MACHINING ANALYSIS ON MILD STEEL

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Abstract
To perform machining operation on work piece, the work piece must be hold firmly by the clamping force. Sometimes the clamping force itself affecting the work piece geometry and finally it will affect the accuracy of the machining operation. Due to clamping itself the work piece starts deformation, so the deformation of the work piece can be minimized by reducing the clamping forces.
The present work is focused on analyzing the clamping forces and the corresponding reactive forces developed in the component subsequently relating its effect on the component accuracy while drilling mild steel The main objective of this work is to analyze the deformation of work piece and to evaluate the stress concentration when clamping loads and cutting forces acting on the work piece by doing the drilling operation for precession machining.
Simulation is done by ANSYS with designed boundary conditions. The component behavior with the effect of clamping forces is analyzed with respect to the feature. The fixture location resting points and the corresponding clamping points are designed and applied. Accordingly the accuracy of the feature machining is analyzed and recorded
Keywords: Feature, accuracy, deformation, reactive forces, stress, clamping forces.

1.1 Introduction

The component can be manufactured by different manufacturing processes like Welding, Casting, Machining and Forming etc. The metal cutting operation involves many forces which can be static or dynamic. So before doing cutting operation on the material, it must be rested on the machine bed by means of Jigs and Fixtures. The purpose of Jigs and Fixtures is to hold the work piece firmly while doing the machining operation. Sometimes, cutting forces as well as clamping forces will act on the work piece which will influence the accuracy of the cutting operation. So the study of the effect of clamping on the material must be taken into consideration.

1.2 Materials

Steel alloys of iron and carbon are widely used in construction and other applications because of their high strength and low cost. Carbon, other elements and inclusions with iron act as a hardening agents that prevent the movements of dislocations that otherwise occur in crystal lattice of other items. Steel contains of carbon typically about 2.1% by its weight.

1.3 Clamping Design Consideration

Following are the factors that should be considered while designing clamping devices

- Method of loading and unloading the component
- Method of clamping the component
- Method of manufacturing the proposed work piece
- Problems of vibration and required rigidity for the same
- Provisions for fixing the body to the table
- Provisions for power operated devices for clamping if needed
- Type and capacity of the machine
- Size, shape, weight etc., of the component.

1.4 Introduction to Fixtures

Fixtures are the devices which help in increasing the rate of production of identical parts and simultaneously reducing the human efforts required for producing the parts. Suppose a central lathe is a suitable machine

tool for producing individual parts of different shapes and sizes, but for producing similar articles in great number its use will not be economical. So every type of article cannot be machined on a capstan or turret lathe and may involve the use of milling, planning and grinding machines etc.
If such articles are to be used for holding and locating purposes so that the repetition work can be done economically.

1.5 Locating Methods

The locating methods depend on the following factors.

- Complexities in the shape and size of the work piece
- Type of operation, which the work piece will undergo.
- Number of components to be manufactured
- Degree of accuracy to be desired
- Degree of surface finish and accuracy available on the work piece surfaces etc.

The most commonly used devices for this purpose are pins of different sizes, V-locaters, bush locaters etc. the pins may be flat, conical or cylindrical.

1.6 Basic Requirements of Clamping Devices

A good clamping device must meet the following basic requirements.

- It should be able to rigidly hold the work piece in a fixture against all the forces acting on the latter
- It should not damage the work piece it holds
- It should force the work piece to remain in firm contact with locating pins or surfaces
- It should exert just sufficient pressure on the work piece
- It should neither distort nor become loose under heavy pressure or vibrations
- Its operation time, that mean releasing and clamping should be minimum

The different types of clamping devices are:-

1. Mechanical Actuation Clamps
2. Pneumatic and Hydraulic Clamps
3. Vacuum Clamping
4. Magnetic Clamping
5. Electrostatic Clamping
6. Non Mechanical Clamping.

1.7 Drilling Operation

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work piece, cutting off chips from the hole as it is drilled.

Drill bits are cutting tools used to create cylindrical holes, almost and always of circular cross section. Drill bits come in many sizes and have many uses. Bits are usually connected to a mechanism often simply refer to as a drill, which rotates them and provides torque and axial force to create the hole. The shank is the part of the drill bit grasped by the chuck of a drill. The cutting edges of the drill bit are at one end and the shank is at other end.

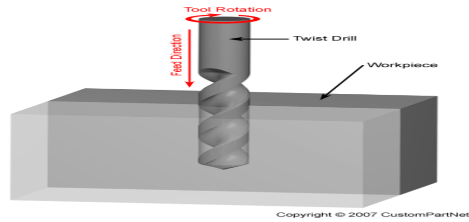

Figure.1 Drilling Operation

2. Literature Review

2.1 Literature Review

Haci Saglam, SuleymanYaldiz, Faruk Unsacar,[1] Done investigation on the affects of rake angle and entering angle in tool geometry and cutting speed on cutting force components and the temperature generated on the tool tip in turning were investigated.

M Thomas and Y Beauchamp [2], Statistical Investigation of Modal Parameters of Cutting Tools in Dry Turning. This study focuses on the collection and analysis of cutting-force, tool-vibration and tool-modal-parameter data generated 66 by lathe dry turning of mild carbon steel samples at different speeds, feeds, depths of cut, tool nose radii, tool lengths and work piece lengths.

Mayur C. Patel, Mr. S. B. Patel, Mr. R.H. Patel[3] ,done research on Parametric Analysis Of Abrasive Water Jet Machining Of Aluminium 6351 T6, they done experiments by varying the process parameters are Traverse rate (mm/min), Abrasive flow rate (gm/min), Standoff distance (mm) and Orifice diameter (mm). They analyzed Surface Roughness (m) and Kerf Taper angle in AWJM.

M. Chithirai Pon Selvan, Dr. N. Mohana Sundara Raju [4], done research on Assessment of Process Parameters in Abrasive Water jet Cutting of Granite. Experiments were conducted in varying water pressure, nozzle traverse speed, abrasive mass flow rate and standoff distance for cutting granite tiles using abrasive water jet cutting process.

Vikas B. Magdum, Vinayak R. Naik[5], done investigation on Evaluation and Optimization of Machining Parameter for turning of EN 8 steel.this paper deals with the use of tool, materials and process parameters for machining forces for selected parameter range and estimation of optimum performance characteristics

2.2 Introduction to Fem

Finite element method is one of the numerical methods that process certain characteristics that take advantage of special facilities, offered by high speed computers. In particular the finite element method can be systematically programmed to accommodate such complex and difficult problems as non-homogeneous material, non-linear stress, strain behavior and complicate boundary conditions

The analysis of a structure by the finite element method can be divided into several distinctive steps. These steps are to a large extent similar to the steps define for the matrix method. Here we give a theoretical approach to the method, and its different steps

2.3 ELEMENT DESCRIPTION

3-d 20-Noded structural solid (SOLID95) Element

SOLID95 is a higher order version of 3-D 8node solid element SOLID45. It can tolerate irregular shapes without as much loss of accuracy. SOLID95 elements have compatible displacement shapes and are well suited to model curved boundaries.

The element is defined by 20 nodes having three degrees of freedom per node, translation in the nodal x, y and z directions. The element may have any spatial orientation. SOLID-95 has plasticity, creep, stress stiffening, large deflection and large strain capabilities.

3. Methodology

The methodology involves the following steps

- Selection of Material
- Geometric construction: creating a model of circular plate in ANSYS
- Description of structure involves dividing the continuum system into equivalent system of smaller bodies or elements. Discretization of a body structures involves deciding number and size of elements used for modeling.
- Defining material properties of the structural material like Young's modulus, Poisson's ratio
- Applying loads.

3. 1 Material Composition and Properties

Material	Chemical Composition
Carbon	0.16 to 0.18%
Silicon	0.40%max
Manganese	0.7 to 0.9%
Sulphur	0.04% max
Phosphorus	0.04%

Table.1 Material Composition

General Characteristics

Steel has high strength to weight ratio(63.1 KN.m/Kg)

Steel has good damping capacity

Stainless steel is more resistant to corrosion

Steel has high strength and low cost

Properties of Mild Steel

Yield Strength :- 247 MPA

Ultimate Tensile Strength :- 841 MPA

Young's Modulus :- 210 MPA

Poisson's Ratio :- 0.3

3.2 Uses and Applications

- Bullets, chains
- Nuts and bolts
- Hinges
- Chains
- Knifes
- Armor
- Pipes
- Motor cycle frames
- Automobile chassis.
- Reinforcement in RCC
- Trusses
- Sheet metal applications

3.3 Geometry of Metal Plate

Geometry details of the plate are as shown in figure. It is circular in cross section and is made with mild steel having young's modulus of 2e5, 0.3 Poisson's ratio. Its circular cross-section is Φ80×10mm.

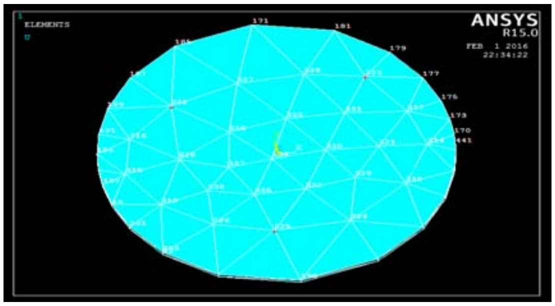

Figure.2 Geometric construction of Circular plate

3.4 Boundary Conditions

Constraints:

The circular plate is supported on 3 points at bottom and constrained all degrees of freedom at those points.

Loading conditions:

Case 1:

a) Clamping load of 200N
b) Clamping load of 400N
c) Clamping load of 600N
d) Clamping load of 600N
e) Clamping load of 1000N

Case 2:

a) Clamping load of 200N+Thrust force of 50N
b) Clamping load of 400N+Thrust force of 50N
c) Clamping load of 600N+Thrust force of 50N
d) Clamping load of 800N+Thrust force of 50N
e) Clamping load of 1000N+Thrust force of 50N

Case 3:

a) Clamping load of 200N+Thrust force of 50N+Torque of 20N
b) Clamping load of 400N+Thrust force of 50N+Torque of 20N
c) Clamping load of 600N+Thrust force of 50N+Torque of 20N
d) Clamping load of 800N+Thrust force of 50N+Torque of 20N
e) Clamping load of 1000N+Thrust force of 50N+Torque of 20N

4. Results and Discussion

A circular plate of Φ80×10mm is supported at three points as indicated by points C1,C2,C3. For our results we have taken E=2e5N/mm and Poisson's ratio= 0.3.At three points of the bottom of the plate was arrested all degree of freedom and at top of the at three points applied Clamping load for performing the drilling operation. above said cases are simulated by the ANSYS.

Clamping load of 200N is applied			
Location	C1	C2	C3
Deformation	0.27269E-03	0.10622E-03	0.15911E-03
Stress	-0.54959	0.24342	0.40182
Clamping load of 400N is applied			
Location	C1	C2	C3
Deformation	0.54539E-03	0.21245E-03	0.31022E-03
Stress	-1.0992	0.48664	0.80364
Clamping load of 600N is applied			
Location	C1	C2	C3
Deformation	0.81808E-03	0.31867E-03	0.47733E-03
Stress	-1.6488	0.73027	1.20055
Clamping load of 800N is applied			
Location	C1	C2	C3
Deformation	-0.10908E-02	-0.42490E-03	-0.63644E-03
Stress	-2.1984	-0.9769	-1.6073
Clamping load of 1000N is applied			
Location	C1	C2	C3
Deformation	-0.13635E-02	-0.53112E-03	-0.53112E-03
Stress	-2.7480	-1.2171	-2.0091

Table.2 Clamping load result

From the Table.2 Results As we observed by increasing the clamping load corresponding to that deformation and stress are increasing. This indicates that without doing any machining operation the work piece starts deformation due to clamping load itself. This deformation depending upon the magnitude of clamping load, so selection of clamping load is very important before doing any machining operation. Selection of the clamping load depending upon the geometry of the work piece and type of machining operation.

Clamping load 200N+thrust force 50N+torque 20Nm is applied			
Location	C1	C2	C3
Deformation	-0.25637E-03	-0.25657E-04	-0.32049E-03
Stress	-1.3262	-3.1102	-0.7753E-01
Clamping load 400N+thrust force 50N+torque 20Nm is applied			
Location	C1	C2	C3
Deformation	-0.46099E-03	-0.50756E-03	-0.58188E-03
Stress	-2.5607	-6.2181	-0.17588
Clamping load 600N+thrust force 50N+torque 20Nm is applied			
Location	C1	C2	C3
Deformation	-0.67127E-03	-0.75855E-03	-0.84326E-03
Stress	-3.7953	-9.3259	-0.27424
Clamping load 800N+thrust force 50N+torque 20Nm is applied			
Location	C1	C2	C3
Deformation	-0.88155E-03	-0.10095E-02	-0.11046E-02
Stress	-5.0298	-12.434	-0.37259
Clamping load 1000N+thrust force 50N+torque 20Nm is applied			
Location	C1	C2	C3
Deformation	-0.10913E-02	-0.12605E-02	-0.13660E-02
Stress	-6.2643	-15.542	-0.47094

Table.3 clamping load and thrust force results

From the table.3 results we applied clamping load as well as Thrust force to perform the drilling operation. We selected thrust force as 50N which is fixed one, and varied clamping load as mentioned above. In this case due to clamping load and thrust load the work piece starts deformation and also stresses are increasing. The values of deformation and stress are greater than the previous case. Because of this dimensional accuracy of the work piece is affected while doing the machining operation. So select the appropriate magnitudes of clamping load and thrust load to get the better dimensional accuracy.

Clamping load of 200N is applied			
Location	C1	C2	C3
Deformation	0.27269E-03	0.10622E-03	0.15911E-03
Stress	-0.54959	0.24342	0.40182
Clamping load of 400N is applied			
Location	C1	C2	C3
Deformation	0.54539E-03	0.21245E-03	0.31022E-03
Stress	-1.0992	0.48664	0.80364
Clamping load of 600N is applied			
Location	C1	C2	C3
Deformation	0.81808E-03	0.31867E-03	0.47733E-03
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Clamping load of 800N is applied			
Location	C1	C2	C3
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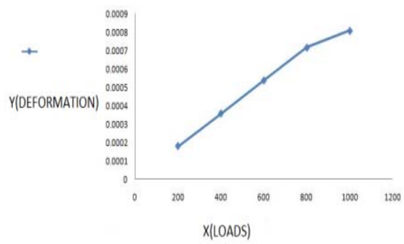
Clamping load of 1000N is applied			
Location	C1	C2	C3
Deformation	-0.13635E-02	-0.53112E-03	-0.53112E-03
Stress	-2.7480	-1.2171	-2.0091

Table.4 clamping load, thrust force and torque results

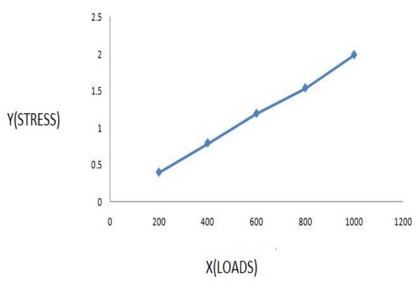
In this case 3 we applied clamping load, thrust load and torque. For this case Thrust load fixed to 50N, torque fixed to 20N and clamping load varied from 200N to 1000N, by this manner results are noted in table 3. From the results we observed that deformation decreases as compared with the previous two cases(Case1&Case2) but stress increases. In this case deformation decreases due to presence of torque, because of torque the localized stiffness increase that leads to decrease in deformation. When deformation decreased then get the good dimensional accuracy. So dimensional accuracy depends upon deformation, i.e. less deformation gives more accuracy.

From above three cases we understood that, because of clamping load itself the works piece will deform, accuracy and precision depends on stiffness of the work piece, i.e. more stiffness more accuracy. So select the minimum clamping load,thrust load and torque to perform drilling operation to get better results.

Case 1:-Clamping Load

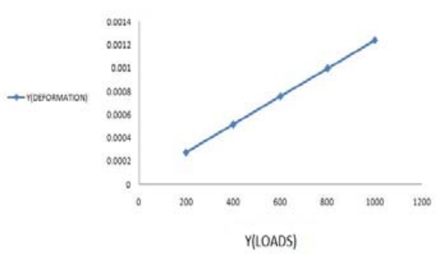


Graph.1.a) Load (Vs) Deformation

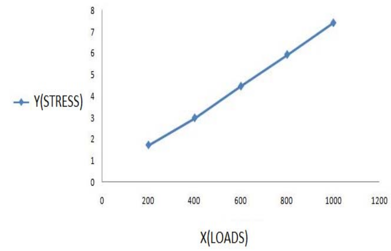


Graph.1.b) Load (Vs) stress

Case 2: Clamping Load and Thrust force

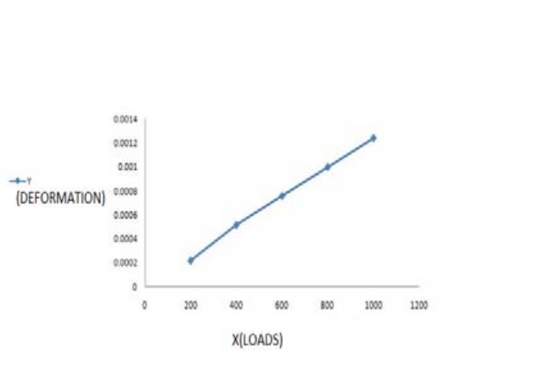


Graph 2.a) Load (Vs) Deformation

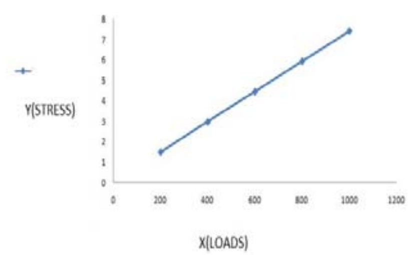


Graph 2.b) Load (Vs) Stress

Case 3:Clamping Load,Thrust and Torque



Graph 3.a) Load (Vs) Deformation



Graph 3.b) Load (Vs) Stress

Case 1, Case 2 & case3 graphs shows that deformation and stresses are directly proportional to clamping load& thrust load. In case 3 deformation decreases as compared to previous cases (case1& Case2)

5. Conclusions

1. As the clamping force& thrust force increases corresponding to that stress and deformation increases.

2. Deformation decreases due to presence of torque.
3. On comparing case1(only clamping) and case3(clamping + thrust + torque) we observed that the deformation decreases , due to increase in the internal stiffness of the material.

6. Future Scope

1. We can do analysis for bottom of the plate.
2. We can compare theoretical FEM analysis values with force measuring systems like dynamometers.
3. A data logger is coupled with the computer to record the further analysis.

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References

1. HaciSaglam, SuleymanYaldiz, FarukUnsacar, The Effect of Tool Geometry and Cutting Speed on MainCutting Force and Tool Tip Temperature, Materials and Design, 2007,28, 101–111

2. M Thomas and Y Beauchamp, Statistical Investigation of Modal Parameters of Cutting Tools in Dry Turning, International Journal of Machine Tools &Manufacture ,2003, 43, 1093–1106.

3. Mayur C. Patel, Mr. S. B. Patel, Mr. R.H. Patel ,parametric analysis of abrasive water jet machining of aluminium 6351 T6, International Journal For Technological Research In Engineering Volume 1, Issue 12, August-2014

4. M. Chithirai Pon Selvan, Dr. N. Mohana Sundara Raju, Assessment of Process Parameters in Abrasive Water jet Cutting of Granite, International Conference on Trends in Mechanical and Industrial Engineering (ICTMIE'2011) Bangkok Dec., 2011

5. Vikas B. Magdum, Vinayak R. Naik Evaluation and Optimization of Machining Parameter for turning of EN 8 steel, International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue5- May 2013

6. D.I. Lalwani, N. K Mehta, P. K Jain, Experimental Investigations of Cutting Parameters Influence on Cutting forces and Surface Roughness in Finish Hard Turning of MDN250 Steel, Journal of Materials Processing Technology, 2008, 206, 167–179.

7. V. Mohankumar, M. Kanthababu, Experimental Investigations on Depth of Cut in Abrasive Water jet Machining, of Al/B4C Metal Matrix Composites, International Journal of Engineering Research, Volume No.5, Issue No.4, pp: 322-326 1 April 2016.