

# Modification of Tailstock Design for the Purpose of Trepanning Operation in Heavy Duty Lathe

Sanal Kumar A.P<sup>1</sup>, Dr.S.Sankar<sup>2</sup>, Dr.K.Senthil Kumar<sup>3</sup>

P.G. Student, Department of Mechanical Engineering, NCERC, Pampady, Thiruvilwamala, Thrissur, Kerala, India<sup>1</sup>

HOD, Department of Mechanical Engineering, NCERC, Pampady, Thiruvilwamala, Thrissur, Kerala, India<sup>2</sup>

HOD, Department of Automobile Engineering, NCERC, Pampady, Thiruvilwamala, Thrissur, Kerala, India<sup>3</sup>

**ABSTRACT:** Trepanning is a drilling process that leaves a core. Trepanning is a deep hole drilling process that has broad application over many industries. A trepanning tool is a carbide cutting tool which is used as a metal cutting tool for varied materials where deep hole boring and cutting large diameters is needed. A trepanning tool creates an annular hole without cutting up to the centre and without removing the core material. Thus the wastage of material is reduced. Also trepanning process takes very less time for the operation. Trepanning tool normally have one carbide tip at the cutting edge, and they sometimes rely on water to cool down the cutting tips and remove chip from the hole being created. Selection of material for the trepanning tool and cutting tips are based on the properties of material to be machined. The purpose of the tailstock design is to conduct trepanning process on a Titanium rod. Trepanning process will help to reduce the wastage of raw material and to save the cost. A conventional type of lathe is used to hold the work piece. It is a heavy duty lathe with 2 tonne capacity and 1000mm holding capacity. The tailstock and the trepanning tool should be able to carry the load during cutting process. The tailstock design should be in such a way that the feed movement of the trepanning tool should be either by a hand wheel rotation or by a motor. The trepanning tool is designed to produce a pipe with inner diameter 170mm from solid shaft of diameter 210mm and 600mm in length.

**KEYWORDS:** Trepanning process, Titanium, Tailstock design Trepanning tool, Carbide tip

## I. INTRODUCTION

Titanium and its alloys have gained widespread applications in aerospace, biomedical industries and marine due to their favorable properties. They are light weight, possess high strength, have excellent fatigue performance and offer high resistance to an aggressive environment. Titanium is a chemical element with symbol Ti and atomic number 22. One of the primary ingredients to successfully machining titanium is a stiff and rigid machine tool and work holder. It is critical that the machine tool and fixture are capable of securing the work-piece as it begins to vibrate, only those fixtures that have been designed with stability as its primary function should be used in titanium machining. Having a stiff and rigid machine design allows the machine tool to counter the high-torque, high-horsepower forces of the spindle and produce consistent part quality with less effort. A cutting tool must have good hardness, toughness and wear resistance in order to produce good quality and economical parts.

In the market standard titanium pipes are available. As per the customer requirement the size of pipe may get varied. If the pipe size doesn't belong to a standard size then trepanning process has to be conducted. Normally trepanning process is conducted on costly materials like titanium alloy. Trepanning reduces the waste and it gives the required size. For trepanning process it is always recommended to use Carbide tools for cutting process as it have high hardness over a wide range of temperatures, high thermal conductivity and high Young's modulus making them effective tool and die materials for a range of applications. Scope of this project is to manufacture a trepanning tool arrangement at very less expense. Trepanning tool helps to create bore on the solid material. The trepanning tool does not machine the whole

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

diameter it removes only a ring at the periphery. Instead of removing all the material in the form of chips, a core is left in the centre of the hole. The core material which is removed from the work piece is also in the form of a shaft which can further utilized for any other part production. Titanium is one of the costly materials and therefore in all cases wastage of material is tried to minimize during various machining operation. Trepanning process is selected in such a way that the trepanning tool has to fix on a modified tailstock design which will be fixed on the lathe bed.

The tailstock design should have a part which has to be fixed on the lathe bed. It is called as lathe bed fix or top fix. On this top fix a main cover has to be designed which carries the trepanning tool. The centre point of trepanning tool and the centre of lathe spindle should be in alignment. The trepanning tool should move to and fro during the operation which will help to cut the material from the periphery of work piece. A main cover is designed in order to hold the trepanning tool which also helps to and fro motion of the trepanning tool. Cutting tips are fastened to the periphery of trepanning tool. During trepanning process tremendous heat is generated. Normally the heat generated between titanium and a carbide tip is around 2000°F (1093°C). The trepanning tool should design in such a way that the lubrication and chip removal from the tool must be easy. For titanium trepanning feed rate is normally 0.1 – 0.2 mm/rev and Cutting speed is 30 -100 m/min as per standard practice the feed rate for trepanning process is occurs at a high load condition with very low feed rate.

## II. MATERIALS AND METHODS

Trepanning tool is having a specific geometry. It is a pipe like structure whose inner diameter represents size of the core produced during machining. External diameter of the trepanning tool represents the internal diameter of the pipe to be produced. Trepanning tool should have good thermal conductivity and good shock resistance. In trepanning operation the cutting tip makes a line of contact and hence the load during cutting operation is more. Trepanning tool must have the ability to withstand the load. Machinability of the material is also important as the trepanning tool has to manufacture separately as per the size requirement. EN24-T and Maraging steel are the two common materials with greater mechanical properties and machinability. These materials are commonly used for die preparation because of its ability to with stand high load during forging operation.

Table.1 Material properties of EN24T

Properties	EN24-T	Maraging steel
Density	8.015g/cm <sup>3</sup>	8.1 g/cm <sup>3</sup>
Melting point	1426-1538°C	1413-1540°C
Thermal conductivity	40.5W/(m-k)	25.5W/(m-k)
Shear modulus	80GPa	77GPa
Ultimate tensile strength	849.95 MPa	255MPa
Youngs Modulus	122GPa	210GPa
Poissons ratio	0.29	0.3
Hardness	65HRC	50HRC

Hardness value, thermal conductivity, ultimate tensile strength and shear modulus of EN-24T is higher than maraging steel. Machinability of EN-24T is also much better than maraging steel. Based on the above comparison study EN-24T is selected as the material for trepanning tool.

Cutting tip is fastened on the periphery of trepanning tool. Titanium is a hard material. Therefore carbide tools are preferred as cutting tip. Based on the study of hardness number with respect to the titanium is conducted and Tungsten carbide is selected as the carbide tip. Carbide tip should have the ability to withstand the immense heat which generated during the trepanning operation. The geometry of the cutting tip also carries importance in the trepanning process. Trepanning operation is similar to that of a milling operation. In turning operation the cutting tip is having only point contact while on milling operation the cutting tip is having a line contact.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

Table.2 Comparison of hardness number

Material	Rockwell hardness number	Mohr's hardness number	Melting point
Titanium	36	6-6.5	1688 °C
Titanium carbide	90	9-9.5	3160 °C
Tungsten carbide	75	8.5-9	3422 °C
Diamond	100	10	-

Tungsten carbide selected as the material for carbide tip. Tungsten carbide is having more hardness number than the titanium material. Material selection for trepanning tool and cutting tip carries greater importance. All the rest of parts which assist the tailstock design can be fabricated using mild steel plates.

Trepanning process has to conduct on the Titanium material. The work piece is a Titanium solid shaft of diameter 210mm. Trepanning tool needs to be in the form that after machining the solid shaft must turn in to a pipe of internal diameter 170mm and external diameter 210mm. Trepanning tool has cutting edges on the periphery. Trepanning tool is placed in the tailstock. Main part of the modified tailstock design is the mechanism which is used for the movement of trepanning tool and the tail stock has three main parts. One part is the base which kept on the lathe bed, second part is used to carry the trepanning tool and the third part is the arrangement which provides movement to the trepanning tool. Principle of screw jack is used to give motion to trepanning tool.

### III. MODIFIED PARTS OF TAILSTOCK

Top fix, main cover, trepanning tool and spindle arrangement are the main parts of the tailstock. All these parts are assembled and placed on the lathe bed. The work piece is placed on the head stock and it is rotating at a speed of 100rpm. Trepanning tool is having only axial movement. Two holding plates are used to prevent any kind of rotation of the trepanning tool. Spindle arrangement will give feed movement to the tool in axial direction. Thus the trepanning tool will enter in to the rotating work piece and the contact of cutting tip will start the material removal.

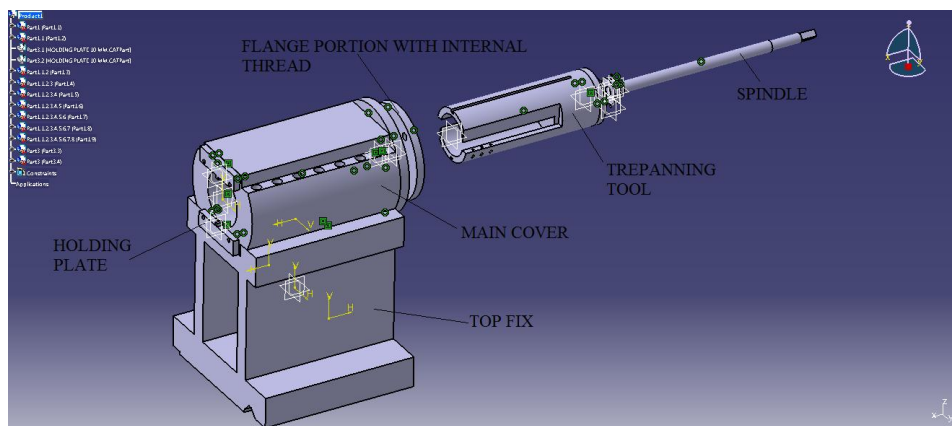


Fig.1 Assembled view of Tailstock design

Working principle of screw jack is utilized for the movement of trepanning tool. A spindle with external thread and flange portion with internal thread is used to give the feed. The flange is fixed to main cover and the spindle will pass through the threaded portion of flange. At one end of the spindle a plate and pin arrangement is fixed as shown in fig.2(b). This plate is placed in the rear plate of trepanning tool. When the spindle is rotated in clockwise direction the plate and pin arrangement of spindle will give a push to the rear part of the trepanning tool. Similarly when the spindle is rotated in anti clockwise direction the plate connected to the spindle will pull back the trepanning tool along with the rear plate fixed to trepanning tool.

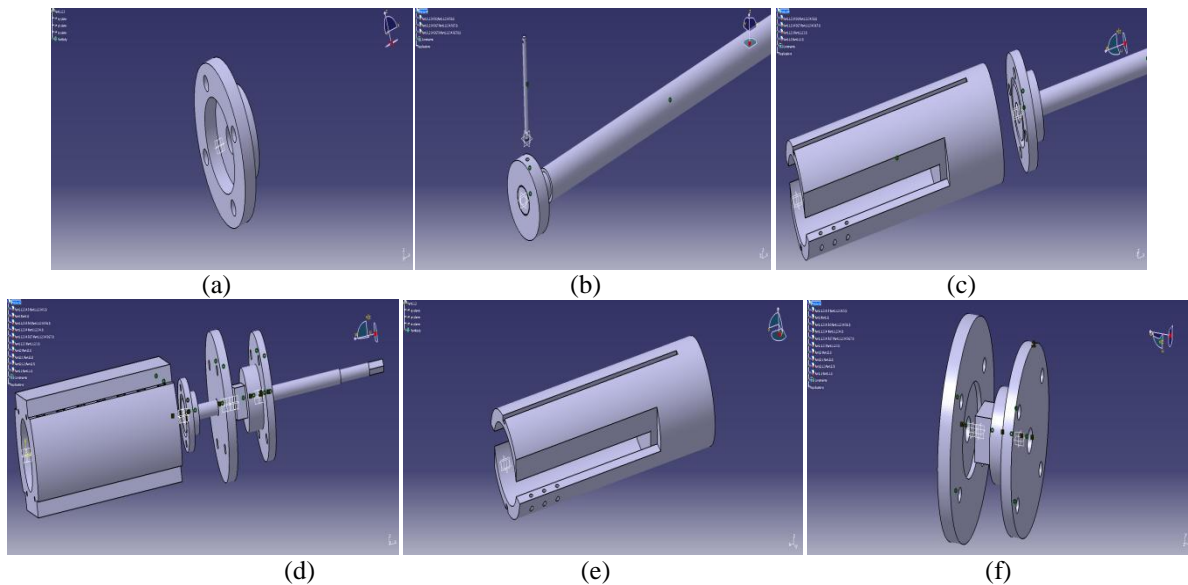


Fig.2 (a) Rear plate of trepanning tool (b) Pin and plate arrangement of threaded bar (c) Arrangement of parts with main cover (e) Trepanning tool (f) Arrangement of parts for spindle movement

Trepanning tool designed such that during trepanning operation the trepanning can conduct up to a length of 300mm. For the spindle movement a separate arrangement is used. A plate is fixed to the rear portion of main cover. This rear plate is connected with a flange with hub part as shown in fig.2 (f). Inside the hub a square hole is provided to carry a square piece with internal threads. The spindle thread will pass through this square piece. Square piece is placed tightly inside the hub hence the rotation of spindle will cause axial movement. This axial movement will give a push to the trepanning tool as shown in fig.2(c). When anticlockwise rotation is given to the spindle it will pull back the trepanning tool.

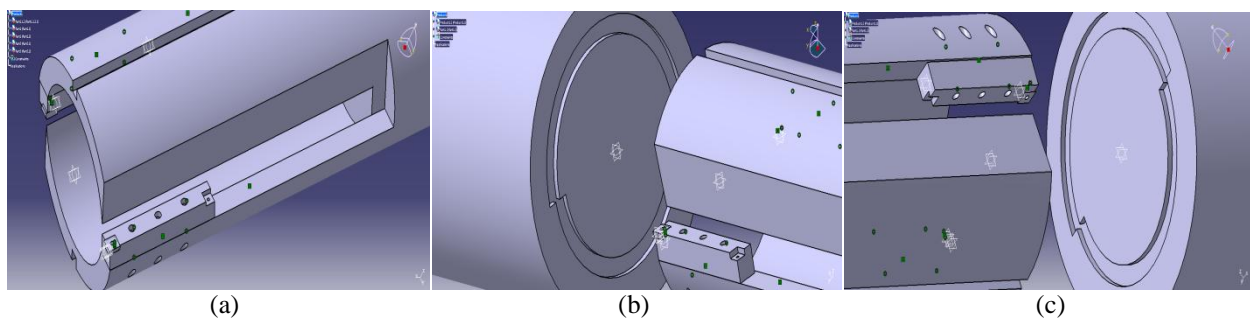


Fig.3 (a) Cutting tip arrangement on trepanning tool (b) Material removal from outer periphery of core (c) Material removal from inner periphery of core.

Cutting tips are arranged on the trepanning tool as shown in the figure 3. Two cutting tips are arranged on the trepanning tool such that one tip will remove material from the outer periphery of core and another tip will remove the material from the inner periphery of core. Once the trepanning process completed for a length of 300mm the same trepanning operation has to conduct from the opposite face of work piece. During this time it is better to fill plaster of paris in to the hollow space created by the trepanning process.



## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

$$T = \frac{60 \times 29828}{2 \times \pi \times 1440}$$

$$= 197.803 \text{ NM}$$

$$T = 197.803 \times 10^3 \text{ N-mm}$$

Maximum torque developed in the lathe operation is  $197.803 \times 10^3 \text{ N-mm}$ .

Maximum tensile strength of EN 24T is  $850\text{-}1000 \text{ N/mm}^2$  and the maximum yield strength is  $680\text{-}700 \text{ N/mm}^2$ . Maximum shear stress value for EN 24T is  $800 \text{ N/mm}^2$ .

We know that the maximum torque can develop in the lathe operation is  $197.803 \times 10^3 \text{ N-mm}$ . For the trepanning tool the outer and inner diameter are  $170\text{mm}$  and  $130\text{mm}$  respectively.

Calculate the maximum shear stress which can develop in the material under the maximum torque condition.

$$T = \frac{\pi}{16} \times \tau \times \frac{D^4 - d^4}{D}$$

Where,

T = Torque developed in N-mm

$\tau$  = Maximum shear stress in  $\text{N/mm}^2$

D = Outer diameter in mm

d = Inner diameter in mm

$$197.803 \times 10^3 = \frac{\pi}{16} \times \tau \times \frac{170^4 - 130^4}{170}$$

$$\tau = 0.311 \text{ N/mm}^2$$

Obtained value is within the safe limit of shear stress, therefore the design is safe.

Stress analysis and deformational analysis of the trepanning tool conducted at different load condition using ANSYS software. For the safe design purpose the value of load changed from  $800\text{N}$  to  $2000\text{N}$ .

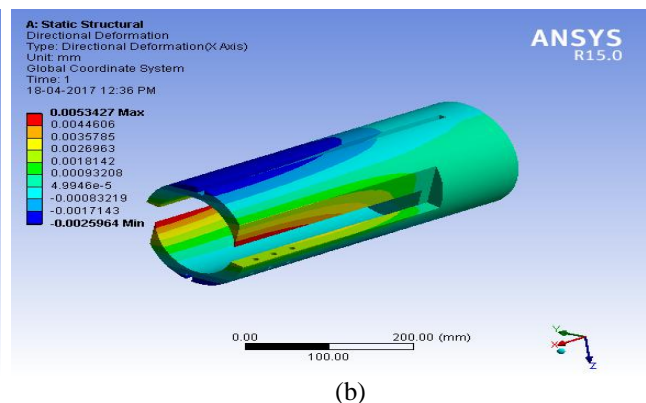
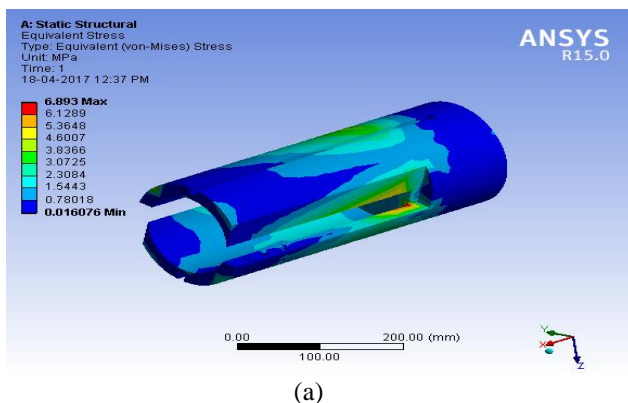


Fig.5 (a) Stress analysis at  $800\text{N}$

(b) Deformational analysis at  $800\text{N}$

The maximum Von-Mises stress developed at  $800\text{N}$  is  $6.8929\text{MPa}$  and the maximum deformation is  $0.0053436\text{mm}$ .

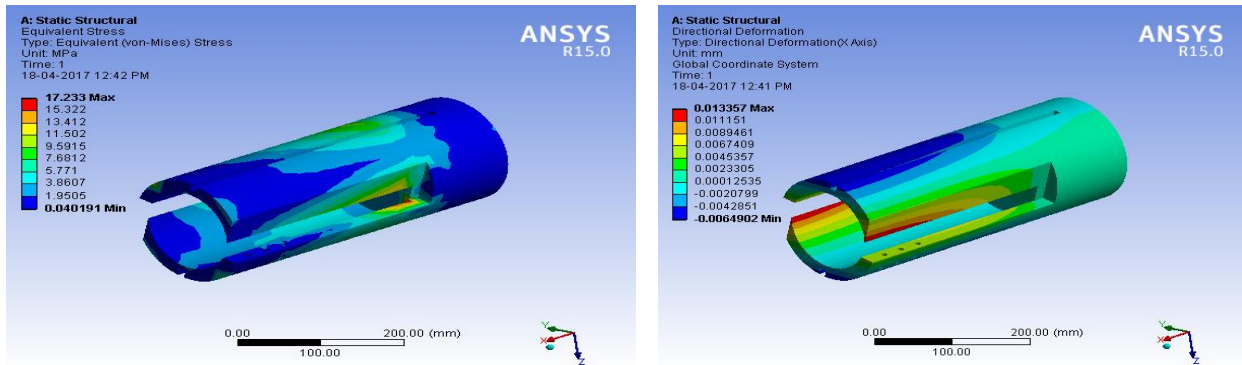


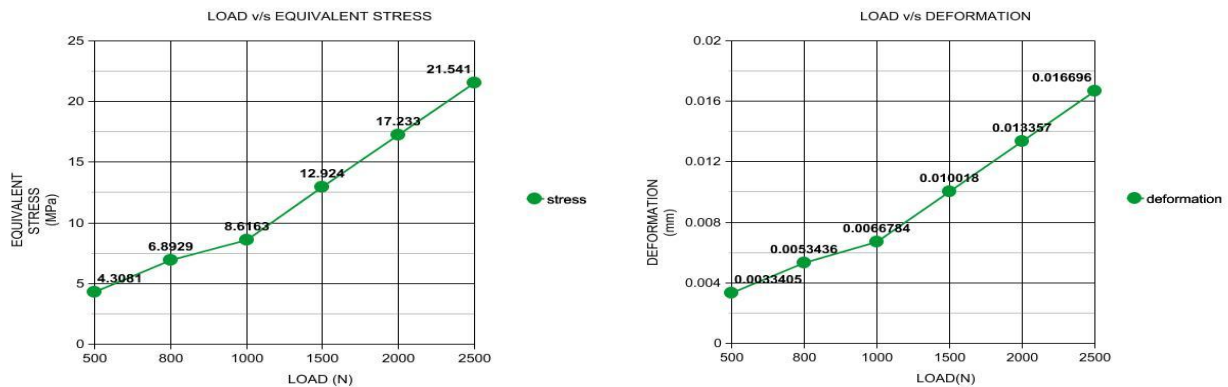
Fig.6 (a) Stress analysis at 2000N

(b) Deformational analysis at 2000N

The maximum Von-Mises stress developed at 2000N is 17.233MPa and the maximum deformation is 0.013357mm. From the above stress analysis it is easy to identify the area where the stress concentration occurs and the value of Von-mises stress at both load condition is in the safe limit.

Table.3 Stress and deformation analysis of EN24T

Material	Load(N)	Maximum stress (MPa)	Maximum deformation (mm)
EN24T	500	4.3081	0.0033405
	800	6.8929	0.0053436
	1000	8.6163	0.0066784
	1500	12.924	0.010018
	2000	17.233	0.013357
	2500	21.541	0.016696



(a)

(b)

Fig7. (a) Load v/s Equivalent stress (b) Load v/s Deformation

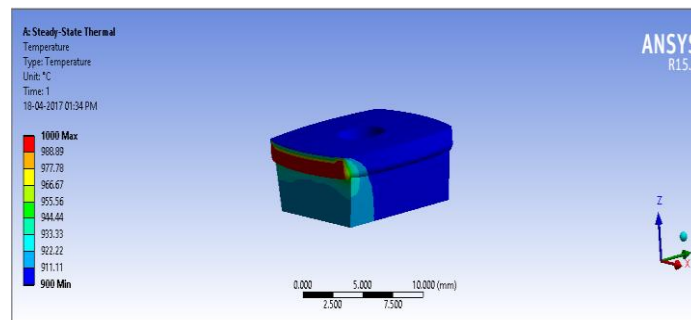


Fig.8 Static state thermal analysis of cutting tip at 1000°C

From the static state thermal analysis it can identify that the maximum heat generation occurs at the edges of cutting tip where the material comes in contact during trepanning process.

#### V. FABRICATION

All the parts for the tailstock is designed with respect to the trepanning tool and lathe specifications. Trepanning tool is fabricated from EN24T material. Rest of the parts are manufactured by using Mild Steel material. Bottom of the top fix is machined in to the size exactly that of lathe bed. The spindle utilized is a M35 threaded bar with 800mm in length.

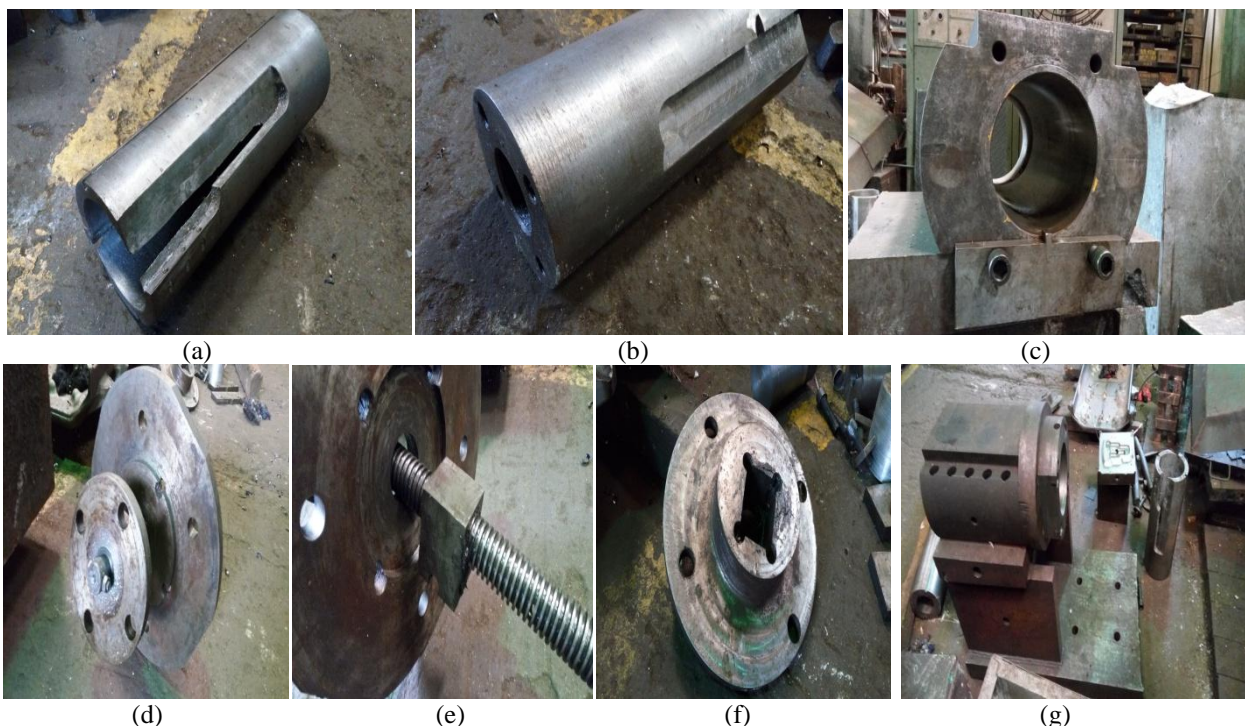


Fig.9 (a) Trepanning tool (b) Rear portion of trepanning tool (c) Holding plate fixed on the main cover (d) Rear plate of trepanning tool with pin arrangement of spindle (e) Spindle and square piece arrangement (f) Flange with square hole (g) Main cover fixed on the top fix

All the parts are manufactured by using normal machining operations and by using normal fabrication methods. All these parts are assembled together and placed on the lathe bed. Top fix is fastened to the lathe bed with normal nut and bolt arrangement same as that of conventional tailstock.





# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 5, May 2017

threads same as that of spindle. Therefore when the chain pulley begins to rotate freely in the bearing it causes the spindle to rotate and the spindle rotation turns in to the feed of trepanning tool.

## VII. CONCLUSION

Trepanning process is conducted in a conventional lathe with the help of modified tailstock design. The process was cheaper than any other process and the amount of wastage during making a hole is very less. The core generated during the trepanning operation can be used a raw material for any other machining process.

## REFERENCES

- [1] Ronald.G.Munro- Material Properties of Titanium Diboride, Volume 105, Number 5, September–October 2000, Journal of Research of the National Institute of Standards and Technology, (J. Res. Natl. Inst. Stand. Technol.105, 709-720 (2000)).
- [2] Vinicius.A.R.Henriques, Institute of Aeronautics and space, Brazil- Titanium production for aerospace application, *Journal of aerospace technology and management*, V.1,n.1 Jan-Jun 2009.
- [3] Jose Mathew, N.Ramakrishnan & N.K. Naik- Investigations into the effect of geometry of a trepanning tool on thrust and torque during drilling of GFRP composites- *Journal of Materials Processing Technology* 91 (1999) 1–11 (DOI: 10.1016/S0924-0136(98)00416-6).
- [4] J.Nithyanandam, SushilLal Das & K.Palanikumar- Influence of cutting parameters in machining of Titanium alloy- *Indian Journal of Science and Technology*, Vol 8(S8), 556–562, April
- [5] Wang Xi and LI Jian-jun- Different Way to Produce Deep Holes – Trepanning. *College of Engineering and Technology, Yunnan Agricultural University, Kunming 650201, China, Journal-Machine Tool & Hydraulics- 2005-04*
- [6] Maniamramasamy.S, Kaviyarasu.P, & Luke Justin Johnson.G- Experimental Investigation of Motorized Screw Jack- *International Journal of Advanced Research in Biology, Ecology, Science and Technology (IARBEST)* Vol. 1, Issue 8, November 2015.
- [7] Akash Tiwari, Niral Panchal, Parth Solanki, Lalit Parmar & Diptesh Patel - Designing and Fabrication of Multipurpose Tool Post for Lathe Machine IJSRD - *International Journal for Scientific Research & Development* Vol. 2, Issue 03, 2014 | ISSN : 2321-0613
- [8] R.Staniek, A.Gessner, J.Zielnica, W.Ptaszyński, A.Myszkowski, O.Cizak, & A.Stoić- Stress And Displacement Analysis Of A Modern Design Lathe Body By The Finite Element Method (FEM)-ISSN 0543-5846METABK 51(1) 51-54 (2012)UDC – UDK UDC – UDK 621.94:620.16:621-7:51=11.
- [9] M. Narasimha, R. Reiji Kumar & Achamelehaemro Kassie- Performance of Coated Carbide Tools- *The International Journal Of Engineering And Science (IJES)* (Volume||2 ||Issue|| 6 ||Pages|| 47-54||2013) ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805.
- [10] Anand Kumar<sup>1</sup>, Pardeep Kumar, Anuj Kumar & Bhupender Singh- Performance Evaluation of Tin Coated Carbide Insert for Optimum Surface Roughness in Turning of AISI 1045 steel- *International journal for research in engineering and technology*, eISSN:2319-1163/pISSN:2321-7308.
- [11] M.Narasimha, Mahaboob Patel & R.Rejikumar- Application of Coating on Carbide Insert- *The International Journal Of Engineering And Science (IJES)*, (Volume || 3 || Issue || 4 || Pages || 01-07 || 2014), ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805
- [12] Jose Mathew, N.Ramakrishnan & N.K.Naik- Trepanning on unidirectional composites: delamination studies- *Journal of Materials Processing Technology* 85 (2002) DOI: 10.1016/S0924-0136(98)00416-6.