# Modelling and Analysis of Four Jaw Chuck

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*Abstract*— The work piece materials from initial stage to finished products that is effectively used in engineering applications successfully needs to be held firmly in machines for machining process. One such application is the lathe where work piece is held in chucks, if in case this holding device malfunctions or there is a loss in gripping force which may lead to the inefficient machining. Present work involves design and analysis of a four jaw chuck used in a small scale industry manufacturing cast iron double flange pipes for irrigation purpose. The work is concentrated on evaluating loss of gripping force in high speed power chucks due to centrifugal effect at the jaws and work piece material. A chuck is modelled in high end CAD tool and Simulated with initial gripping force using ANSYS tool and gripping force variation analysis is carried out. The FE analysis shows the successful evaluated results. In advent of sophisticated FEA tools such as ANSYS which has been extensively used in this dissertation work to design and development of a Four jaw chuck to hold the work-piece satisfying all and additional requirements.

***Keywords:*** CAD Modeling, Finite Element Analysis, Four Jaw Chuck

## I. INTRODUCTION

For a manufacturing company to compete in today's market they must produce a quality product at the highest possible efficiency, productivity and less maintenance cost. Vibration during machining can affect the quality of manufactured parts, precision, life of tool, performance of lathe machine and cutting rates.

1) Three jaw chuck
2) Four jaw chuck

Three jaw chuck have advantage of self-centering and limitation is that it not recommended for high speed load condition.

Four Jaw Chucks are critical units of the high speed horizontal lathe, while the interference fit between the chuck and spindle is one of most important factors influencing the performance of the high speed horizontal lathe. It is very important to monitor the chucking condition of the power chucks for safety consideration in Lathes, especially high speed lathes. They can be used to hold irregularly shaped parts. Multiple gripping method is one of the advantage of four jaw chuck.

High speed cutting is used more and more widely because of high efficiency and perfect quality. For ensuring human safety and avoiding damages to expensive machine tools, real-time condition monitoring to spindle units, clamping devices and feeding units is becoming important.

## II. FUNCTION OF CHUCK

1) Four- jaw independent chuck has four jaws; each of which can be adjusted independently by a chance wrench.
2) They are used to held wound, square, hexagonal, and irregular-shaped work pieces.
3) The jaws can be reversed to hold work by the inside diameter.
4) Grip rectangular and other non-cylindrical shapes for turning or facing.
5) Hold stock off-center for turning cams or drilling off-center Holes.

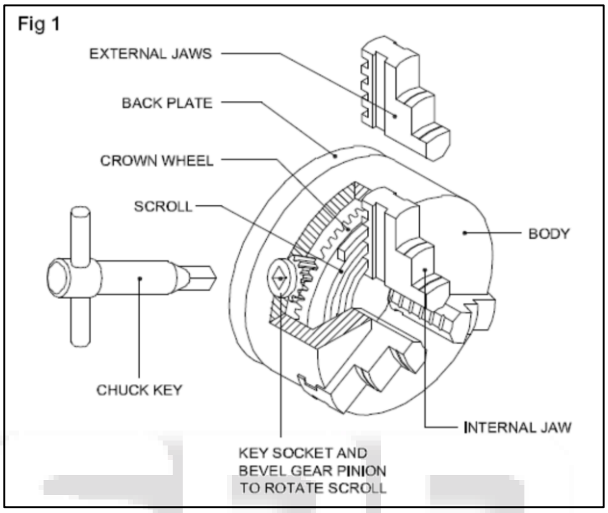


Fig. 1: Schematic Diagram of Chuck

### *A. Advantages of a Four Jaw Chuck:*

1) Work can be centered to high precision
2) Can handle square/rectangular bar
3) Can turn work off-center
4) Slightly more grip on round stock

## III. FORCE CALCULATION FOR FOUR JAW CHUCK

### *A. Main Cutting Force turning operation*

$$Fs = s*t*kc$$

main cutting force = 11 KN

### *B. Required Gripping Force for turning operation is calculated using equation*

$$\text{Req. G.F.} = Fs.Sz/\mu sp*dz/dsp$$

=132 KN.

### *C. Centrifugal Force of Chuck*

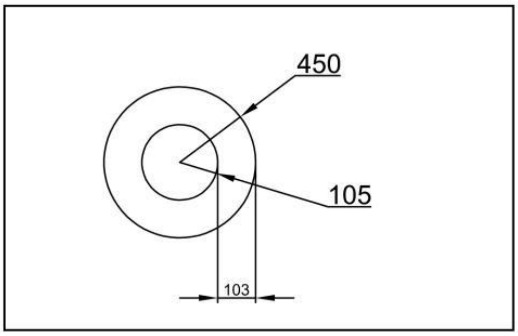


Fig. 2: Dimension of existing chuck of related machine

Centrifugal force for chuck = 29 KN

### *D. To calculate Centrifugal Force for workpiece.*

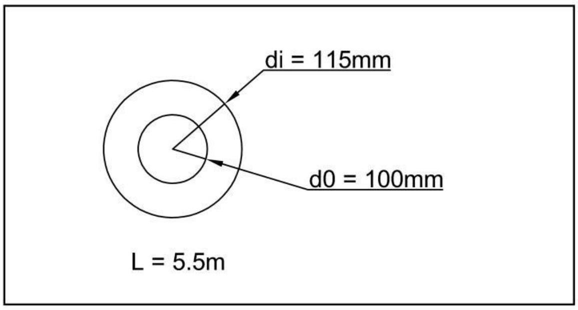


Fig. 3: Dimension of workpiece

To find deflection of pipe due to relative weight we consider the length of pipe in between chuck and tailstock.

Deflection of pipe due to self-weight 983.84

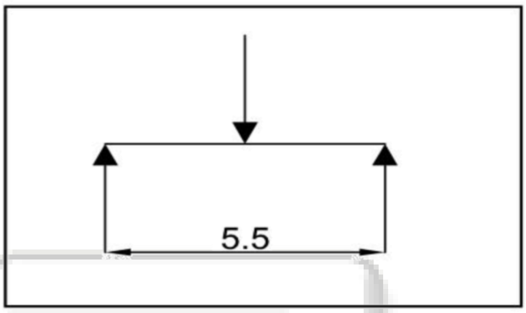


Fig. 4: deflection due to self-weight

Therefore,

Weight of pipe=Wp =weight of pipe/meter length = 983.84/5.5

= 178.88 N

= 178.88 N

Wp =180 N/m

Deflection of pipe

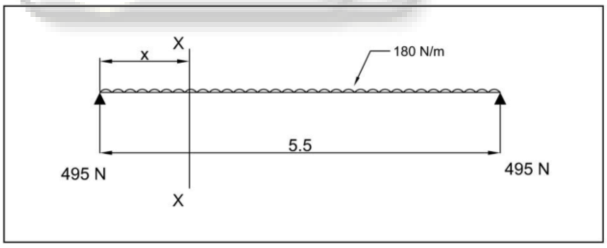


Fig. 5: Deflection of pipe uniformly distributed load

Moment of inertia for deflection

$I = \pi/64\ (d04 - di4)$

$I = 3.67 * 10\text{-}6\text{mm}4$

Centrifugal Force of workpiece = 4.393 KN

3.5. Total centrifugal force chuck and work piece

$Fc = mv2/r + mv2/r$

Fc = 33.39KN

= 33394.24N

### *E. Fatigue Life Calculations:*

Section modulus of hollow circular spindle

$Z = \Pi/32 * (do^3 - di^3)$

$= 51136.78\text{mm}^3$

Bending moment

M=P.e

=5445000

Bending stress

$\sigma b = M/Z$

=106.47

Now finding the number of cycles for material

EF =DB*AE/AD=(6-3)(2.29-2.02)/(2.29-1.88)

EF = 1.97

Log10 N = 3 + EF

Log10 N = 3 + 1.97

Log10 N =4.97

N = 93325.33 Cycles.

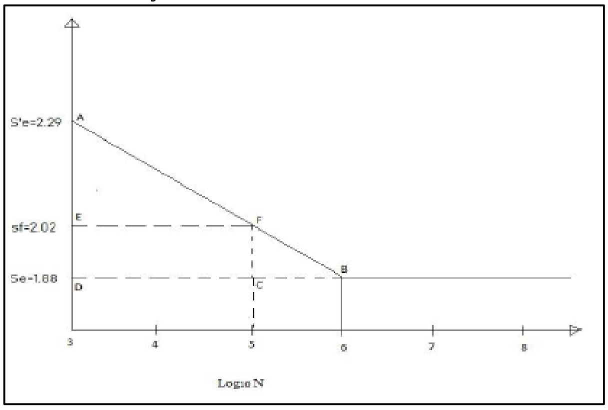


Fig. 6: Actual Plotting of S-N Curve for Malleable cast iron

## IV. CAD MODELING

Cad model of the four jaw chuck as per the calculation.

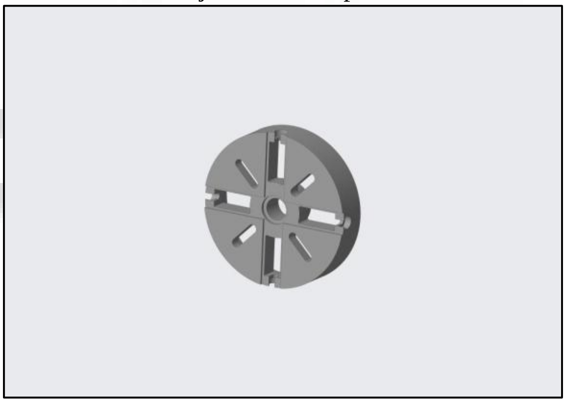

Fig. 7: Model of Four Jaw Chcuk

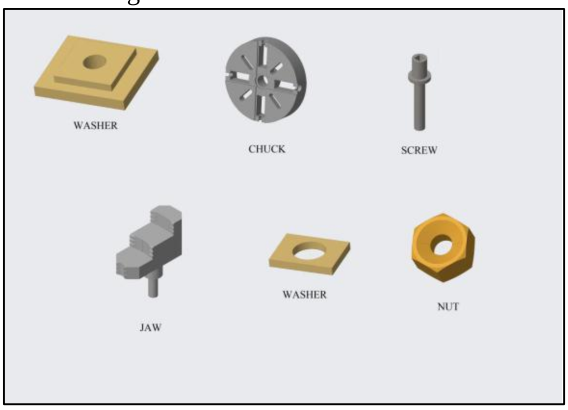


Fig. 8: Parts of four jaw chuck assembly are as chuck, washer, screw, jaw, nut

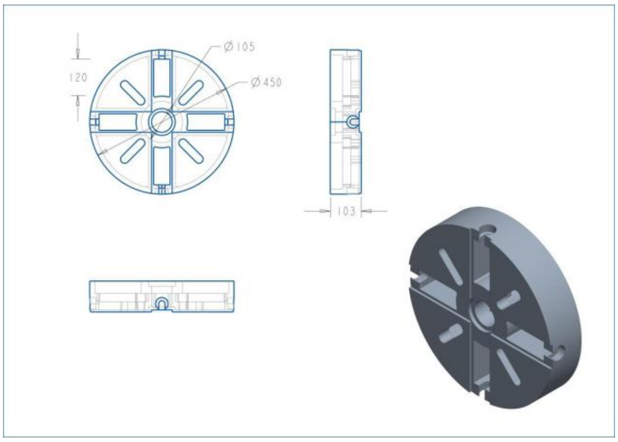


Fig. 9: Model of four jaw chuck

## V. FINITE ELEMENT ANALYSIS

The finite element method (FEM) is one of the most used methods in engineering. These methods and programs based on it are fundamental usage in CAD. FEA / FEM are indispensable in all engineering analysis where high performance is required. The main purpose of the study is to see a practical application using FEA to improve design of a typical mechanical component.

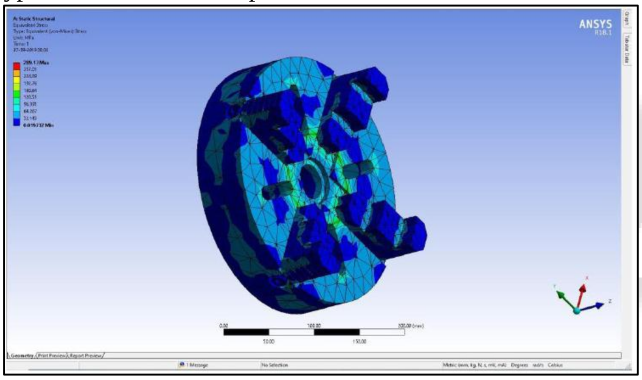


Fig. 10: Equivalent von misses stress for four jaw chuck for centrifugal force.

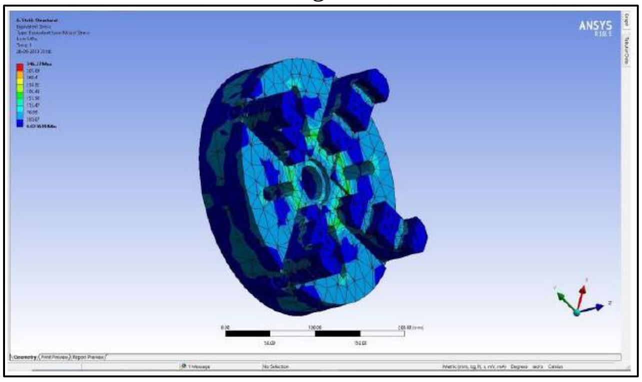


Fig. 11: Equivalent von misses stress for four jaw chuck for gripping force.

1) Using bounding condition in which centrifugal forces is applied, we found following results. Equivalent von Mises stress = 289mpa, Deformation =0.181mm, Equivalent von Mises strain=0.0015.
2) Using bounding condition in which gripping forces is applied, we found following results. Equivalent von Mises stress= 316mpa, Deformation =0.216mm, Equivalent von Mises strain=0.0018.

## VI. RESULT DISCUSSION

1) 3D model of four jaw chuck has been developed in Creo Parametric 5.0, static structural analysis of four jaw chuck assembly is done with the help of ANSYS 18.1.
2) The four jaw chuck has been designed with help of gripping force and centrifugal force which are developed due to rotation of chuck as well as workpiece.
3) From analytical calculation of various forces acting on four jaw chuck we calculated gripping force and centrifugal force which are 132kN, 33.33kN respectively.
4) By choosing the material for four jaw chuck malleable cast iron we found fatigue life cycle increased to 93325.25 cycles.
5) Further we have done finite element analysis on four jaw chuck using bounding condition in which centrifugal forces is applied FEM package ANSYS 18.1 we found following results. Equivalent von Mises stress=(289mPa), Deformation=0.0015mm, Equivalent von Mises strain=0.181.
6) Further we have done finite element analysis on four jaw chuck using bounding condition in which gripping forces is applied FEM package ANSYS 18.1 we found following results. Equivalent von Mises stress =316mPa, Deformation=0.216 mm, Equivalent von Mises strain=0.0018
7) After comparing values of result from FEM package and allowable values we found that FEM values are less than allowable values henceforth we can conclude that our product is safe.

## VII. CONCLUSION & FUTURE SCOPE

### *A. Conclusion:*

This work involves modeling and analysis of four jaw chuck under static loading condition. 3D model is prepared in Creo Parametric 5.0 and analysis is performed in the ANSYS 18.1 It is observed that due to vibration in chuck the improper quality of the final product was observed, so reduce this we have to reduce vibration of chuck and workpiece.

Our objective is to determine the various forces developed due to machining these forces causes the deflection as well as vibration in the chuck which further leading to improper finishing of final good.

For solving this problem we have done CAD modeling of four jaw chuck using Creo Parametric 5.0 furthermore ANSYS tool is used to verify whether designed of chuck parameters are within permissible limits. In which we got equivalent stress which is less than allowable stress. The finite element analysis shows the successful evaluated results.

Also we found that by choosing the material for four jaw chuck as malleable cast iron, the fatigue life cycle increased. All the analytically calculated values of forces and stress are closely matching and are with permissible limits with the values obtained from ANSYS.

### *B. Future scope:*

1) Further modern techniques can be used to reduce the unwanted forces acting on chuck operation.

 

2) Different material can be used for the chuck and durability can be further improved.
3) YOGLAKSHMI Industry in future may expand their business to different products with lathe operation.
4) In future it is possible to change geometrical dimension of four jaw chuck so that it can sustain the heavy impact loading.

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