a matter of quality and cost. The properties of the materials must be adequate to meet design requirements and service condition. Fixtures are made from a variety of materials, some of which can be hardened to resist wear. Most of the parts are made of ferrous materials. Knobs and handles are made of plastic materials. Glass-fiber is used in making assembly fixtures. Given below are the materials used often in fixtures.

2.4.1 CARBON STEELS :

Main constituents are iron, carbon and manganese. phosphorus, sulphur and silicon are present in various quantities. The various combinations of the above elements give a wide range of properties.

These can be hardened to 62RCto 63RC hardness. Carbon steels are mainly used for drill brushes, locators and other parts which are subject to wear and need to be hardened. C65 can be used for springs.

2.4.2 MILD STEEL :

This is a low carbon steel with no precise control over the composition or mechanical properties. The cost is low in comparison with other steels. Mild steel contains less than 0.3% carbon and 0.1% to 0.8% manganese. Most of the fixtures are made of steel.

2.4.3 CAST IRON :

Cast iron is primarily an alloy of iron, carbon and silicon. Carbon content between 1.7% to 4.5%. it has self lubricating properties.

Cast iron can be used for bases and bodies of fixtures. Cast iron has very good vibration damping properties.

2.4.4 CARBON AND ALLOY STEEL :

EN 8 is a class of alloy steel. EN 8 is British standard mode of representation. EN 8 is used for making bolts, screw, nuts etc. OHNS (oily hardened non shrinkage) is mainly used for bushes. OHNS is highly wear resistant, relatively inexpensive, good machinability, good resistance to decarburization.

2.4.5 NYLON AND PLASTIC FIBRE:

These are used as soft lining for clamps to prevent denting or damage to work piece due to clamping force or pressure. Nylon cable assemblies are used to fasten loose parts like bushes, locating pins etc. to fixture body.

2.4.6 ALUMINIUM:

Aluminium weights approximately one-third as much as steel. Due to this lightness, it is being used for many jigs and fixtures that were formerly made of cast iron or steel plate. Aluminium handles are being put on tools, and parts of special machines are now being designed and made from this metal.

2.6 ADVANTAGES OF FIXTURES

The fixtures are the economical means to produce repetitive type of works by incorporating special work holding and tool guiding devices. The following are some advantages of employing fixtures in mass production works.

1) It eliminates the marking out, measuring and other setting methods before machining.
2) It increases the machining accuracy, because the work piece is automatically located and the tool is guided without making any manual adjustment.
3) It enables production of identical parts which are interchangeable. This facilitates the assembly function.
4) It increases the production capacity by enabling a number of work pieces to be machined in the single set up, and in some cases a number of tools may be made to operate simultaneously.

5) The handling time is greatly reduced due to quick setting and locating of the work. The speed, feed, and depth of cut for machining can be increased due to high damping rigidity of fixtures.

6) It reduces the operators work and consequent fatigue as the handling operations are minimized and simplified.

7) It enables semi-skilled operator to perform the operations as the setting operation of the tool and the work are mechanized. This saves labour cost.

8) It helps in the production of a batch of components of acceptable quality and standards.

9) It reduces the expenditures on the quality control of the finished products.

10) It reduces the overall cost of machining by fully or partially atomizing the process.

2.7 ELEMENTS

Generally jigs and fixtures consists of

1. Locating elements.
2. Clamping elements.
3. Tool guiding and setting elements.

2.7.1 LOCATION :

The location refers to the establishment of a desired relationship between the workpiece and the fixture. Correct location influences the accuracy of the finished products. The fixtures are so designed that all possible movements of the component must be restricted. The determination of the locating points and clamping of the workpiece serve to restrict the movements of the component in any direction.

The locating points are determined by first finding out the possible degrees of freedom of the workpiece, which are then restrained by suitable arrangements which serve as locators.

2.7.2 CLAMPING :

The clamp serves the purpose of holding workpiece securely on the fixtures against the cutting forces. In order to achieve the most efficient clamping, the following operational factors must be considered.

1. The clamping pressure should be exerted on the solid supporting part of the work to prevent distortion.
2. The clamping pressure should be kept low. It should be sufficient to hold the work against the cutting pressure.

3. The movement of the clamp for the loading and unloading purposes should be kept limited.
4. The clamp should be positively guided to facilitate loading action.
5. The design should be such as to enable the clamp to be completely lifted out of the work, while unloading.
6. The clamp should be simple and fool-proof.
7. The clamp should be sufficiently robust to prevent bending.
8. The clamp should be affected by operating a lever, a knurled or a flatted nut. The hexagonal headed nuts or bolts should be avoided as far as possible to eliminate the use of spanners. If it becomes essential to use hexagonal nuts, only one size spanner should be used throughout.

9. The clamps should be case-hardened to prevent wear of the clamping faces.
10. The clamp should be so arranged on the work to Perform as many operations as possible in one setting.
11. The clamping parts should be designed to make it non- detachable from fixtures.

TYPES OF CLAMPS :

The following are the different types of clamps, which are commonly used with fixtures.

1) Screw clamp
2) Double acting clamp
3) Latch clamp
4) Cam clamp
5) Wedge clamp
6) Flat clamp
7) Equalizing clamp
8) Swing-plate clamp
9) Pivoted clamp

PROJECT ANALYSIS

3. PROJECT ANALYSIS

3.1 DESCRIPTION OF PROJECT:

The component for which we have designed the machining fixture is used in alternator part of the automobile. Material of the component is Aluminium alloy. For all automobile parts we need high precision and accuracy. So We have to go for a machine in which there is high accuracy, repeatability. The company asked to design the machining fixture for the S.R.E. bracket in vertical machining center.

3.2. REASONS FOR SELECTING VERTICAL MACHINING CENTER :

1) Number of operations per component is more.
2) Labour cost of component is high.
3) Skill required by operators is high.
4) Time lag between operations is high.
5) Setup time/Inspection time is high.

3.2.1. ADVANTAGES:

1) For effective machine utilization.
2) Machines can switch over to different jobs as setup times are very low.
3) Greater quality control.
4) Eliminates re-work and scrap to a very high degree.
5) Reduced floor space.
6) Dependence on skilled operator can be dispensed

3.4 STUDY OF DRAWING:

3.4.1 FRONT VIEW:

1) Top facing for length correction of 79.90 mm.
2) 3 Holes drill and tap of size M6 at angles of 110^0 220^0 and 330^0 from datum at pitch circle diameter of 32 mm.
3) Face grooving of diameter 65.117 mm, Depth 4 mm, of tolerance -0 to +0.030.
4) Drilling of diameter 3 mm, at an angle of 45^0, at a distance of 25 mm from datum.

3.4.2. BOTTOM VIEW:

1) 4 through holes and tapping of size M5.
2) Internal diameter boring of 125.08 mm,125.02 mm with tolerance of 0.08 to 0.02.
3) Internal diameter boring of 13.60 mm reaming.
4) Internal diameter boring of 35 mm With tolerance of 2.5 micrometer radians.
5) Internal diameter boring of 32 mm with tolerance of 2 micrometer radians.

3.4.3. TOP VIEW :

1) 2 Holes tapping of size M6.
2) 2 Holes drilling and tapping of size M5 for a depth of 12 mm.

SEQUENCE OF OPERATIONS

PROCESS 1

OPERATION 1:

S.NO	OPERATION	SIZE	TOLERANCE	TOOLS REQUIRED
1.	Boring	Φ125	0.02-0.08mm	Φ10&mill roughing Φ10 solid carbide End mill finishing (by interpolation)
2.	Boring	Φ35	2.5μmpa	Φ35rough boring bar Φ35 micro boring bar
3.	Boring	Φ32	2μmpa	Φ32 rough boring bar Φ32 micro boring bar
4.	Drilling & Tapping 4nos	M5	-	Φ4.2 drill Φ5.0 tap
5.	Reaming	Φ13.6	-	Φ13.4 drill Φ13.6 ream

OPERATION 2 :

S.NO	OPERATION	SIZE	TOLERANCE	TOOLS REQUIRED
1.	Drilling & tapping 2 nos	M5	-	4.2 mm drill M5 tap
2.	Tapping 2 nos	M6	-	M6 tap

OPERATION 3:

S.NO	OPERATION	SIZE	TOLERANCE	TOOLS REQUIRED
1.	Face grooving	65H7X4		Special tool
2.	Drilling & tapping 3 nos	M6		5 mm drill Φ 6 tap
3.	Top facing.	-	2μmRa	Φ6 solid carbide end mill roughing Φ6 solid carbide end mill finishing

PROCESS 2:

S.NO	OPERATION	SIZE	TOLERANCE	TOOLS REQUIRED
1.	Drilling	3 mm	-	3mm drill

3.3 VERTICAL MACHINING CENTER

3.3.1 FEATURES OF MCV-720

These machines are vertical machining centers for metal cutting like steel, iron, copper, Aluminium and stainless the other material please doesn't cut by this machine. They automatically changes tools for milling, drilling, boring, and tapping. Please do not use these machines for other purpose. Special features are as follows:

1. The tool unclamp button is located on the front end of the headstock for the purpose of easy operations.
2. The x-y-z motions are a guided using diameter 40-10P ball screw, which ensures high rigidity. Both ends of the screws are supported on preloaded bearings specifically designed for ball screws. All the ball screws are also preloaded.
3. Each ball screws is directly driven by a servomotor in order to reduce backlashes and increases precision.

4. The servomotors for the X, Y, and Z axes are installed on the outer-part of the machine body in order to allow easy maintenance.
5. The automatic-tool-changer is set up vertically, and it operates without using a tool-changing arm. This design improves the reliability of tool changing.
6. The X and Y axes are guided with linear motion guides, which allow quick motions. The Z axis uses the TURCITE design, which reduces vibrations during operations.
7. The front end and both sides of the work table are designed with large slots to prevent the coolant from overflowing. This design also strengthens the work table.
8. The enclosed guard provides a safe and clean operations environment.

9. Although some other materials such as plastic. Carbon or wood have considered that customers may cut it by this machine, and it may able to do depend on cutting condition, we insist that to think about health and safety, do not do such things unless they really know how to do it safe.

3.3.2 SPECIFICATION OF MCV-720

TABLE-1

MODEL	UNIT	MCV-720
TABLE		
WORKING SUFACE	mm	950x460
	inch	37.4 x80
T-SLOT (SIZE x NUMBER)	mm	18 X 3
	inch	0.7 X 3
MAXIMUM TABLE LOAD	Kg	500
	lbs	1100

TABLE-2

TRAVEL		
LONGITUDINAL (X) TRAVEL	mm	720
	inch	28.3
CROSS TRAVEL (Y)	mm	460
	inch	18
HEAD STOCK TRAVEL (Z)	mm	510
	inch	20
DISTANCE OF SPINDLE ENDTO TABLE TOP	mm	150-660
	inch	5.9-26
DISTANCE OF SPINDLE CENTER TO	mm	480
	inch	18.9

TABLE-3

SPINDLE		
SPINDLE SPPED	rpm	40-4000(s) 60-6000(H) 100-10000(SH)
MINIMUM SPEED	rpm	1
SPINDLE NOSE	-	N.T.40

TABLE-4

FEED		
CUTTING FEED	mm/min	1-4000
	inch/min	0.04-157
RAPID TRAVEL	mm/min	12000
	inch/min	472
MINIMUM INPUT INCREMENT	mm	0.001
	inch	0.0001

TABLE-5

TOOL SPECIFICATION

RANGE OF USED TOOLS

	MCV-720
MAX.DIAMETER	90 mm
MAX.LENGTH	250 mm
MAX.LENGTH(*)	300 mm
MAX.WEIGHT	6 kg

(*) If tools of maximum length and work pieces are maximum height are used do not change tools above the work piece since interferences may occur.

DESCRIPTION OF THE DESIGNED FIXTURE

4. DESCRIPTION OF DESIGNED FIXTURE

GENERAL VIEW:

In designing milling fixtures it is considered good practice to have the milling fixture as low as possible. In other words, the closer we can bring the work that is located in a fixture on a milling machine table to the table, the less the possibilities of chatter or of springing the work.

Milling fixtures are usually provided with keys for locating the fixture properly in the T-slot of the milling table. Clamps for the milling fixtures should be designed to be as strong as possible and should be provided with springs on the stud so that the clamp itself will spring away from the work when the nut is loosened.

The location of clamps of the milling fixture is very important, as the work must be held rigidly in the milling fixture in order to prevent movement. It is necessary that the workpiece be located against definite stops.

However, there are jobs where, because of the design of the piece part, the work will have to locate against a clamp this should be avoided if possible.

BASE PLATE:

Fixture consists of a base plate in which a U-groove of 150mm pitch is present to fix the base plate on the table of the Vertical machining center. Mild steel are usually used for the parts of jigs, fixtures, dies etc., where it is desired to carburize, harden and then grind. The purpose of selecting mild steel is its low cost compared with other steel.

ANGLE PLATE:

In designing jigs and fixtures it is necessary at times to use angle plates. The angle plate fixture consist of base plate on which there is an undercut of size 2.5mm into which the angle plate is fixed using M10 screws on the top and bottom plates. The angle plate consists of four plates on which the component is being inserted and a hole of diameter 3mm is being drilled.

PILLAR PLATE:

There are totally four plates, two side plates are of size 208x200mm and two front plates of size 525x350mm which is being screwed on the undercut in the base plate. We can totally hold 8 components on four pillar plates, six components on two front plates, two component on two side plates using locating pin and readymade clamp.

TOP PLATE:

This is the plate onto which the component is being located and clamped rigidly. To perform the machining operation the dimension of the plate is 525x200mm. There will a projection of 5mm for a diameter of 125mm onto which the component is being located. The component is being clamped using strap clamps and machining operations are performed.

DESIGN ANALYSIS

K = Material factor

M = Bending moment in kgf.cm

I = Moment of inertia in cm^4

P = Total force in kgf

D_c = Drill diameter in mm

a_p = Cutting depth in mm

V_c = Cutting speed in m/min

n = Spindle speed in rev/min

v_f = Feed speed in mm/min

K_c = Specific cutting force in N/mm^2

F_f = Feed force in N

P = Cutting fluid force in Mpa.

N = Spindle speed in rpm

V = Cutting speed in m/min

F = Feed in mm/rev

f = Feed rate in mm/min

D = Diameter of the tool

Total thrust force P $= T_h + W_b$ (Weight of the base plate)

$= 87.08 + 1.0$

$= 88.08$ kgf

Maximum bending moment $= M_b = \frac{P \times L}{4}$

$= \frac{88.08 \times 70}{4}$

$= 1541.4$ kgf.cm

Moment of inertia $I = \frac{b \times h^3}{12}$ cm^4

$= \frac{35 \times h^3}{12}$

$= 2.91h^3$ cm^4

Bending stress $\sigma_b = \frac{M_b \times y}{I}$

$= \frac{1541.4 \times \left(\frac{h}{2}\right)}{2.91 \times h^3}$

$= \frac{264.85}{h^2}$ 1

COMPONENTS TO BE DESIGNED ARE:

1. Base plate
2. Clamp and bolt
3. Pins
4. Angle plate

5.2 DESIGN OF BASE PLATE:

Thrust force T_h = 1.16 X K X D X (100 X S)$^{0.85}$ Kgf.

K = Material factor = 2.2

S = Feed/revolution = 0.13 mm/rev

D = 4.2 Diameter in mm

S = 0.13 mm/rev

Thrust force T_h = 1.16 X 2.2 X 4.2 X (100 X 0.13)$^{0.85}$

= 87.08 kgf

Safe tensile load = Stress area X Design area

Stress area = $\frac{44.04}{450}$

= $0.0978\ cm^2$

= $9.78\ mm^2$

Choose M6 bolt according to calculation for rigidity purpose we choose M8 bolt.

5.4 DESIGN OF CLAMP THICKNESS:

Thrust force T_h = 88.08 kgf

Thrust force per bolt = 44.04 kgf

Maximum bending moment M_b = $\frac{P \times L}{4}$ kgf.cm

$= \frac{44.04 \times 70}{4}$

= 770.4 kgf.cm

$[\sigma_b]_{max}$ = 3000 kgf/cm^2 (PSG DDB Pg.no 1.95)

Factor of safety n= 8

$\sigma_b = \frac{3000}{8}$ = 375 kgf/cm^2 2

Substitute 2 in 1

$375 = \frac{264.85}{h^2}$

h = 0.84 cm = 8.4 mm

R5 series PSG DDB Pg.no 7.20 Rounded of h = 10 mm

5.3 DESIGN OF CLAMPS AND BOLTS:

Total force acting on 2 bolts = 88.08 kgf

Force acting on one bolt = 44.04 kgf

Design stress = $\frac{3600}{8}$

= 450 kgf

5.5 DESIGN OF ANGLE PLATE :

Diameter 3mm drilling at angle by 45 degree

Thrust force $T_h = 1.16 \text{ X } K \text{ X } D \text{ X } (100 \text{ X } S)^{0.85}$ Kgf

$T_h = 1.16 \text{ X } 2.02 \text{ X } 3 \text{ X } (100 \text{ X } 0.1)^{0.85}$

= 49.76 kgf

Total force $P = T_h + WB$

= 49.76 + 2.25

= 52.01 kgf

Maximum bending moment = $M_b = \frac{P \times L}{4}$

$= \frac{52.01 \times 25.45}{4}$

= 330.9 kgf.cm

Moment of inertia $I = \frac{b \times h^3}{12}$ cm^4

$= \frac{18 \times h^3}{12}$

$= 1.50h^3$ cm^4

Moment of inertia $I = \frac{b \times t^3}{12}$ cm^4

$= \frac{35 \times t^3}{12}$

$= 2.91t^3$ cm^4

Bending stress σ_b $= \frac{M_b \times y}{I}$ kgf/cm^2

$= \frac{770.4 \times \left(\frac{t}{2}\right)}{2.91t^3}$

$= \frac{132.37}{t^2}$ kgf/cm^2 1

$[\sigma_b]_{max}$ = 3000 kgf/cm^2 (PSG DDB Pg.no 1.95)

Factor of safety n = 8

$\sigma_b = \frac{3000}{8}$ = 375 kgf/cm^2 2

Substitute 2 in 1

$375 = \frac{132.37}{t^2}$

$t = \sqrt{\frac{132.37}{375}}$ = 0.59 cm = 5.9 mm

Choose according to calculation for thickness

standard value PSG DDB Pg. no 7.20 R5 series 6.3 mm.

5.6 TO CHECK DESIGN FOR SAFETY:

5.6.1 BORING OPERATION :

DESIGN FOR DIAMETER 125mm BORING:

Cutting speed = v = $\frac{\pi \times d \times n}{1000}$ m/min

For Aluminium Al , v = 80 m/min

$$80 = \frac{\pi \times 125 \times n}{1000}$$

n = 203.72 rpm

Feed rate = $\frac{v}{n}$

$$= \frac{80}{203.72}$$

= 0.39 mm

Thrust force due to boring = 1.16 X K X D X (100 X S)$^{0.85}$ Kgf

Thrust force due to boring = 1.16 X 2.02 X 125 X (100 X 0.39)$^{0.85}$

= 6593.6 kgf

Total force P = T_h + WB

= 6593.6 + 2.25

= 6595.85 kgf

Bending stress σ_b $= \dfrac{M_b \times y}{I}$

$$= \frac{330.9 \times \left(\frac{h}{2}\right)}{1.5 \times h^3}$$

$$= \frac{110.3}{h^2} \text{ kgf/cm}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

$[\sigma_b]_{max} = 3000$ kgf/cm^2 (PSG DDB Pg.no 1.95)

Factor of safety n = 8

$$\sigma_b = \frac{3000}{8}$$

$= 375$ kgf/cm^2 2

Substitute 2 in 1

$$375 = \frac{110.30}{h^2}$$

h = 0.54 cm

= 5.4 mm

Thickness of the angle plate is standardized by

R5 series PSG DDB Pg.no 7.20 Rounded of h = 6 mm

Thrust force due to boring = 1.16 X K X D X (100 X S $)^{0.85}$ Kgf.

Thrust force due to boring = 1.16 X 2.02 X 35X (100 X 0.1$)^{0.85}$

= 580.60 kgf

Total force P = T_h + WB

= 580.6 + 2.25

= 582.85 kgf

Allowable Bending stress = $\frac{Totalforce}{Area}$

$= \frac{582.85}{26 \times 20}$

= 1.12 kgf/cm^2

$[\sigma_b]_{max} > \sigma_b$

Hence the Maximum bending stress is greater than the allowable bending stress. So the design is safe.

DESIGN FOR DIAMETER 32mm BORING:

Cutting speed $= v = \frac{\pi \times d \times n}{1000}$ m/min

For Aluminium Al , v = 80 m/min

$$80 = \frac{\pi \times 32 \times n}{1000}$$

$$n = 795.8 \text{ rpm}$$

Feed rate $= \frac{v}{n}$

$$= \frac{80}{795.8}$$

$$= 0.10 \text{ m}$$

Thrust force due to boring = $1.16 \times K \times D \times (100 \times S)^{0.85}$ Kgf

Thrust force due to boring = $1.16 \times 2.02 \times 32 \times (100 \times 0.1)^{0.85}$

$$= 530.8 \text{ kgf}$$

Total force P $= T_h + WB$

$$= 530.8 + 2.25$$

$$= 533.05 \text{ kgf}$$

Allowable Bending stress = $\frac{Totalforce}{Area}$

$$= \frac{533.05}{26 \times 20}$$

$$= 1.025 \text{ kgf/cm}^2$$

$$[\sigma_b]_{max} > \sigma_b$$

Hence the Maximum bending stress is greater than the allowable bending stress. So the design is safe.

5.6.2 DRILLING OPERATION :

DESIGN FOR DIAMETER 13.2mm DRILLING:

Feed rate = 0.2 mm/rev

Thrust force T_h = 1.16 X K X D X (100 X S)$^{0.85}$ Kgf

Thrust force T_h = 1.16 X 2.02 X 13.2 X (100 x 0.2) $^{0.85}$

= 394.7 kgf

5.6.4 CHECK FOR PIN :

Material of the pin : EN8

Thrust force T_h = 1.16 X K X D X (100 X S $)^{0.85}$ Kgf

T_h = 1.16 X 2.02 X 5 X (100 X 0.13$)^{0.85}$

= 103.66 kgf

Total force P = T_h + WB

= 103.66 + 2.25

= 105.91 kgf

Therefore force acting on the four pins = 105.91 kgf

The force acting on one pin = $\frac{105.91}{4}$

= 26.5 kgf

By, Gordan - Rankin's formula,

$$P = \frac{F_c \times A}{\left(1 + a\left(\frac{l}{r}\right)^2\right)}$$

Where,

P = crippling load in kgf

F_c = Crushing stress in kgf/cm^2

Total force $P = T_h + WB$

$= 394.70 + 2.2$

$= 396.90$ kgf

Stress on the base plate $= \frac{396.90}{70 \times 35}$

$= 0.16$ kgf/cm^2

5.6.3 REAMING OPERATION :

DESIGN FOR DIAMETER 13.66mm REAMING:

Feed rate = 0.51 mm/rev

Thrust force $T_h = 1.16 \times K \times D \times (100 \times S)^{0.85}$ Kgf

Thrust force $T_h = 1.16 \times 2.02 \times 13.66 \times (100 \times 0.51)^{0.85}$

$= 905.09$ kgf

Total force $P = T_h + WB$

$= 905.09 + 2.25$

$= 907.34$ kgf

Stress on the base plate $= \frac{907.34}{70 \times 35} = 0.37$ kgf/cm^2

a = Constant, which depending on material

$\frac{l}{r}$ = Slenderness ratio

A = Area of the cross section in cm^2

l = Effective length in cm

for EN 8,

$F_c = 3600$ kgf/cm^2

a= 1/7500

L= l/2

l = 25mm

L=25/2

= 12.5 mm

= 1.25 cm

Area = A1 + A2 + A3

$$= \frac{\pi \times d_1^{\,2}}{4} + \frac{\pi \times d_2^{\,2}}{4} + \frac{\pi \times d_3^{\,2}}{4}$$

$$= \frac{\pi \times 12^2}{4} + \frac{\pi \times 16^2}{4} + \frac{\pi \times 5.6^2}{4}$$

= 338.79 mm^2

= 3.38 cm^2

Allowable Bending stress = $\frac{Totalforce}{Area}$

$$= \frac{6595.85}{26 \times 20}$$

$= 12.68$ kgf/cm^2

$[\sigma_b]_{max} > \sigma_b$

Hence the Maximum bending stress is greater than the allowable bending stress. So the design is safe.

DESIGN FOR DIAMETER 35mm BORING:

Cutting speed = v = $\frac{\pi \times d \times n}{1000}$ m/min

For Aluminium Al , v = 80 m/min

$$80 = \frac{\pi \times 35 \times n}{1000}$$

$n = 727.57$ rpm

Feed rate = $\frac{v}{n}$

$$= \frac{80}{727.57}$$

$= 0.10$ mm

5.DESIGN ANALYSIS

5.1 NOMENCLATURE

σ_t	=	Tensile stress in kgf/mm^2
σ_y	=	Yield stress in kgf/mm^2
σ_b	=	Bending stress in kgf/mm^2
F.S	=	Factor of safety
$[\sigma]$	=	Design stress in kgf/mm^2
L	=	Length of the plate in cm
b	=	Width of the plate in cm
h	=	Thickness of the plate in cm
E	=	Young's modulus of the material in kgf/mm^2
G	=	Modulus of rigidity in kgf/mm^2
W_b	=	Weight of the body in kgf
T_h	=	Axial thrust in kgf
D	=	Diameter of the drill in mm
S	=	Feed rate in mm/rev

$$\text{Crippling load } P = \frac{3600 \times 3.38}{\left(1 + \frac{1}{7500}\left(\frac{1.25}{1.2}\right)^2\right)}$$

$$= 12166.2 \text{ kgf}$$

$$\text{Maximum allowable load} = \frac{12166.2}{8}$$

$$= 1520 \text{ kgf}$$

Therefore force acting on the pin is less than the maximum allowable load. Hence the design is safe.

FEA ANALYSIS FOR CLAMPS

6.FEA ANALYSIS FOR CLAMPS

6.1 MODEL CREATION BY PRO-ENGINEER

ABOUT THE SOFTWARE:

Pro/Engineer provides engineers with a revolutionary approach to mechanical design automation based on a unique, parametric, feature based solid modeling technology. The parametric feature based capabilities provide engineers with unprecedented ease and flexibility. In addition, the unique data structure of Pro/Engineer provides full associatively among all engineering discipline, tying together the entire design-through-manufacturing of a product.

This enables companies to develop their products and manufacturing process concurrently and to easily evaluate multiple designing alternative resulting in better designed products produced faster and at a lower cost.

BASIC CONSTRUCTION FEATURES:

PROTRUSIONS:

After you have created the initial solid feature. You can add material by creating secondary features with the protrusion option in the solid menu. Some forms of protrusion are Extrude, Revolve, Blend, Sweep etc.

CUTS:

Remove material from a specified side.

1. Choose feature from part menu, create from the feature menu
2. Choose 'cut' from solid menu.
3. Choose desired option from solid option menu.

   Pro/E displays the appropriate dialog box, proceed creating the feature according to the chosen form.

6.2 ANALYSIS USING ANSYS

PERFORMING A TYPICAL ANSYS ANALYSIS:

The ANSYS program has many FE analyses, capabilities ranging from a simple, linear, static analysis to complex, nonlinear, transient dynamic analysis.

A typical ANSYS analysis has 3 distinct steps,

1. Build the model
2. Apply loads and obtain the solution
3. Review the results

BUILD THE MODEL:

Building a FEM require more of an ANSYS user's time than any other part of the analysis. First specify a job name and analysis title. Then, use the PREP7 preprocessor to define the element types, element real constants, material properties and the model geometry.

DEFINING ELEMENT TYPES:

The ANSYS element library contains more than 100 different element types. Each element type has a unique number and a prefix that identifies the element category. BEAM4, PLANETT, SOLID96 etc.

The table of material references numbers Vs material property sets is called the material table.

GUI path: **main menu > preprocessor > material properties**.

APPLY LOAD AND OBTAIN THE SOLUTION:

In this step, use the solution to define the analysis type and analysis options, apply loads, specify load step options and initiate the finite element solution. We also can apply loads using the PREP7 preprocessor.

APPLYING LOADS:

The word loads are used in this manual includes boundary condition (constraints supports etc) as well as other externally and internally applied loads. Loads in ANSYS program are divided into 6 categories,

a. DOF constraints
b. Forces
c. Surface loads
d. Body loads
e. Inertia loads
f. Coupled field loads

The following are some of the element categories,

BEAM, PIPE, PLANE, SOLID, SHELL

USER , FLUID, LINK, MASS, MATRIX.

We use PREP7, the general preprocessor, to define element types. The GUI path is

Main menu > preprocessor > element type > add/ edit/ delete.

DESIGNING ELEMENT REAL CONSTANTS:

Element real constants are properties that depend on the element type such as cross sectional properties of a beam element. GUI path is :

Utility menu > list > properties > all real constants.

DEFINING MATERIAL PROPERTIES:

Most element types required material properties. Depending on the application, material properties may be,

a) Linear or nonlinear

b) Isotropic, orthotropic or anisotropic

c) Constant temperature or temperature dependent.

ASSEMBLY OF FIXTURES

FIXTURE FOR FIRST PROCESS:

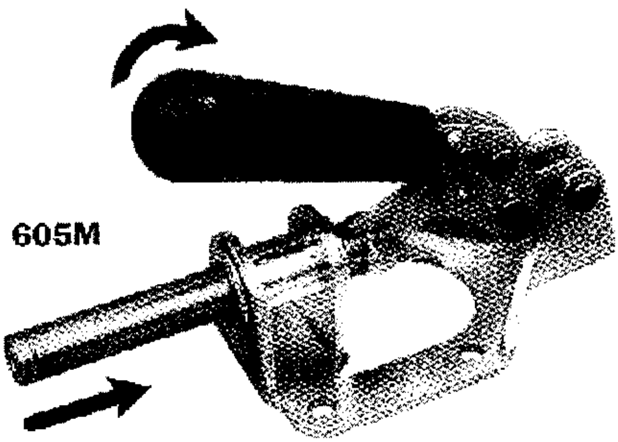
Fixture consists of base plate of size 700 x 350 mm in which an undercut of 2.5mm is taken using milling operation. The two front plates are bolted on the two sides of a base plate and two sides base plate are bolted on other two sides of the base plate using m10 bolts.

The top base plate is being placed above these four plates. There will be a projection of 5mm on top base plate. Then the top plate is placed on the top base plate. These will be an undercut of 5mm in top plate with which it is being matched in to top base plate in which component is being placed and clamped using strap clamp and first operation is performed.

After performing operation one, the top plate is being remained and another top plate is being placed on it for performing fourth operation. These are 12 pins located on it on to which are component is being located. The clamping for two operations is done using readymade toggle clamps as shown below:

TYPE OF CLAMP	CAPACITY	HANDLEBAR MOMENT	MODEL NO.
TOGGLE CLAMP	68Kg	$60^0/90^0$	213

TOGGLE CLAMP

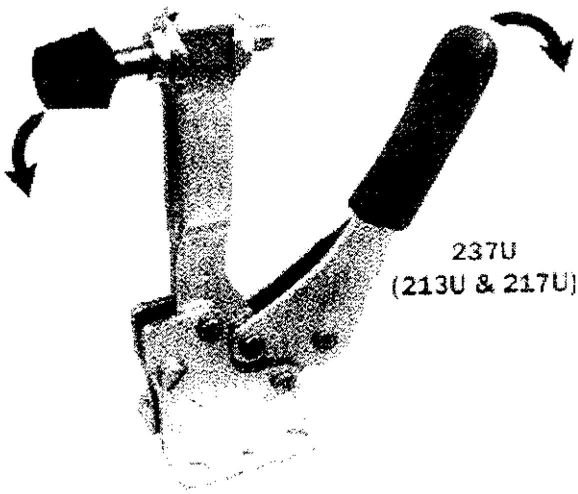


ANGLE PLATE FIXTURE:

Angle plate fixture consists of a base plate of size 600mmx600mm. The base plate consists of undercut in which four angle plates are matched with it. Each angle plate consists of 4 pins on which the component is being inserted. The clamping is done using readymade clamps as shown in figure given below.

Type of clamp	Capacity	Plunger travel	Model no.
Plunger type	130Kg	32mm	605M

TOGGLE CLAMP



237U
(213U & 217U)

ASSEMBLY OF FIXTURES

7. ASSEMBLY OF FIXTURES

FIXTURE FOR FIRST PROCESS:

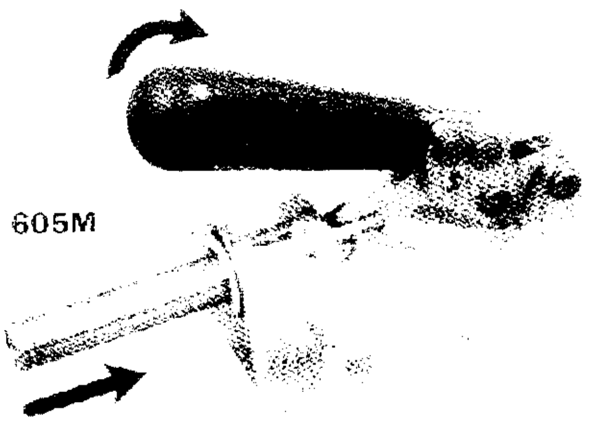
Fixture consists of base plate of size 700 x 350 mm in which an undercut of 2.5mm is taken using milling operation. The two front plates are bolted on the two sides of a base plate and two sides base plate are bolted on other two sides of the base plate using M10 bolts.

The top base plate is being placed above these four plates. There will be a projection of 5mm on top base plate. Then the top plate is placed on the top base plate. These will be an undercut of 5mm in top plate with which it is being matched in to top base plate in which component is being placed and clamped using strap clamp and first operation is performed.

After performing operation one, the top plate is being removed and another top plate is being placed on it for performing third operation. These are 12 pins located on it on to which are component is being located. The clamping for two operations is done using readymade toggle clamps as shown below:

Type of clamp	Capacity	Plunger travel	Model no.
Plunger type	130Kg	32mm	605M

TOGGLE CLAMP

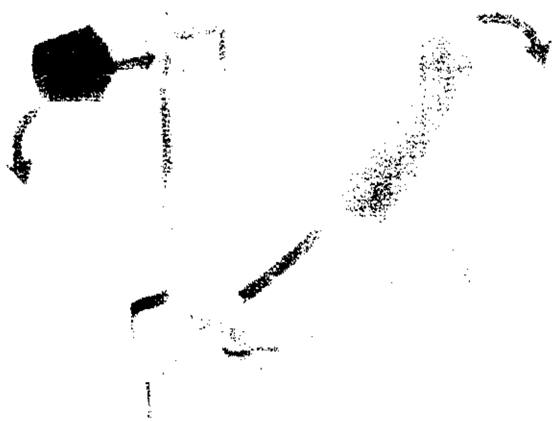


ANGLE PLATE FIXTURE:

Angle plate fixture consists of a base plate of size 600mmx600mm. The base plate consists of undercut in which four angle plates are matched with it. Each angle plate consists of 4 pins on which the component is being inserted. The clamping is done using readymade clamps as shown in figure given below.

TYPE OF CLAMP	CAPACITY	HANDLEBAR MOMENT	MODEL NO.
TOGGLE CLAMP	68Kg	$60^0/90^0$	213

TOGGLE CLAMP



COST ANALYSIS

8.COST ANALYSIS

S.NO	OPERATION	SIZE (mm)	SPEED (RPM)	FEED (mm)	CYCLE TIME (sec)
1.	Boring	Φ125	203.75	0.39	7.2
		Φ35	727.57	0 .1	33
		Φ32	795.8	0.1	22.6
2.	Face grooving	Φ65H7	391.96	0.2	3
3.	Drilling 6 Nos	Φ4.2	6066.1	0.13	16.5
4.	Drilling 3 Nos	Φ5	5095.5	0.13	9.9
5.	Tapping 5 Nos	Φ6	1326.96	0.18	21.1
6.	Tapping 6Nos	Φ5	1592.35	0.13	23.4
7.	Drilling	Φ3	8492.56	0.1	1.12
8.	Drilling	Φ13.4	1901.32	0.25	2.4
9.	Reaming	Φ13.6	1165.7	0.4	1.93

FORMULA USED FOR CALCULATING

MACHINING TIME :

$$t_m = \frac{L}{S_r \times n} \quad \text{min}$$

$$t_m = \frac{L \times \pi \times d}{S_r \times v \times 1000} \quad \text{min}$$

Machining time= (Length of tool travel / Feed per minute)

Where,

L = Length of drill travel in mm

$L = l + 0.3d$

d = Diameter of drill in mm

n = Revolutions per minute

S_r = Feed in mm/rev

S = Feed per minute

v = Cutting speed in m/min

$$v = \frac{\pi \times d \times n}{1000}$$

$$n = \frac{v \times 1000}{\pi \times d} \quad \text{min}$$

MACHINING TIME

Total cycle time = 42.15 sec

= 2.36 minutes

total operation time = total cycle time + total clamping time + tool changing time

total clamping time = 0.75 minutes

tool changing time = 1.53 minutes

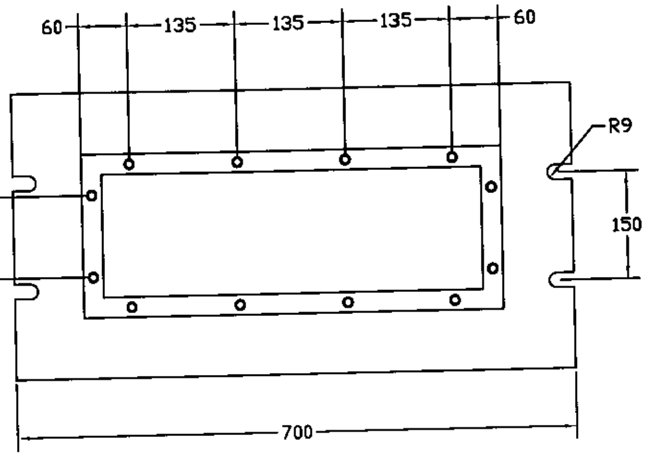
total operation time = 2.36 + 0.75 + 1.53

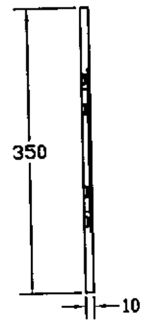
= 4.64 minutes

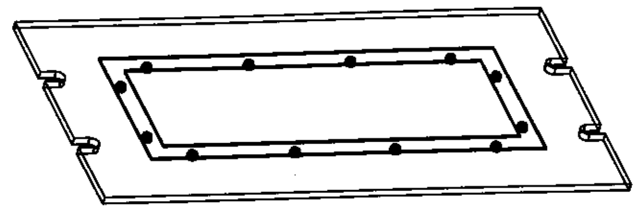
COST DETAILS

1. cost/hour in vertical machining centre = Rs. 400
2. cost per minute = Rs. 6.66
3. total operation time per component = 4.64 minutes
4. cost per component = Rs. 31
5. productivity per hour = 13 component

DRAWINGS

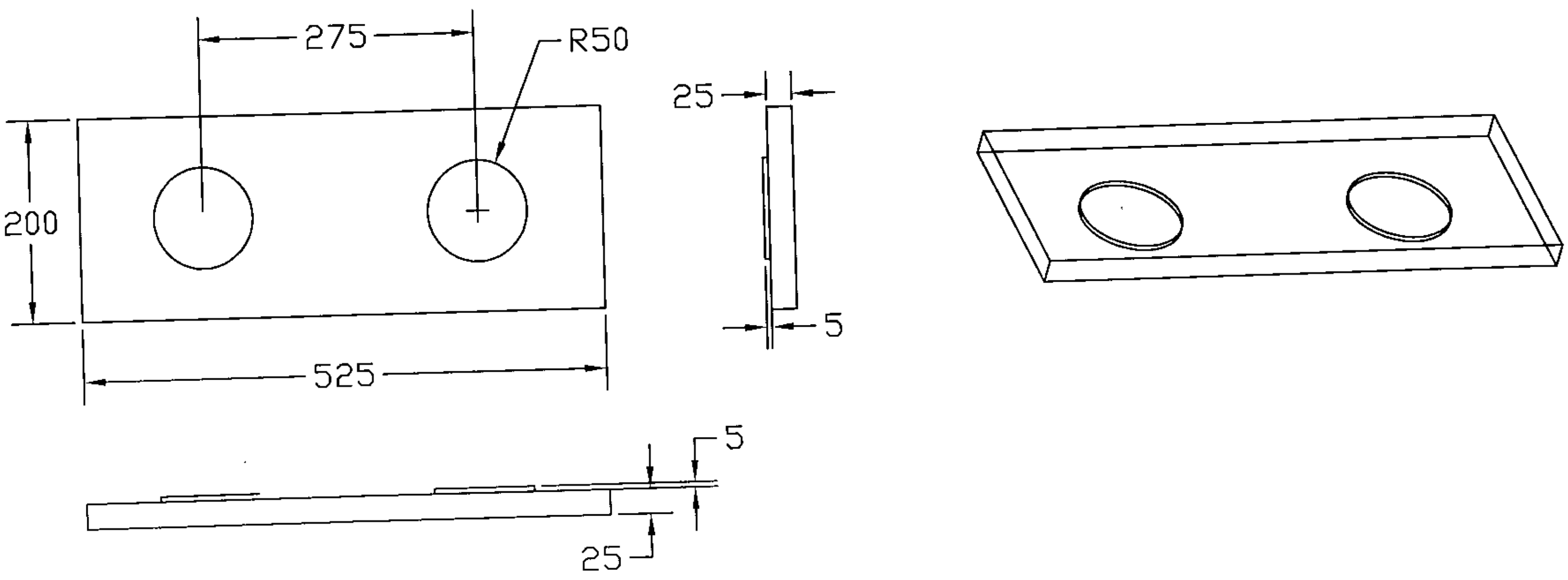






ALL DIMENSIONS ARE IN mm

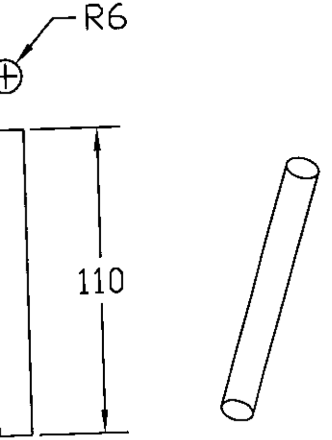
MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME: BASE PLATE		
SCALE	MATERIAL: MS	PROJECT MEMBERS M.RAM PRABHU
QUANTITY :		P.YOGANANDHAN M.NATESH KUMAR
DRG.NO:		S.SURESH



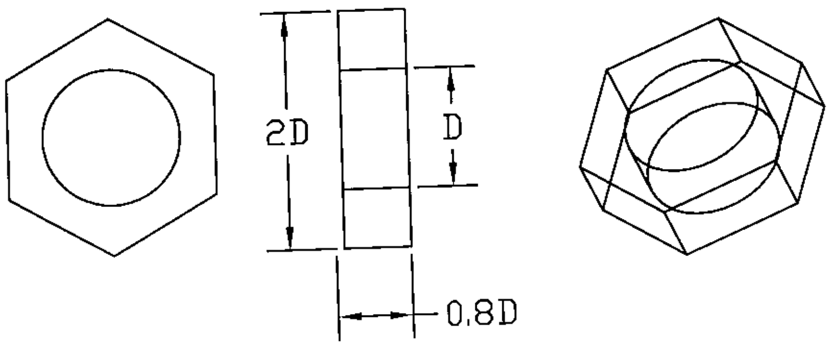
ALL DIMENSIONS ARE IN mm

MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME:TOP BASE PLATE		
SCALE	MATERIAL: MILD STEEL	PROJECT MEMBERS
		M.RAM PRABHU
QUANTITY :		P.YOGANANDHAN
		M.NATESH KUMAR
DRG.NO:		S.SURESH

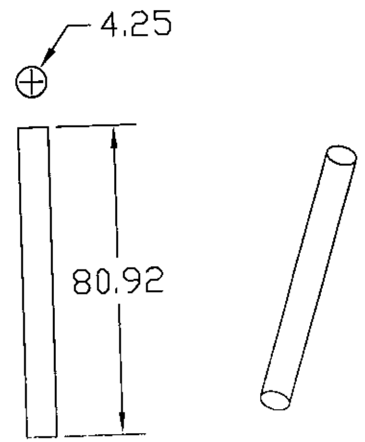
STUD



NUT



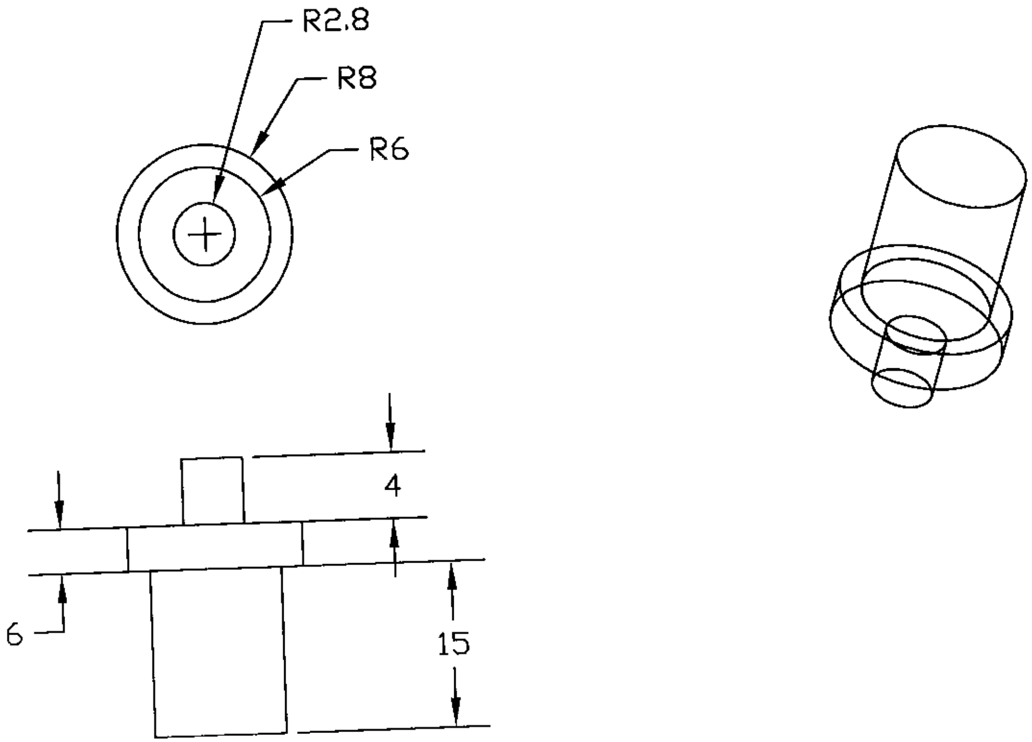
SUPPORT



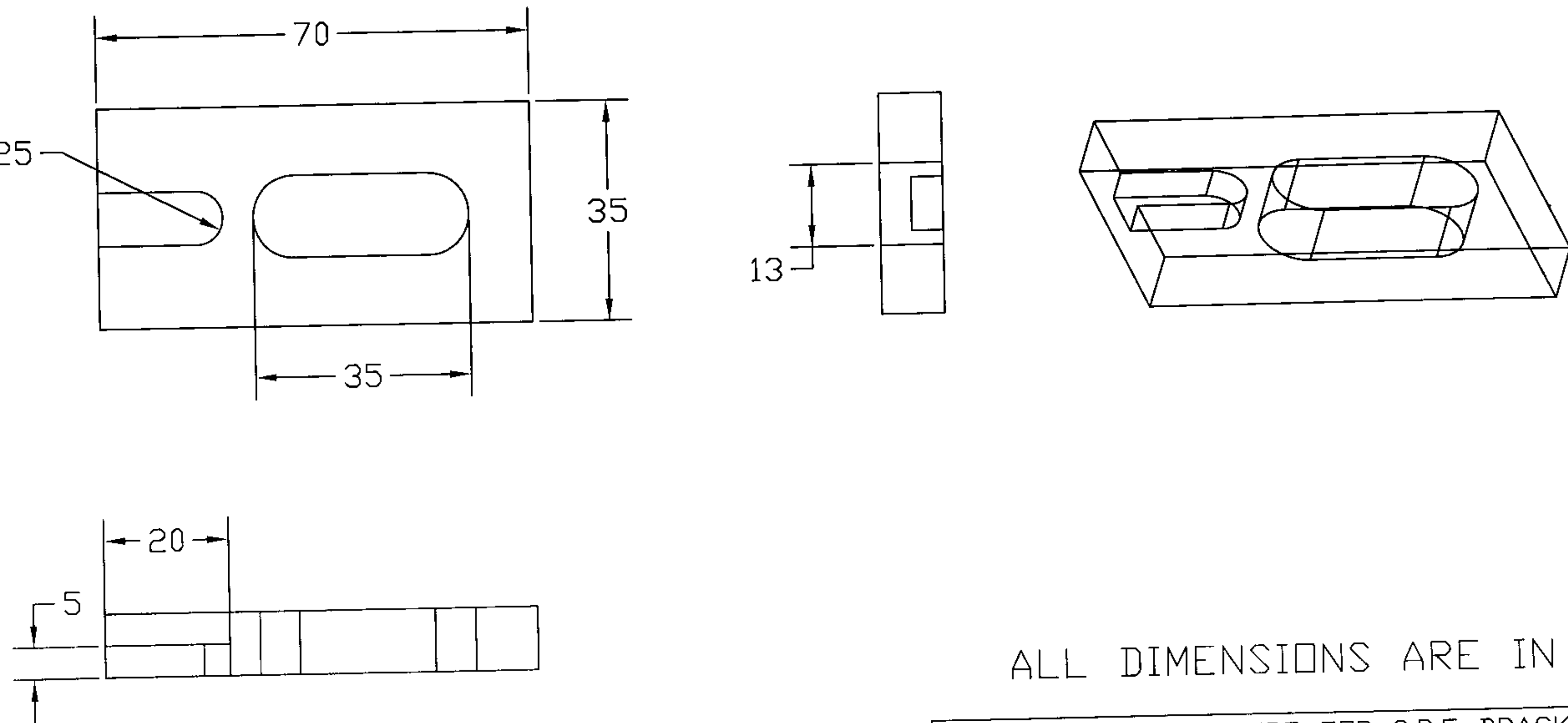
BILL OF MATERIALS		
PART NAME	MATERIAL	QTY
STUD	MS	6
SUPPORT	MS	6
NUT M8	EN8	6
NUT M10	EN8	24

ALL DIMENSIONS ARE IN mm

MACHINING FIXTURE FOR S.R.E BRACKET	
SCALE: NTS	PROJECT MEMBERS
QUANTITY :	M.RAM PRABHU
DRG.NO:	P.YOGANANDHAN
	M.NATESH KUMAR
	S.SURESH

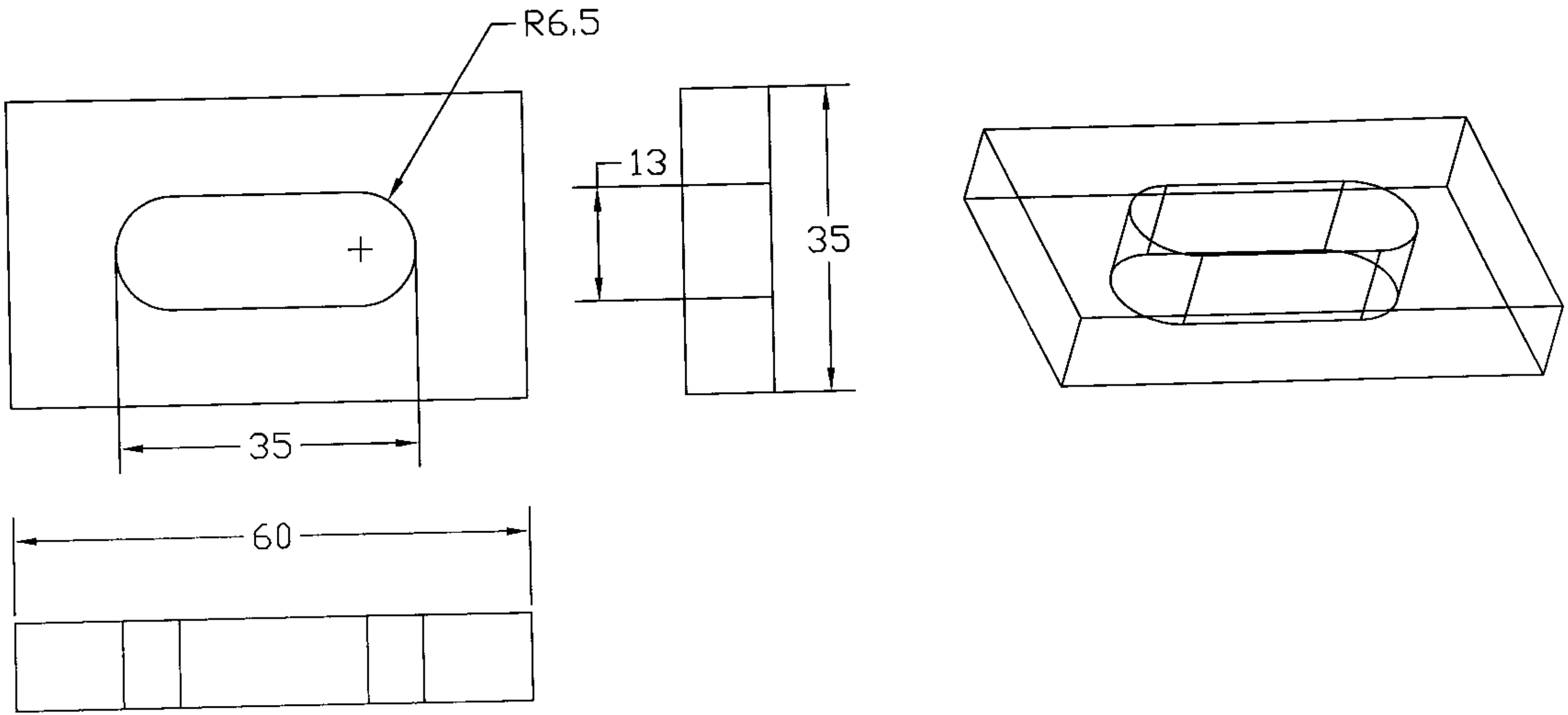


MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME:PIN		
SCALE	MATERIAL: MILD STEEL	PROJECT MEMBERS
QUANTITY :48		M.RAM PRABHU
		P.YOGANANDHAN
DRG.NO:		M.NATESH KUMAR
		S.SURESH



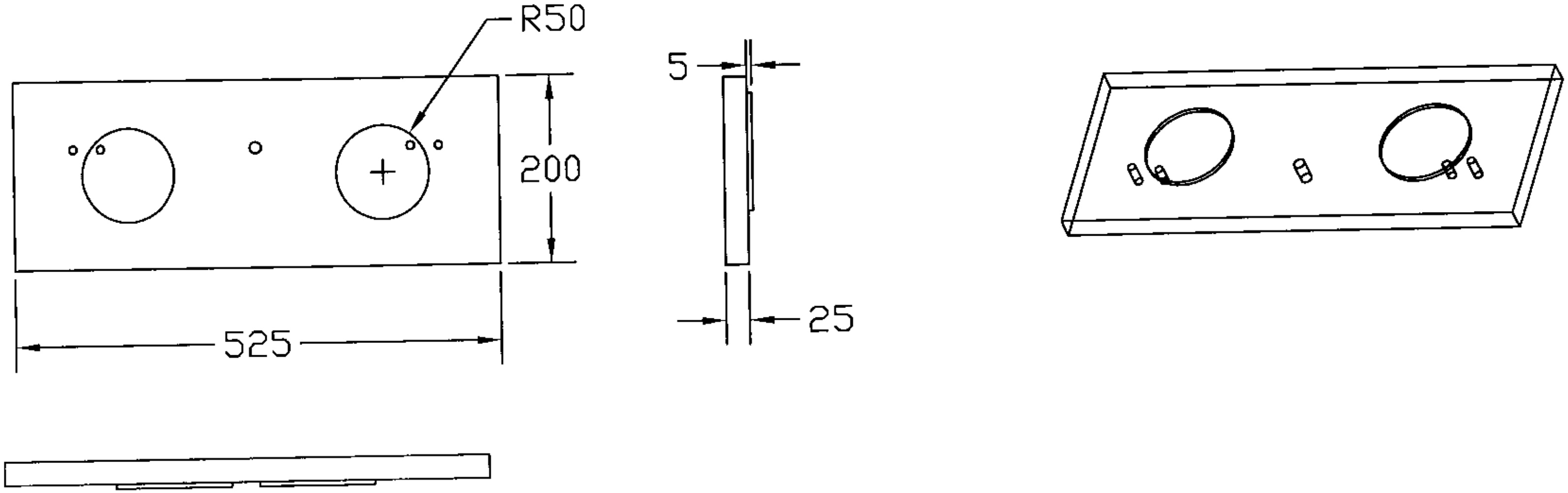
ALL DIMENSIONS ARE IN mm

MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME: STRAP CLAMP		
SCALE	MATERIAL: MILD STEEL	PROJECT MEMBERS
QUANTITY :4		M.RAM PRABHU
		P.YOGANANDHAN
		M.NATESH KUMAR
DRG.NO:		S.SURESH



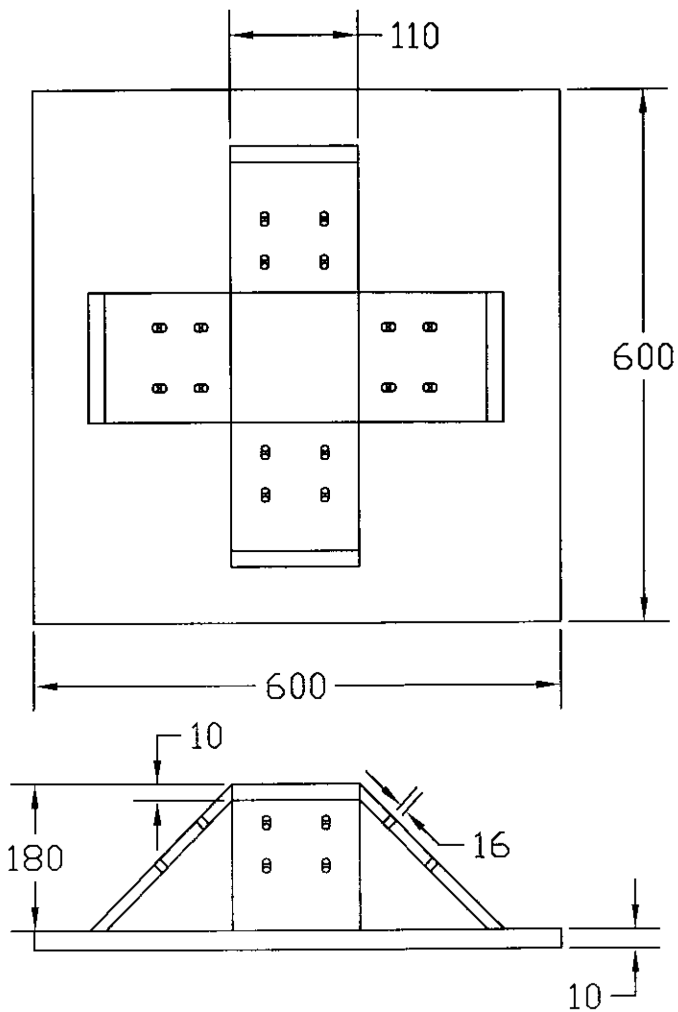
ALL DIMENSIONS ARE IN mm

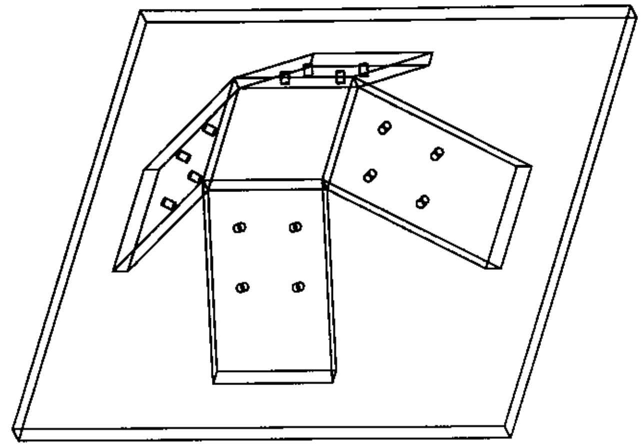
MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME:CENTER CLAMP		
SCALE	MATERIAL: MILD STEEL	PROJECT MEMBERS
QUANTITY :2		M.RAM PRABHU
DRG.NO:		P.YOGANANDHAN
		M.NATESH KUMAR
		S.SURESH



ALL DIMENSIONS ARE IN mm

MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME: ANGLE PLATE FIXTURE		
SCALE	MATERIAL: MILD STEEL	PROJECT MEMBERS M.RAM PRABHU
QUANTITY :		P.YOGANANDHAN M.NATESH KUMAR
DRG.NO:		S.SURESH

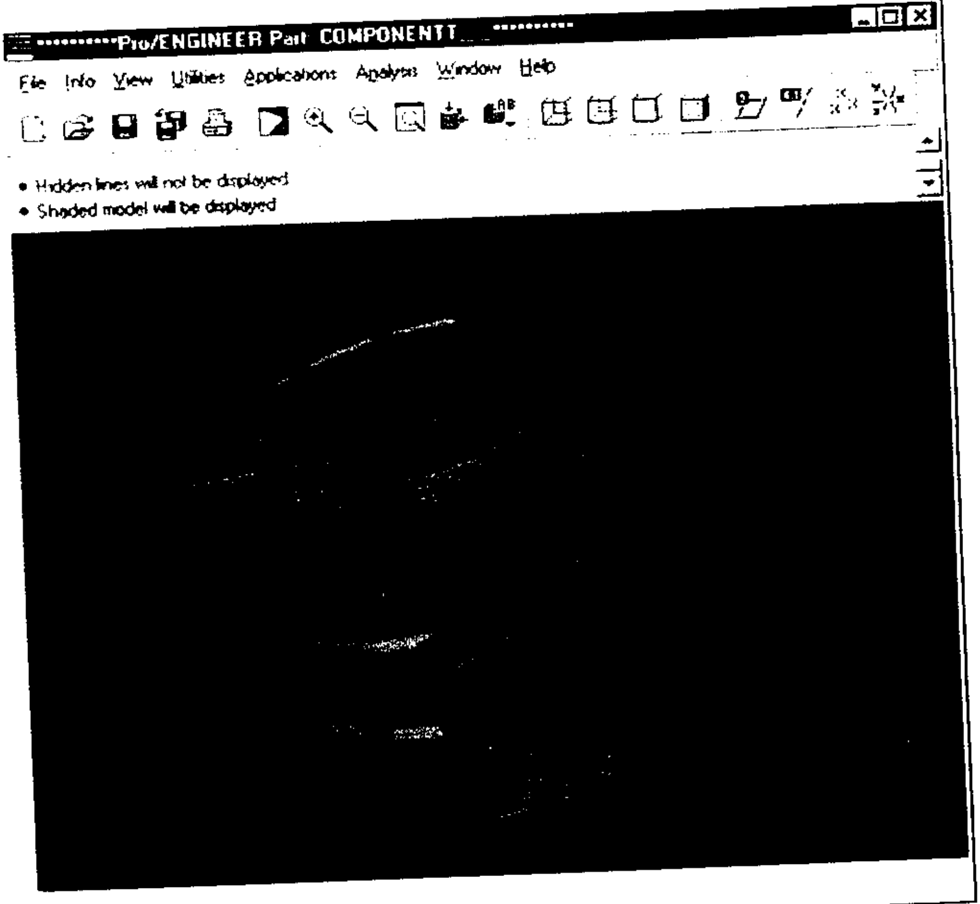


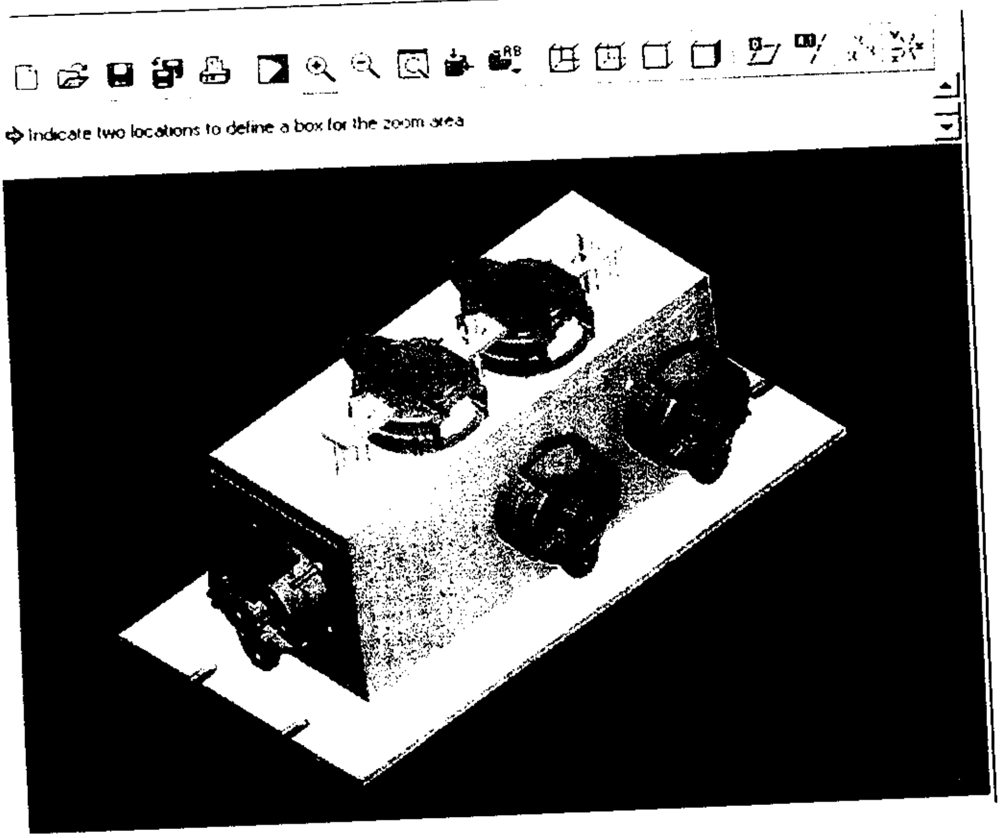


ALL DIMENSIONS ARE IN mm

MACHINING FIXTURE FOR S.R.E BRACKET		
DRAWING NAME: ANGLE PLATE FIXTURE		
SCALE	MATERIAL: MILD STEEL	PROJECT MEMBERS
QUANTITY :		M.RAM PRABHU
		P.YOGANANDHAN
DRG.NO:		M.NATESH KUMAR
		S.SURESH

PHOTOGRAPHS


Pro/ENGINEER Part COMPONENT1
File Info View Utilities Applications Analysis Window Help
• Hidden lines will not be displayed
• Shaded model will be displayed


Indicate two locations to define a box for the zoom area

CONCLUSION

CONCLUSION

So far the component taken for study is being machined in a CNC machine, but it is found to be cost ineffective as well as productivity ineffective. Now with the development of fixture for vertical machining center it is expected to achieve the above set goals. After the development of the fixture the productivity is considerably increased.

Even semi skilled workers can perform various operations on the bracket with high reliability and accuracy with this fixture. It reduces machining time and helps in mass production.

It reduces operator's work and consequent fatigue as handling operations are minimized and simplified. This fixture can be use only for a particular size of component.

In future the clamping can be made more efficient by using power assisted hydraulic clamping system.

APPENDIX

n = **Revolutions per min—Cutting speed** *v*—**Diameter** *d*

ϕ in mm *d*	Cutting speed *v* in m/min											
	8	10	15	20	25	30	35	40	50	80	100	150
	Revolutions per min											
5	510	636	955	1272	1590	1912	2230	2548	3180	5095	6360	9550
6	425	531	797	1060	1325	1593	1856	2124	2650	4240	5300	8000
7	364	455	683	910	1136	1365	1593	1820	2275	3630	4550	6800
8	318	400	597	796	996	1194	1393	1592	1990	3180	3980	6000
9	283	354	530	708	886	1060	1240	1415	1770	2830	3540	5200
10	255	318	478	637	796	956	1125	1274	1590	2550	3180	4800
11	231	289	434	580	724	868	1013	1157	1445	2310	2890	4350
12	212	265	398	531	663	796	928	1060	1325	2130	2660	4000
14	182	228	341	455	568	682	796	910	1136	1820	2280	3410
16	159	199	298	398	497	597	695	796	995	1590	1990	2980
18	142	177	265	354	443	530	620	708	885	1420	1770	2660
20	128	159	239	319	398	478	558	637	795	1270	1590	2390
22	116	145	217	290	362	434	506	579	723	1150	1450	2170
25	102	128	192	255	319	383	446	510	638	1020	1280	1910
28	91	114	171	227	284	341	398	455	568	910	1140	1710
32	80	100	149	199	249	298	348	398	498	800	1000	1490
36	71	89	133	177	221	265	310	354	442	710	890	1330
40	64	80	119	159	199	239	278	318	393	640	800	1200
45	57	71	106	142	177	214	248	283	354	570	710	1060
50	51	64	96	127	159	191	223	255	318	510	640	950
55	46	58	87	116	145	174	203	231	298	460	580	870
60	43	53	80	106	133	159	186	212	265	420	530	800
70	36	46	68	91	144	136	169	182	227	360	450	680
80	32	40	60	80	100	119	139	159	199	320	400	600
90	28	35	53	71	89	106	124	142	177	285	355	530
100	26	32	48	64	80	96	111	127	159	255	320	480
110	23	29	43	58	73	87	101	116	145	232	290	435
125	20	26	38	51	64	76	89	102	127	200	255	380
140	18	23	34	46	57	68	80	91	114	180	228	340
160	16	20	30	40	50	60	70	80	100	160	200	300
180	14	17	27	35	44	53	53	71	88	140	175	265
200	12	16	24	32	40	48	62	64	80	125	160	240
220	11.6	14	22	29	36	43	50	57	71	114	143	210
250	10.2	12.7	19	25	32	38	44	51	64	100	125	190
275	9.2	11.6	17	23	29	35	40	47	58	93	115	175
300	8.5	10.6	16	21	26	32	37	43	53	85	105	160
350	7.2	9.1	14	18	22	28	32	36	45	73	91	135
400	6.3	7.9	12	16	20	24	28	32	40	64	80	120
450	5.6	7.1	10.6	14	18	21	24	28	36	57	71	105
500	5	6.4	9.5	13	16	19	22	26	32	51	64	95

$v = \pi \times d \times n$ $\quad n = \frac{v}{\pi \times d}$ $\quad d = \frac{v}{\pi \times n}$ $\quad$ put *d* in metre in the formula

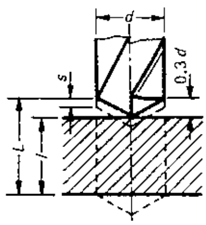
Calculating machining time for drilling operations

The machining (drilling) time is the period of time in which the machine performs the actual drilling operation

rpm—known

L = length of drill travel in mm
$L = l + 0.3\ d$
d = diameter of the drill in mm
n = revolutions per minute
s_r = feed in mm/revolution
s = feed per minute

t_m = machining time



rpm—unknown

$L = l + 0.3\ d$
d = diameter of the drill in mm
s_r = feed in mm/revolution
v = cutting speed in m/min
$v = \frac{\pi \times d \times n}{1000}$
$n = \frac{v \times 1000}{\pi \times d}$ min

t_m = machining time

$$t_m = \frac{L}{s_r \times n}\ \text{min}$$

$$\text{Machining time} = \frac{\text{length of tool travel}}{\text{feed per min}}$$

$$t_m = \frac{L \times \pi \times d}{s_r \times v \times 1000}\ \text{min}$$

Example: $l = 35$ mm $d = 30$ mm
$s_r = 0.2$ mm/rev, $n = 300$ rpm
$L = l + 0.3d = 35 + 0.3 \times 30$
$= 35 + 9 = 44$ mm
$t_m = \frac{L}{s_r \times n} = \frac{44}{0.2 \times 300} = 0.73$ min

Example: $l = 35$ mm $d = 30$ mm
$s_r = 0.2$ mm/rev $v = 28$ m/min
$L = l + 0.3\ d$ $= 35 + 9 = 44$ mm
$t_m = \frac{L \times \pi \times d}{s_r \times v \times 1000} = \frac{44 \times \pi \times 30}{0.2 \times 28 \times 1000}$
$= 0.73$ min

Machining time in minutes per 10 mm length of tool travel

rpm n	Feed s in mm/rev: 0.1	0.12	0.16	0.2	0.25	0.32	0.4	0.5	0.65
	Machining time t_m in min/10 mm								
11.2	8.93	7.44	5.85	4.46	3.57	2.79	2.23	1.78	1.38
14	7.15	5.95	4.46	3.57	2.85	2.23	1.78	1.43	1.09
18	5.56	4.36	3.47	2.77	2.22	1.73	1.39	1.11	0.85
22.4	4.47	3.71	2.79	2.23	1.78	1.39	1.11	0.89	0.68
28	3.57	2.97	2.23	1.78	1.42	1.11	0.88	0.71	0.55
35.5	2.82	2.34	1.76	1.40	1.12	0.86	0.70	0.56	0.43
45	2.22	1.85	1.39	1.11	0.88	0.69	0.55	0.44	0.34
56	1.79	1.31	1.12	0.89	0.71	0.55	0.44	0.36	0.27
71	1.41	1.17	0.88	0.70	0.53	0.44	0.35	0.28	0.21
90	1.11	0.92	0.69	0.55	0.44	0.34	0.28	0.22	0.17
112	0.89	0.74	0.58	0.44	0.36	0.28	0.22	0.18	0.14
140	0.71	0.59	0.44	0.36	0.28	0.22	0.18	0.14	0.109
180	0.55	0.43	0.35	0.28	0.22	0.17	0.14	0.111	0.085
224	0.45	0.37	0.28	0.22	0.18	0.13	0.111	0.081	0.068
280	0.36	0.29	0.22	0.18	0.14	0.111	0.088	0.071	0.055
355	0.28	0.23	0.17	0.14	0.112	0.086	0.070	0.056	0.043
450	0.22	0.18	0.14	0.111	0.088	0.069	0.055	0.044	0.034
560	0.18	0.13	0.112	0.089	0.071	0.055	0.044	0.036	0.027
710	0.14	0.117	0.088	0.070	0.053	0.044	0.035	0.028	0.021
900	0.111	0.092	0.069	0.055	0.044	0.034	0.028	0.022	0.017
1120	0.089	0.074	0.058	0.044	0.036	0.028	0.022	0.018	0.014
1400	0.071	0.059	0.044	0.036	0.028	0.022	0.018	0.014	0.011
1800	0.055	0.043	0.035	0.028	0.022	0.017	0.014	0.011	0.008
2240	0.045	0.037	0.028	0.022	0.018	0.013	0.011	0.009	0.007
2800	0.035	0.029	0.022	0.018	0.014	0.011	0.009	0.007	0.006

BIBLIOGRAPHY

TITLE	AUTHOR
JIGS AND FIXTURE DESIGN	G.HOFFMAN
DIES MOULD AND DESIGN	OLEG MESHKAR
TOOL DESIGN	DONALDSON
TOOL ENGINEERING AND DESIGN	G.R.NAGPAL
PSG DESIGN DATA BOOK	FACULTY OF MECHANICAL ENGG.
PRODUCTION TECHNOLOGY	H.M.T.
WORKSHOP TECHNOLOGY-I	A.K&S.K.HAJRA CHOUDHURY
WESTERNMANN TABLES FOR THE METAL TRADE	-