International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-03, Issue-12, Mar 2018

Design Analysis, Simulation and Fabrication of Spur Gear Cutting Attachment for Lathe Machine

[1]Gunturu Mohan, [2]C. Vijayabhaskar Reddy

[1]UG Student, [2]Professor, Sri Venkateswara College of Engineering Technology (Autonomous)

R V S Nagar, Chittoor, Andhra Pradesh, India.

[1]gunturumohan5@gmail.com, [2]bhaskarreddychalla@gmail.com

Abstract—Lathe is a very important manufacturing subsystem in many sectors. Even though it is a versatile machine, it has some limitations while performing certain operations like a spline, gear cutting. The use of milling machines in the production of gear cutting is well recognized. This paper aims at the design and development of an attachment that can help lathe operations to machine spur gear product effectively. Attachment is designed as able to cut spur gear accurately and flexible to use. Milling machine cutting load and thrust loads is applied while doing the analysis. The results are studied and analyzed whether the attachment is able to withstand the load with the help of ANSYS tool. Finally, from the results obtained attachment is fabricated.

Keywords— Design, analysis, motion simulation, fabrication. Attachment assembly and machining.

I. INTRODUCTION

Job shops and small-scale industries are heavily constrained to use general purpose machines due to financial limitations. Machines such as Lathes and Milling machines are versatile with these groups as they required minimum funding and are easy to maintain. Researchers always attempt to help these industries through innovative methods to enlarge the ambit their production using these general purpose machines [1]. A variety of attachments are already in use by these industries. As so far the literature reviews collected based on some lathe machine attachments like the keyways, slotting, internal keyway, and grinding wheel attachments for lathe machine. These papers are helping lathe machine to obtain maximum efficiency and utilization. literature collected on gear cutting related journal explained about the parameters to be considered while doing the design of an attachment and required instructions to be considered while doing gear cutting attachment for lathe machine.

J.C.Harbison (1994), [2] presented a milling attachment for lathes. He modified the attachment that cutting tool fitted to the arbor and that is supported by chuck and tailstock. He modified direct indexing to compound indexing.

J.W.Bracus (1942), [3] presented a gear cutting attachment. He was studied and modified smith's attachment and he tried to initiated indexing in the attachment.

T.E.Smith(1940), [4] presented a keyway and gear cutting attachment for lathes. He is the initiator for this concept he builds a gear and keyway cutting attachment for lathe by adding another motor to the cutting tools and chuck modified as holding and indexing device but this attachment is heavy and complex.

1.1 Gears

Assume that two plain wheels mounted bolt to two parallel shafts and pressed tightly connected with one another. If one wheel is rotated regarding its axis, the opposite wheel conjointly can rotate due to the friction between them as shown in Fig 1. The rotation is thus transmitted from one shaft to another.

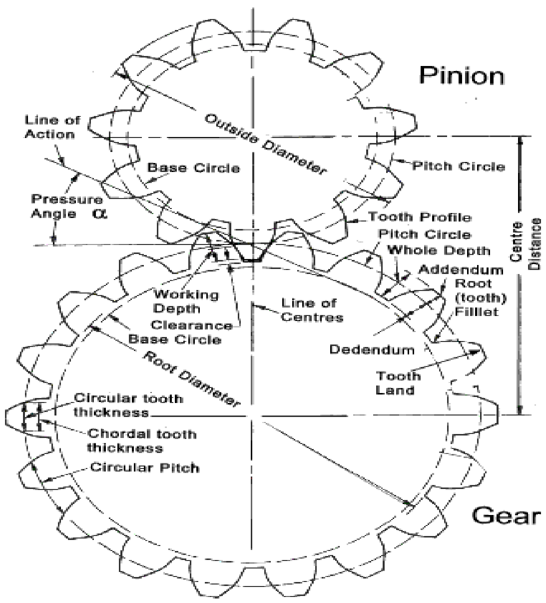

Fig.1. Gears

The surfaces of the two wheels will move at constant speed if there is no slipping. it's obvious that with the increase in

 DOI : 10.18231/2454-9150.2018.0051

ISSN : 2454-9150 Vol-03, Issue-12, Mar 2018

Load to be transmitted, the wheels will begin to slide on one another. to stop slipping slots is additionally cut on the cylindrical surfaces of the wheels and projections added between them. These slots and projections form the teeth and wheels with such teeth area unit known as toothed wheels or gears

1.2 Spur gear

Spur gears have their teeth parallel to the axis and are used for transferring power between two parallel shafts. they're simple in construction as shown in Fig 1, simple to manufacture and low cost. They need the most effective potency and smart accuracy rating. they are used in high speed and high load application altogether varieties of trains and an honest sort of velocity ratios. Hence, they perceive wide applications right from clocks, organization gadgets, motorcycles, vehicles, and railways to aircrafts.

1.3 Gear manufacturing methods:

Gear producing is divided into two classes particularly forming and machining. Forming consists of direct casting, molding, drawing, or extrusion of tooth forms in liquid, powdered, or heat softened materials and machining involve roughing and finishing operations [5] as shown in Fig 2.

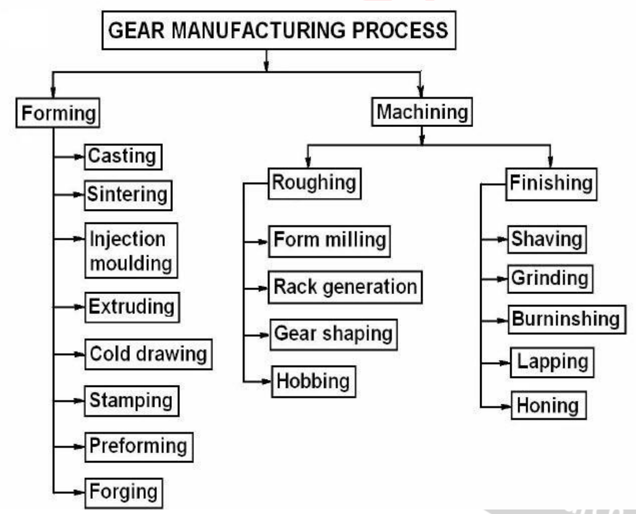

Fig.2. Gear manufacturing processes

1.3.1 Forming gear teeth

Altogether tooth-forming operations, the teeth on the gear area unit formed all right away from a mold or die into that the tooth shapes are machined. The accuracy of the teeth is entirely hooked into the quality of the die or mold and commonly is far but that will be obtained from roughing or finishing ways in which. Most of these ways that have high tooling costs making them appropriately only for high production quantities

1.3.2 Machining

The bulk of power transmission metal gears of machinery area unit made by machining process from the cast, forged, or hot rolled blanks. Refer Fig 2 for classification of machining processes. Roughing processes embrace milling the tooth form with shaped cutters or generating the form with a rack cutter, a shaping cutter or a hob cutter Despite its name, the roughing processes truly manufacture a sleek and accurate gear tooth. just for high exactness and quiet running,

1.4 Requirement of gear cutting attachment in lathe:

Lathe is a very important manufacturing subsystem in many sectors. Even though it is a versatile machine, it has some limitations while performing certain operations like a spline, gear cutting. The use of milling machines in the production of the spline and gear cutting is well recognized. If an attachment on general purpose lathe is made available, the cost of production of a product could be reduced. A CNC machine can perform the said operations more effectively since the human involvement is limited. However, due to increase in the cost of a CNC machine and the indirect costs associated with these machines, they are considered as white elephants in a certain class of manufacturing units.

II. METHODOLOGY

In this chapter, the methodology is covered to create gear cutting attachment for a lathe to perform the gear cutting operation in it. Initially, a Flow chart is shown in Fig 3. It consists of methods of making gear cutting attachment, Selection of a method, Basic drawings, designing and modifications, Design and analysis, material selection as per requirement, Fabrication, Assembly and Testing [6].

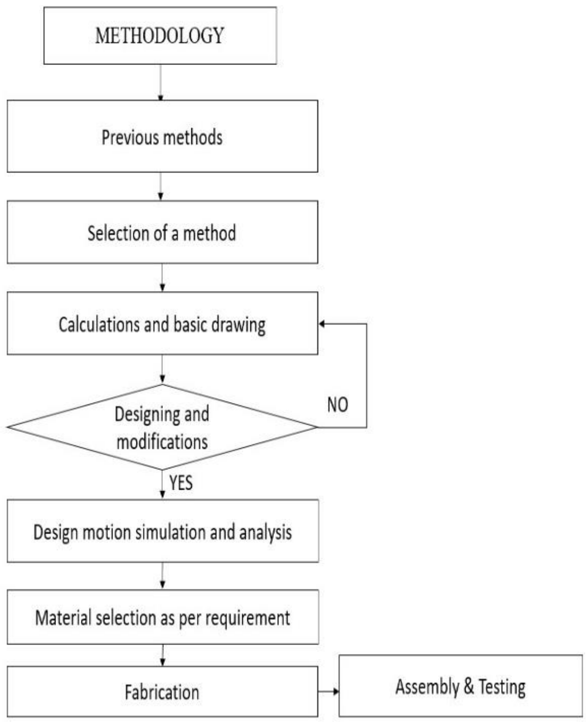

Fig.3. Methodology flow chart

2.1 Previous Methods

Two concepts are being attempted in the design and development of the attachment. One is to provision the headstock with the workpiece while tool post is loaded with a tool and is guided by a special purpose motor. The second

DOI : 10.18231/2454-9150.2018.0051

ISSN : 2454-9150 Vol-03, Issue-12, Mar 2018

method is that the headstock containing the tool is going to rotate at various speeds while the tool post or tailstock contains workpiece for holding, cutting angle and changing direction to perform gearing and slotting operations.

2.2 Selection of A Method

This project, therefore, aims at the design and development of an attachment that can help lathe operations to produce splines and gears of a product effectively and also realize cost reduction. It is essential that the product quality should be made comparable with that of milling operation or even better. Ways and means will be found to incorporate features both at design stage and production stage to achieve this goal. Such an attachment will increase the flexibility of the lathe.

After analyzing the methods, In the end, choose the method based on some consideration like work piece holding tendency external bodies to be attached in lathe machine regarding complete setup it should be strong, safety, flexible, low cost and also it should be easy to attach and remove.
By considering all these things thefirst method was chosen.

2.3 Design of Indexing and Spur Gear

2.3.1 Indexing [8]

In general, direct indexing plate has 24 holes in a circle
The workpiece is divided by using the formula
Holes by which pin is to be moved = 24/n
n = no divisions in work piece
by this direct indexing plate, these many slots can be cut

2 divisions in work piece = 24/2 = 12 holes
3 divisions in work piece = 24/3 = 8 holes
4 divisions in work piece = 24/4 = 6 holes
6 divisions in work piece = 24/6 = 4 holes
8 divisions in work piece = 24/8 = 3 holes
12 divisions in work piece = 24/12 = 2 holes
24 divisions in work piece = 24/24 = 1holes
2, 3, 4, 6, 8, 12, 24.

To get other divisions I have taken 18 holes in the same plate

2 divisions in work piece = 18/2 = 9 holes
3 divisions in work piece = 18/3 = 6 holes
6 divisions in work piece = 18/6 = 3 holes
9 divisions in work piece = 18/9 = 2 holes
18 divisions in work piece = 18/18 = 1 holes
2, 3, 6, 9, 18

2.3.2 Spur gear creation [7]

Whole Depth (W) = 2.157/P
Addendum (a) = 1/P
Tooth Radius (R) = ¾(CP)
Pitch Diameter (D1) = N/P
Circular Pitch (CP) = 3.1416/P
Diametral Pitch (P) = N/D1
Teeth number (N) = D1xD
Dedendum (d) = W-a
Outside Diameter (D) = (N+2)/P
Cordial Thickness (T) = D1sin(90/N)

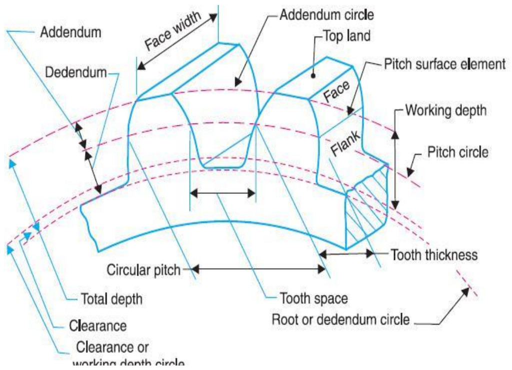

Fig.4. Spur gear nomenclature

Work piece diameter 50 mm
For this work piece if the number of teeth 18 then the gear parameters will be

1) Outside Diameter D = (N+2)/P
Outside Diameter = 50 mm
Teeth number = 18
50 = (18+2)/P
P = 20/50
= 0.4 mm
2) Pitch Diameter D1 = N/P
P = 0.4
D1 = 18/0.4
= 45 mm
3) Addendum a = 1/P
= 1/0.4
= 2.5 mm
4) Dedendumd = w-A
5) Whole Depth W = 2.157/P
= 2.157/0.4
= 5.3925
D = 5.3925 – 2.5
= 2.8925 mm
6) Circular Pitch CP = 3.1416/P
= 3.1416/0.4
= 7.854 mm
7) Tooth Radius R = ¾(CP)
= ¾ (7.854)
= 2.94 mm
8) Module m = D1/N
= 45/18
= 2.5
9) Chordal thickness T = D1 sin(90/N)
= 45 sin (90/18)
= 3.922 mm

Workpiece diameter 50 mm

For this workpiece, if the number of teeth 24 then the gear parameters will be

1) Outside Diameter OD = (N+2)/P
Outside Diameter = 50 mm
Teeth number = 24

DOI : 10.18231/2454-9150.2018.0051

$50 = (24+2)/P$

$P = 26/50$

$= 0.52$ mm

2) Pitch Diameter $D1 = N/DP$

$P = 0.52$

$D1 = 24/0.52$

$= 46.15$ mm

3) Addendum $a = 1/DP$

$= 1/0.52$

$= 1.92$ mm

4) Dedendum $d = w\text{-}A$

5) Whole Depth $W = 2.157/P$

$= 2.157/0.52$

$= 4.15$ mm

$d = 4.15 – 1.92$

$= 2.23$ mm

6) Circular Pitch $CP = 3.1416/P$

$= 3.1416/0.52$

$= 6.04$ mm

7) Tooth Radius $R = ¾(CP)$

$= ¾ (6.04)$

$= 4.53$ mm

8) Module $m = D1/N$

$= 46.15/24$

$= 1.922$

9) Chordal thickness $T = D1 \sin(90/N)$

$= 46.15 \sin (90/24)$

$= 26.38$ mm

III. MODELLING

All CAD models are modeled with help of CATIA V5 tool. Modeling of parts is divided into 5 steps

- Basic lathe.
- Attachment design.
- Work holding design.
- Tool holding design.
- Assembly.

3.1 Basic lathe

Modeling basic lathe deals with basic lathe parts. These parts specifications are taken from general purpose standard lathe and few are assumed measurements. Modeled parts names are given below.

- ➢ Lathe bed
- ➢ Headstock
- ➢ Tailstock
- ➢ Carriage
- ➢ Chuck
- ➢ Cross slide
- ➢ Carriage wheel
- ➢ Cross slide wheel
- ➢ Power shaft

3.2 Attachment model

Attachment modeling deals with necessary parts required to hold and guide the work piece to perform the operation. Parts modeled for attachment is given below.

- ➢ Main base with guides.
- ➢ Supporting base with guides.
- ➢ Cap.
- ➢ Main guide center.
- ➢ Supporting guide center
- ➢ Shaft with thread.

3.3 Work holding design

Work holding modeling is nothing but modeling required parts to hold the work piece between centers.

3.4 Tool holding design

To accomplish machining it is necessary to insert toll between headstock and tailstock. Required models are made to insert tool.

3.5 Assembly

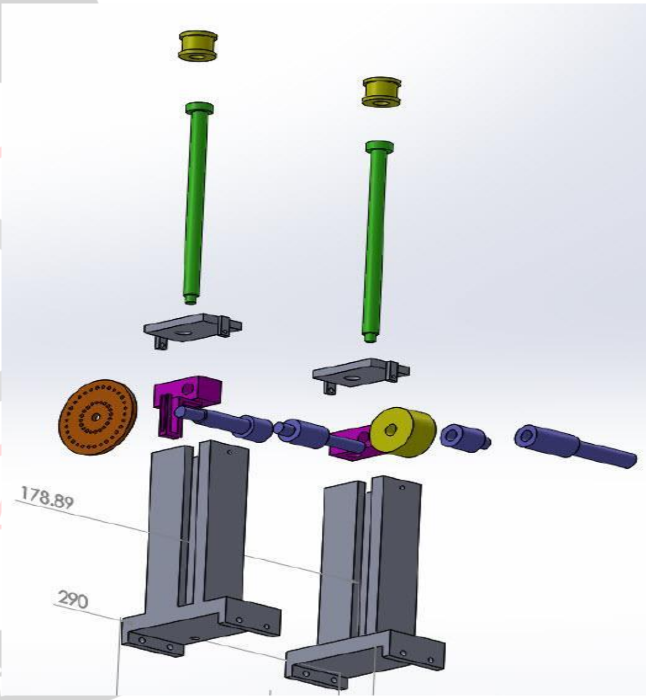

Fig.5. Detail view

In assembly stage, Bottom to top approach was selected to perform assembly in assembly workbench. Each part dragged in to assembly workbench and accomplished assembly. The detail view is shown in Fig 5 Initially, themain base and supporting base with guides are fitted to the cross slide with base nuts and bolts. Threaded shafts are fitted to centers of main and support. This subassembly is fitted to the main base and supporting bases. Now caps are fitted to base and shaft with help of rows. As shown in Fig 6

This sub assembly is attached the cross slide. Now work piece is aligned in between two bases with help of work holding the device. pulleys aligned to the threaded shaft. Belt arranged in-between two pulleys. Indexing plate attached to work holder which is fitted to the center of the

 DOI : 10.18231/2454-9150.2018.0051

ISSN : 2454-9150 Vol-03, Issue-12, Mar 2018

main guide, both ends are tightened by hexagonal nuts as shown in Fig 6.

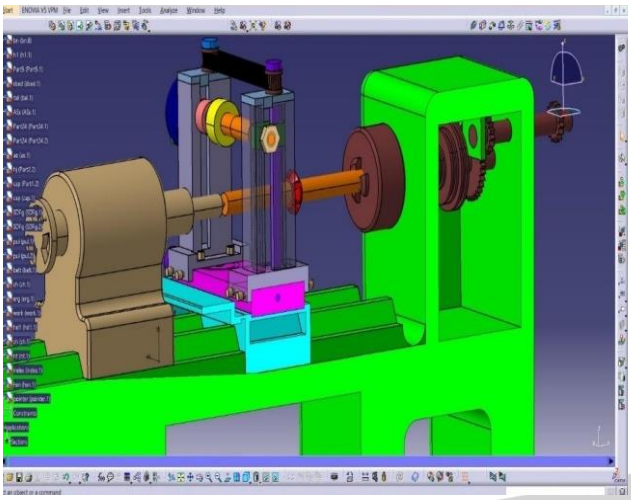

Fig.6. Details of assembly

.5.1 Final assembly

Detailed view of final assembly is shown in Fig 7

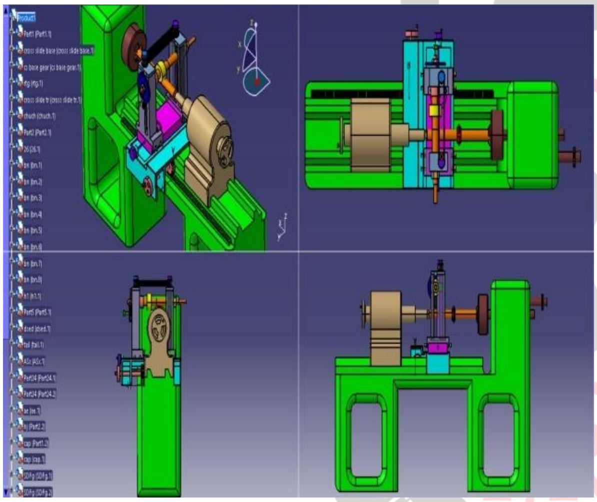

Fig.7.Final modified assembly

3.5.2 Rendered image

Rendering is nothing but converting 2D or 3D models in to realistic images. Rendered image of lathe machine with attachment is shown in Fig 8

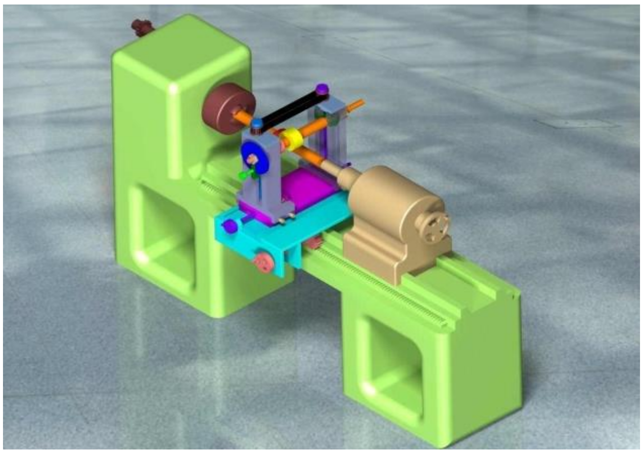

Fig.8. Rendered image

IV. MOTION SIMULATION AND ANALYSIS

4.1 Motion simulation

To perform motion simulation we chosen solid works motion simulator so all Catia v5 parts are converted from '.catpart and .catproduct' in to '.igs' format. All required motions are applied to the assembly parts and the final animated video was saved. Motions applied to the assembly parts are illustrated in Table 1

S.NO	PARTS	X linear (mm)	X rotation (RPM)	Y linear (mm)	Y rotation (RPM)	Z linear (mm)	Z rotation (RPM)
1	Carriage	-200	0	0	0	0	0
2	Centers	0	0	0	0	-100	0
3	Cross slide	0	0	150	0	0	0
4	chuck	0	600	0	0	0	0
5	other	0	0	0	0	0	0

Table.1. Motion simulation details

Initially, motion applied to the carriage to position the work with respect to cutting tool as carriage -200 mm linear motion in x-direction after moving the carriage in x negative direction check weather tool and work are properly arranged or not if it is arranged then give linear motion to the shaft by applying screw joint in between center and shaft. Center linear motion in z negative direction i.e., -100 mm by this motion depth of cut applied.

Next motion is given to the cross slide in y positive direction 150 mm this is like guiding workpiece towards cutting tool for machining. Before doing all these things rotary motion given to the cutting tool i.e., chuck 600 rpm. Now align the timer in a sequence to perform motion simulation. Checked all motions given to the parts and result video were saved. Sample video frame was shown in Fig 9

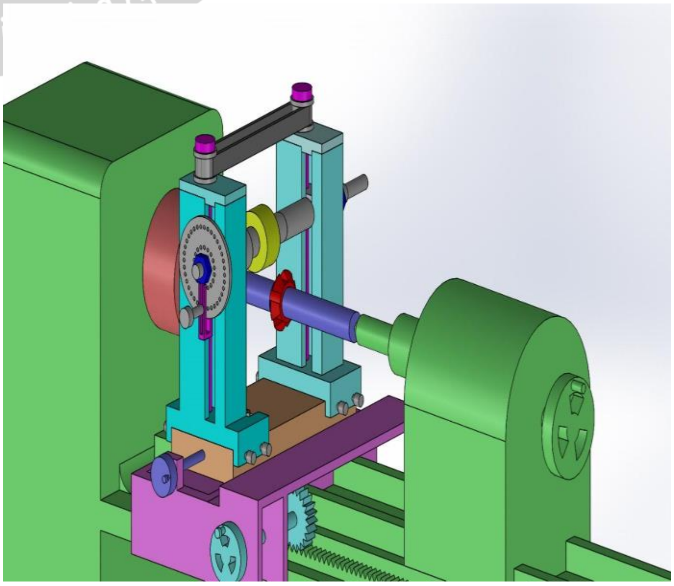

Fig.9. Simulation frame image

DOI : 10.18231/2454-9150.2018.0051

ISSN : 2454-9150 Vol-03, Issue-12, Mar 2018

4.2 Analysis

In analysis stage, we have considered two forces which exist in milling machine operation

I. Cutting force
II. Thrust force

I. Cutting force

Power (P) = 1 kw
Cutter diameter(D) = 45 mm

Speed of chuck (N) = 600 rpm

Velocity (V) = πDN / 60
= (π*0.045*600)/60
V = 1.88 m/s
Power (P) = F. V
Cutting force (F) = P / V
= 1000/1.88
F_1 =796 N
F_2 =7960 N Taken for test attachment strength.

II. Thrust force

Cutter diameter (D) = 45 mm
Speed of chuck (N) = 600 rpm
Thrust force constant (K) = 42.35
Feed rate (f) = 1.5 mm/min
Thrust force (th) = K*N*D*f^0.7
= 42.35*600*0.045*1.5^0.7
= 1200 N

All parameters are taken from general purpose lathe and milling machine Now these values will be applying on the modeled assembly structure and analyzed by using ansys software 'static structural analysis'

Terms are going to find with this analysis:

- Equivalent elastic stress (von- mises)
- Equivalent stress (von- mises)
- Max shear stress
- Maximum principal elastic strain

❖ *Units:*

Units considered while doing analysis stage are shown in Table 5.2

Unit system	Metric (mm, kg, mv) Degree red/s
Angle	Degree
Rotational velocity	red/s

Table.2. Units

❖ *Meshing:*

Meshing details are given in Table 3

Object Name	Mesh
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Element Order	Program Controlled
Sizing	
Size Function	Adaptive
Relevance Center	Fine
Element Size	5.0 mm
Initial Size Seed	Assembly
Transition	Fast
Span Angle Center	Coarse
Automatic Mesh Based Defeaturing	On
Defeature Size	Default
Minimum Edge Length	2.50 mm

Table.3. Meshing

❖ *Equivalent elastic stress (von- mises):*

Equivalent elastic stress i.e., von- mises stresses is show in Fig 10

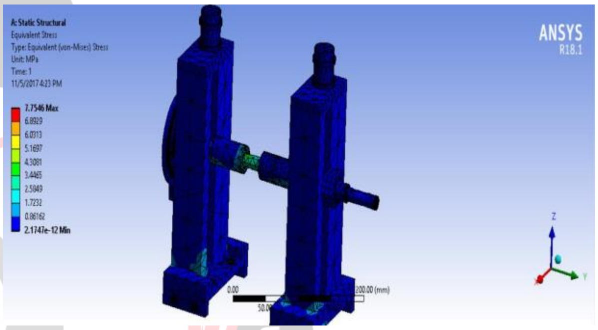

Fig.10. Equivalent elastic stress in MPa

❖ *Equivalent stress (von- mises)*

Equivalent stress is shown in Fig 11

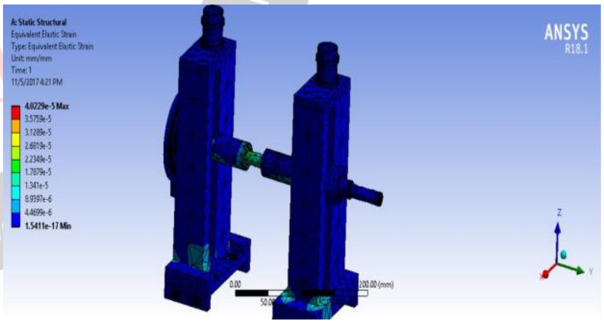

Fig.11. Equivalent stress

❖ *Max shear stress:*

Max shear stress is shown in Fig 12

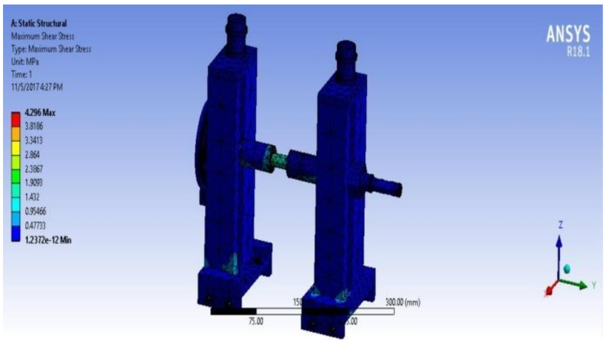

Fig.12. Max shear stress in MPa

DOI : 10.18231/2454-9150.2018.0051

ISSN : 2454-9150 Vol-03, Issue-12, Mar 2018

❖ *Maximum principal elastic strain*

The maximum principal elastic strain is shown in Fig 13

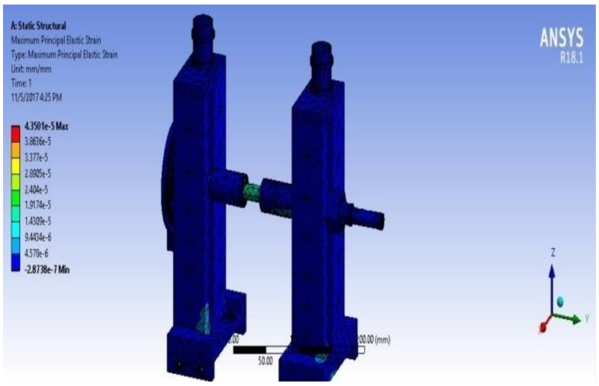

Fig.13.Maximum principal elastic strain

Simulation calculations:

Hence stress concentration factor F_1 ($\alpha_\circ$) = $\frac{\sigma max}{\sigma}$

$$= \frac{247}{7.76} = 31.8$$

Hence stress concentration factor F_2 ($\alpha_\circ$) = $\frac{\sigma max}{\sigma}$

$$= \frac{247}{77.87} = 3.17$$

Hence stress concentration factor for F_1 and F_2 are in save zone. The maximum load can apply on the attachment is 7960 N and the load which we have collected from the milling machine is 796 N stress concentration factor is far most saver side so that we can consider the attachment can accept the load analysis stage successfully completed. All results are verified and the modeled assembly design is in safe condition now moving into next step i.e., material selection and fabrication.

V. MATERIAL SELECTION & FABRICARION

5.1 Material Selection

The material what we have to select that should be less costly and available every ware So that all job shops can use this attachment easily. That is why we have chosen stainless steel as the standard for the structure. For few parts like threaded shaft and center, we have taken another grade of stainless steel which consists more hardness than existing one.

5.2 Fabrication Work

In fabrication stage production drawings are produced for main and supporting bases with supports, a center for the main base and supporting bases, caps, work holding and tool holding shafts, andthreaded shafts. These are fabricated one by one. In the end, all parts are assembled and attached to the lathe. One of its Subassembly is shown in Fig 14. It is main base sub assembly combines with the main base with guides, cap, threaded shaft, center part, few screws, and bolts.

Fig.14. main base assembly

5.3 Attaching the attachment to the lathe:

In general, lathe consists of tool post mounts on the cross slide but to attach this attachment to the lathe tool post is removed as shown in Fig 15

Fig.15. Carriage

After fitting main and supporting bases to the carriage, Pulleys and belt are fitted to threaded shafts to transfer rotary motion from main base shaft to supporting base shaft. This will help centers to maintain equal vertical motions shown in Fig 16

Fig.16. Final assembly

VI. FEATURES, RESULTS, AND CONCLUSION

6.1 Advantages

- Initial cost will be reduced.
- Flexible in operation.
- Simple in operation and no need for a skilled operator.
- Good accuracy can be achieved.

 DOI : 10.18231/2454-9150.2018.0051

- Simple construction.
- Easy to install.
- Work piece diameter can be extended up to 200mm

6.2 Disadvantages

- Spline gear cutting work piece thickness should not exceed 150 mm.
- There is a chance to get vibration during operation.
- Hard material like high carbon steel cannot be cut (unless until structure should make up of strong metal like cast iron etc.).

6.3 Area of Application

- Production of the spur gear, spline shaft, grooves etc.
- In small workshop where milling machine is not affordable.

VII. RESULTS AND CONCLUSION

The attachment is made to cut spur gear which is done by Modeling and assembly of CAD parts are accomplished by CATIA V5 software. Motion simulation was done by SolidWorks motion simulator software and the video was recorded. The static structural analysis was done by ANSYS software and results are examined. Fabrication of the attachment is completed by using raw material as stainless steel. Final fabricated model is fitted to the lathe machine and sample gear is produced. Produced samples might competitive with milling accuracy. A lot of investment is saved instead of buying a gear cutting machine. Also by using this attachment production cost of making gear also reduced.

VIII. FUTURE SCOPE

In this attachment direct indexing chosen as dividing head. This has particular limitation it is only a few no of divisions can make by using this attachment. This limitation can overcome by using compound indexing. If the centeris combined with bushes, then the shaft wear and tear will be reduced material like cast iron and stainless steel will be improving the strength of the attachment and that will allow us to perform almost all horizontal milling operations

REFERENCES

[1] JahnaviMadireddy**"Importance of Lathe Machine in Engineering Field and Its Usage"**ISSN: 2249-4596., 2014

[2] J.C.Harbison**"Milling Attachment for Lathes"**

No: 2453315., Nov. 9, 1948

[3] J.W.Bracus**"Gear Cutting Attachment"**No:2286709., June 16, 1942

[4] T.E.Smith**"Keyway and Gear Cutting Attachment for Lathes"**
US; No: 2188447., Jan 30, 1940

[5] GadakhRamesh S, Londhepradip G, Shaikh Bilal A And Shaikhfiroj S **"Gear Manufacturing By Using Conventional Lathe Machine"**

eissn: 2319-1163 | pissn: 2321-7308

[6] Sagar, Mr. Neeraj Kumar and Mr. Jagbir Sharma **"Analysis of Spur Gear Cutting Using Milling Machine"**

issn: 2347 – 4718., february-2016, issn: 2320-2092., aug.-2016

[7] Dr. Ramachandra C G, Shashank S, Raghavendra M J and Kaushikranganath T **"Design and Fabrication of Gear Cutting Attachment for Lathe"** e-issn: 2454-6135., oct -2017

[8] R. K. Jain **"Production Technology"** Page no: 891 to 894

 DOI : 10.18231/2454-9150.2018.0051