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Experimental Investigation of Optimizing En8 and En19 Steels Using Cryogenic Technique With Ansys Results

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Abstract :*In general high speed steel is used as a cutting tool for its better quality and reliability at lower rates while compared with other cutting tools. To increase the ability of the tool, the best way is to increase the hardness of the tool. The brainstormed ideas to alternate tool material properties by using a method called Cryogenic Technique. This technique increases the wear properties and decreases the machining time of the tool. The process involved in the Cryogenic Technique is deep cryogenic process. The sample pieces of EN8 & EN19 carbon steel components are placed in a specially constructed tank containing Cryogenic solution as Liquid Nitrogen (Refrigerant) and at the temperature of around 196°c (77k) and treated for for 24 hours. It is designed using CATIA software and imported the model to ANSYS work bench software. From the results in structural analysis, the properties of the treated EN8 & EN19 Steels are enhanced than the untreated EN8 & EN19 Steels. It has been concluded that EN8 & EN19 steels after cryogenic technique decreases machining time and no tool wear.***

keywords :*Cryogenic treatment ,Hardness, High Speed Steel, Properties ,Tool Wear.*

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I. Introduction

NASA engineers were the first to notice the effects of cold temperatures on materials. They noticed that many of the metal parts in the aircraft that had returned from the cold vacuum of space came back stronger than they were before flight. Since then sub-zero treatment (-80°C) has been used for many years, but with inconsistent results. Many of the inconsistencies were reduced by longer soaking periods and with deep cryogenic treatment (-190°C).

Tool steels are high quality steels made to close compositional and physical tolerances. These are used to make tools for cutting, forming or shaping a material into a part or component adapted for a specific use. In service most tool steels are subjected to extremely high loads that are applied rapidly. The material must withstand these loads a great number of times without breaking and without undergoing excessive wear or deformation.

The performance of a tool in service depends on
(i) Proper tool design,
(ii) Accuracy with which the tool is made,
(iii) Selection of proper tool steel, and
(iv) Application of proper heat treatment.

A tool can perform successfully in service only when all four requirements have been fulfilled. All tool steels must be heat treated to develop specific combinations of wear resistance, resistance to deformation or breaking under high loads, and resistance to softening at elevated temperatures.

For a given tool steel at a given hardness, wear resistance may vary widely depending on the wear mechanism involved and the heat treatment used. Among tool steels with widely differing compositions but identical hardness, wear resistance may vary widely under identical wear conditions.

In the heat treatment of tool steels the problem of retained austenite after heat treatment has prevailed since the development of tool steels. The retained austenite is soft and unstable at lower temperatures that it is likely to transform into martensite. Freshly formed martensite is brittle and only tempered martensite is acceptable. The transformation of austenite into martensite yields 4% volume expansion causing distortion, which cannot be ignored. Therefore, the retained austenite should be transformed to the maximum possible extent before any component or tool is put into service. Treating the material after heat treatment at sub-zero or cryogenic temperatures transforms the retained austenite into martensite. Greater wear resistance can be obtained with longer soaking periods because of the formation of η−carbides which improves the wear resistance to the maximum possible extent.

1.1 Reason For Selecting This Project:
There are different types tools used for machining processes such as high speed steel, carbide tipped, diamond tipped, etc. These tools may get failure due to increase in temperature and tool wear may occur while machining high hardened steels. Due to these drawbacks in different tool materials while machining we have selected the cryogenic treatment of tool to machine the materials. Although, literature in function is available, we have selected this alternative to experiment

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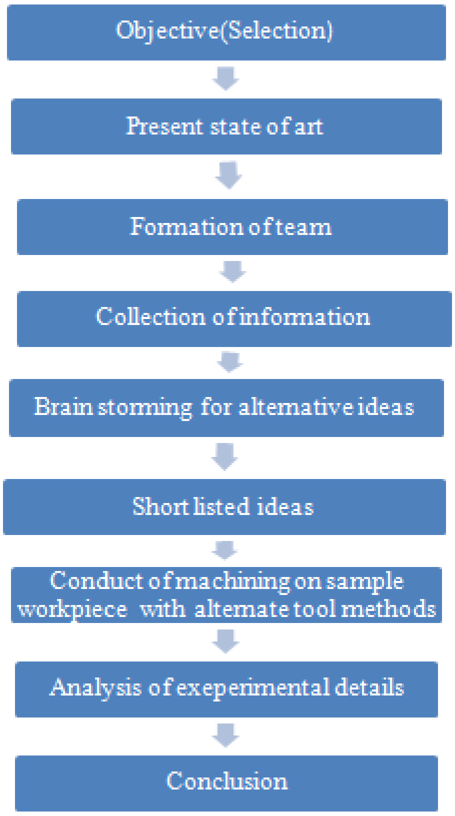


1.2.Approachmethodology:
1.3. Present State

As early as the 1930's, studies were made to improve the properties of steels by means of ordinary cold (sub -zero) treatment. Conducted at temperatures down to about -80°C (using methanol, dry ice or freon), the purpose of the process was to transform residual austenite, retained after initial hardening to martensite, in order to stabilize the tempered structure. By the 1970s, the development of low temperature technology had extended the cryogenic treatment temperature down to -196 °C.

Cryogenic treatment at about liquid-nitrogen temperature (-196°C) is referred to as deep cryogenic treatment in order to distinguish it from the previous ordinary sub-zero treatment. Various studies show that, after DCT, the mechanical properties of high-speed steels, mould steels and bearing steels are, on the whole, improved. Although the results are sometimes variable the service life of lathe tools, milling cutters, boring tools and rollers is doubled.

Particular studies were conducted in the work described here to establish the effect of DCT on the microstructure of the high-speed steels. The results show that DCT not only transforms residual austenite into martensite, but it alters the morphology of martensite and precipitates out ultrafine carbides as well. These additional changes brought about during DCT, after normal heat treatment by quenching and tempering, have fundamentally changed the conventional view of cold treatment.The effect of DCT on the mechanical properties of high speed steels, including Experimental results on the practical performance of treated cutting tools, is also reported here.

1.4. Information Phases On Cutting Tool Materials

1.4.1 Selection Of Tool Materials

The various materials are used to remove metal from work piece. The tool must be harder than the material which is to be cut. The selection of cutting tool material will depend upon the following factors.

- Volume of production
- Tool design
- Type of machining process
- Physical and Chemical properties of work material
- Rigidity and condition of machine

1.4.2 Properties of Cutting Tool Materials

The cutting tool material should possess the following properties.

a. Hot Hardness
b. Wear Resistance
c. Toughness
d. Low friction
e. Cost of tool

Hot Hardness:

It is the ability of the cutting tool to withstand high temperature without loosing its cutting edge. The tool must maintain its hardness at high temperature. This hardness is higher than that of work piece. The addition of following materials will improve hot hardness: Chromium, Molybdenum, Tungsten and Vanadium.

Wear Resistance:

It is the ability to resist wear. During machining, friction between work piece and tool cause wear in the tool. If the tool is not having sufficient wear resistance, it will fail quickly. This will lead to poor surface finish. Addition of cobalt increases the wear resistance property of the tool.

Toughness:

It is the combined property of strength and ductility. The tool material should have sufficient toughness to withstand shock and vibrations. If tool materials have sufficient toughness, the fine cutting edge of the tool does not break or chip, when the tool is suddenly loaded. This property limits the hardness of the tool. High hardness tool will be brittle and weak in tension. Addition of molybdenum and nickel increases toughness.

Low friction:

The co-efficient of friction between tool and the work piece must be low. This will reduce friction, heat developed and tool wear.

Cost of tool:

Tool material should be economical in production. It should be easy to manufacture the tool from the material.In addition to the above properties, the tool material should possess the following properties:

- High thermal conductivity
- Resistance to thermal shock
- Easy to grind and sharp
- Low mechanical and chemical affinity for the work material.

1.4.3 Classification of Cutting Tool Materials:

Tool Material	**Work Materials**	**Drawbacks**
Carbon steels	Low strength, softer materials, non ferrous alloys, plastics.	Low cutting speeds, low strength materials.
Low/medium alloy steels	Low strength, softer materials, non ferrous alloys, plastics.	Low cutting speeds, low strength materials
HSS	All materials of low and medium strength and hardness.	Low to medium cutting speeds, low to medium strength materials.
Cemented Carbides	All materials up to medium strength and hardness.	Not suitable for low speed application.
Coated carbides	Cast iron, alloy steels, stainless steels, super alloys.	Not for titanium and ferrous alloys
Ceramics	Cast iron, Ni-base super alloys, non ferrous alloys, plastics.	Not for low speed operation or interrupted cutting, not for machining Al, Ti alloys.

Cubic Boron Nitride (CBN)	Hardened alloy steels, HSS, Ni-Base super alloys, hardened chill cast iron, and commercially pure nickel.	High strength, hard materials.
Diamond	Pure copper, aluminium, AI-Si alloys, cold pressed cemented carbides, rock, cement, plastics, glass-epoxy composites, non ferrous alloys, hardened high carbon alloy steels, fibrous composites.	Not for machining low carbon steels, Co, Ni, Ti and Zr.

1.5 Toolwear

During machining process, the tool is subjected to three important factors such as forces, temperature and sliding action due to relative motion between tool and work piece. This results in loss of dimensional accuracy, increased surface roughness and increased power requirements etc. The unsatisfactory performance results tool wear due to its continuous use. Therefore the tool requires periodical reconditioning or replacement. This will result in loss of production and cost.

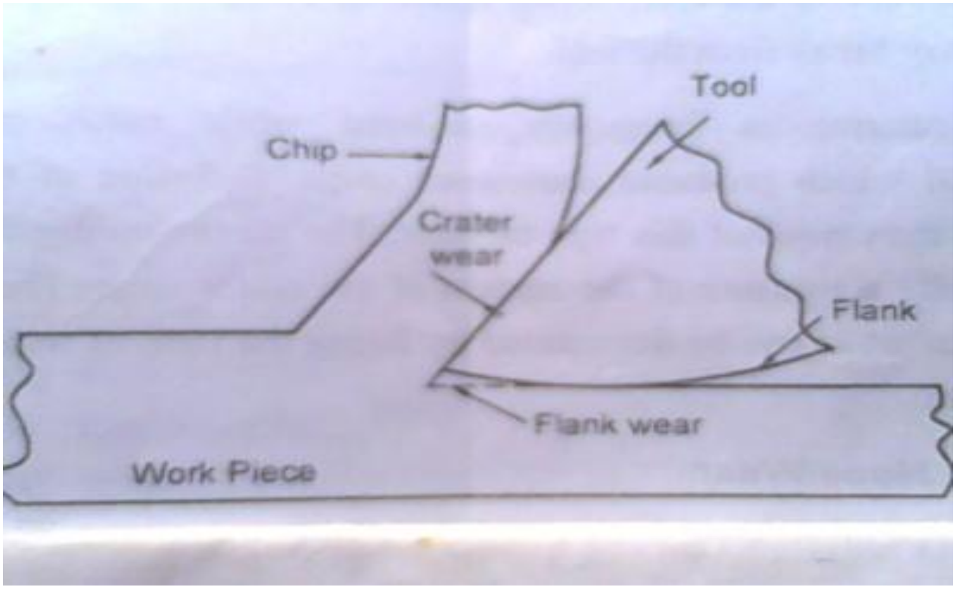


Fig. 1.1

1.5.1Types Of Tool Wear

1. FLANK WEAR
2. FACE WEAR
3. NOSE WEAR

Flank wear: This is also called “EDGE WEAR”. Friction, abrasion, adhesion are the main causes for this type of wear. Flank wear is a flat worn out portion behind the cutting edge. The worn out region of the flank is known as wear land. This wear takes place when machining brittle material like cast iron. It also occurs when the feed is less than 0.15mm/rev. When the wear land increases, the frictional heat will cause excessive temperature of the tool at the cutting edge thereby decreasing its hardness rapidly and hence failure of the tool will occur. Flank wear results in a rough machined surface.
Face wear: This wear is also known as “CRATER WEAR”. The face of the tool is always contacted with the chip. The chip slides over the face of the tool. Due to the pressure of the sliding chip the tool face wears out gradually. A cavity is formed on the tool face. The cavity is called crater. The major tendency of this type of wear is abrasion between the chip and the face of the tool.
Nose wear: The wear occurs on the nose radius of the tool. When the nose of the tool is rough, abrasion and friction between the tool and work piece will be high. Due to this more heat will be generated. Also more cutting force will act on the tool. This type of wear is more prominent than flank wear.

1.5.2 Modes of Tool Wear

Tool Materials	General Characteristics	Modes of Tool wear or Failure	Limitations
High-speed steels	High toughness, resistance to fracture, wide range of roughing and finishing cuts, good for interrupted cuts.	Flank wear, crater wear	Low hot hardness, limited hardenability, and limited wear resistance.
Uncoated carbides	High hardness over a wide range of temperatures, toughness, wear resistance, versatile and wide range of applications.	Flank wear, crater wear	Cannot use at low speed because of cold welding of chips and micro-chipping.
Coated carbides	Improved wear resistance over uncoated carbides, better frictional and thermal properties.	Flank wear, crater wear	Cannot use at low speed because of cold welding of chips and micro-chipping
Ceramics	High hardness or elevated temperatures, high abrasive wear resistance.	Depth- of-cut line notching, micro-chipping, gross fracture.	Low strength, low thermo-mechanical fatigue strength.
Polycrystalline cubic boron nitride(CBN)	High hot hardness, toughness, cutting-edge strength.	Depth- of-cut line notching, chipping, oxidation, graphitization.	Low strength, low chemical stability at higher temperature.
Polycrystalline diamond	Hardness and toughness, abrasive wear resistance.	Chipping, oxidation, graphitization.	Low strength, low chemical stability at higher temperature.

1.5.3Formation of Chip

The form and dimension of chip in metal machining indicate the nature and quality of a particular machining process, but the type of chip formed is greatly influenced by the properties of material cut and various cutting condition.

In engineering manufacture particularly in metal machining process hard brittle metals have a very limited use, and ductile metals are mostly used. Chips of ductile metals are removed by varying proportions of torsion, shear and flow. This results in three general types or shapes:
1. The discontinuous chip or segmental form chip
2. The continuous or ribbon type
3. The continuous with built-up edge.

The discontinuous chip or segmental form chip: The discontinuous chip or segmental chips consists of elements fractured into fairly small pieces ahead of the cutting tool. This type of chip is obtained in machining most brittle materials, such as cast iron and bronze. These materials rapture during plastic deformation, and form chips as separate small pieces. As these chips are produced, the cutting edge smoothes is over the irregularities and a fairly good finish obtained. Tool life is also reasonably good and the power consumption is low. Discontinuous chips can also be formed on some ductile metals only under certain conditions particularly at a very low speed coefficient of friction is low with ductile metals, how ever, the surface finish is bad and the tool life is short.

Conditions tending to promote its formation include:
1. Brittle material
2. Greater depth of cut
3. Low cutting speed
4. Small rake angle

The Continuous or Ribbon Type: Continuous chip consists of elements bonded firmly together with out being fractured. Under the best condition the metal flows by means of plastic deformation, and gives a continuous ribbon of metal, which, under the microscope, shows no signs of tears or discontinuous. The upper side of a continuous chip has small notches and shiny.

Factors
1. Fine feed
2. High cutting speed
3. Large rake angle
4. Smooth tool surface

The Continuous with Build Up Edge: The term build up edge implies the building of a ridge of metal on the top surface of the tool and above the cutting edge. It appears that when the cut is started in ductile metals, a pile of compressed and highly stressed metal forms at the extreme edge of the tool.

Factors

1. Low cutting speed
2. Low rake angle
3. High feed
4. Large depth of cut

1.6 Cutting Parameters

Cutting Speed: Cutting speed is the distance traveled by the work surface in unit time with reference to the cutting edge of the tool.The cutting speed, v is simply referred to as speed and usually expressed in m/min.

Feed: The feed is the distance advanced by the tool into or along the workpiece each time the tool point passes a certain position in its travel over the surface.In case of turning, feed is the distance that the tool advances in one revolution of the workpiece.Feed f is usually expressed in mm/rev. Sometimes it is also expressed in mm/min and is called feed rate.

Depth of cut: It is the distance through which the cutting tool is plunged into the workpiece surface.Thus it is the distance measured perpendicularly between the machined surface and the unmachined (uncut) surface or the previously machined surface of the workpiece.The depth of cut d is expressed in mm.

1.6.1 Selection of cutting speed and feed: The selection of cutting speed and feed is based on the following parameters:

- Workpiece material
- Tool Material
- Tool geometry and dimensions
- Size of chip cross-section
- Types of finish desired
- Rigidity of the machine
- Types of coolant used

1.6.2 Cutting tool materials hardness and strength

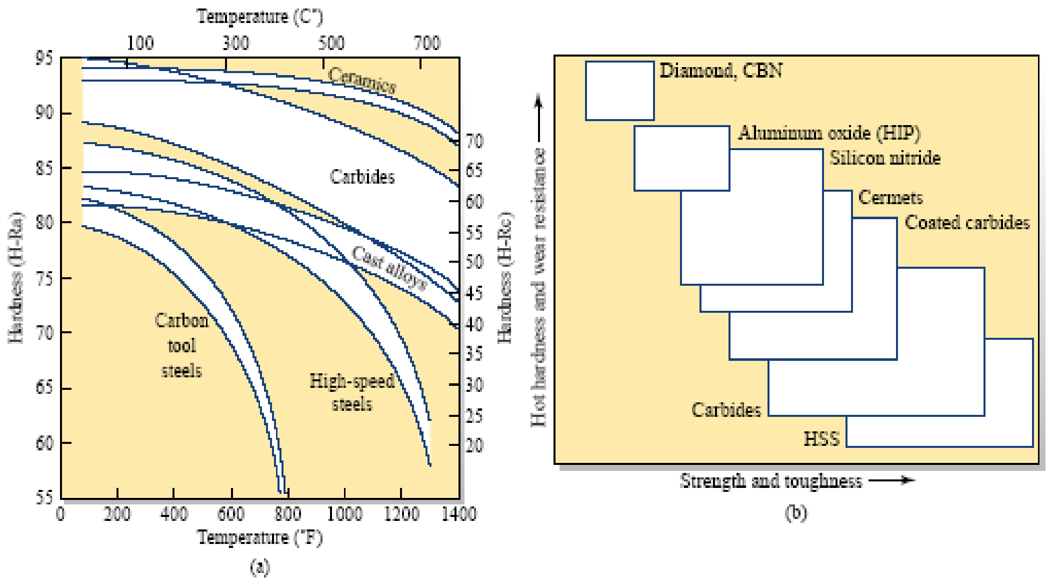


Fig. 1.2 (a) Hardness of various cutting-tool materials as a function of temperature. (b) Ranges of properties of various groups of materials Source: George Schneider,Jr. CMfgE, Cutting Tool Applications.

1.7 TOOL GEOMETRY

1.7.1 Single Point Cutting Tool Geometry

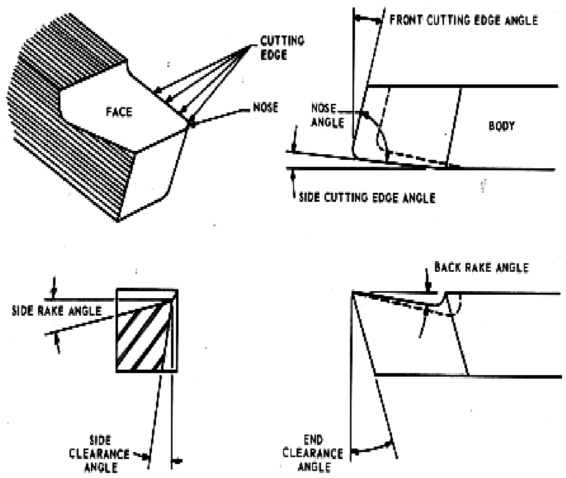


fig 1.3

1.7.2Cutting tool angles and their significance

Back rake angle:: The back rake angle is the angle between the face of the tool and a line parallel to the base of the shank in a plane parallel to the side cutting edge.The back rake angle affects the ability of the tool to shear the work material and form chip.

side Rake Angles: It is the angle by which the face of the tool is inclined side ways.

The Rake Angle:

- The rake angle is always at the topside of the tool.
- The side rake angle and the back rake angle combine to form the effective rake angle. This is also called true rake angle or resultant rake angle of the tool.
- The basic tool geometry is determined by the rake angle of the tool.
- Rake angle has two major effects during the metal cutting process.
- One major effect of rake angle is its influence on tool strength. A tool with negative rake will withstand far more loading than a tool with positive rake.
- The other major effect of rake angle is its influence on cutting pressure. A tool with a positive rake angle reduces cutting forces by allowing the chips to flow more freely across the rake surface.

The rake angle has the following function:

- It allows the chip to flow in convenient direction.
- It reduces the cutting force required to shear the metal and consequently helps to increase the tool life and reduce the power consumption. It provides keenness to the cutting edge.
- It improves the surface finish.

Positive Rake:

- Positive rake or increased rake angle reduces compression, the forces, and the friction, yielding a thinner, less deformed and cooler chip.
- But increased rake angle reduces the strength of the tool section, and heat conduction capacity.
- Some areas of cutting where positive rake may prove more effective are, when cutting tough, alloyed materials that tend to work-harden, such as certain stainless steels, when cutting soft or gummy metals, or when low rigidity of work piece tooling, machine tool, or fixture allows chatter to occur.

Negative Rake:

- To provide greater strength at the cutting edge and better heat conductivity, zero or negative rake angles are employed on carbide, ceramic, polycrystalline diamond, and polycrystalline cubic boron nitride cutting tools.
- These materials tend to be brittle, but their ability to hold their superior hardness at high temperature results in their selection for high speed and continuous machining operation.
- Negative rakes increases tool forces but this is necessary to provide added support to the cutting edge. This is particularly important in making intermittent cuts and in absorbing the impact during the initial engagement of the tool and work.
- Negative rakes are recommended on tool which does not possess good toughness (low transverse rupture strength).

- Thus negative rake (or small rake) causes high compression, tool force, and friction, resulting in highly deformed, hot chip.

The rake angle for a tool depends on the following factors:Type of material being cut:
A harder material like cast iron may be machined by smaller rake angle than that required by soft material like mild steel or aluminum.
Type of tool material: Tool material like cemented carbide permits turning at very high speed. At high speeds rake angle has little influence on cutting pressure. Under such condition the rake angle can minimum or even negative rake angle is provided to increase the tool strength.

Depth of cut: In rough turning, high depth of cut is given to remove maximum amount of material. This means that the tool has to withstand severe cutting pressure. So the rake angle should be decreased to increase the lip angle that provides the strength to the cutting edge.
Rigidity of the tool holder and machine: An improperly supported tool on old or worn out machine cannot take up high cutting pressure. So while machining under the above condition, the tool used should have larger rake angle.
Side cutting edge angle:The following are the advantages of increasing this angle:

- It increases tool life as, for the same depth of cut; the cutting force is distributed on a wider surface.
- It diminishes the chip thickness for the same amount of feed and permits greater cutting speed.
- It dissipates heat quickly for having wider cutting edge.
- The side cutting edge angle of the tool has practically no effect on the value of the cutting force or power consumed for a given depth of cut and feed.
- Large side cutting edge angles are lightly to cause the tool to chatter.

End cutting edge angle: The function of end cutting edge angle is to prevent the trailing front cutting edge of the tool from rubbing against the work. A large end cutting edge angle unnecessarily weakens the tool.It varies from 8 to 15 degrees.
Nose radius: The nose of a tool is slightly rounded in all turning tools.
The function of nose radius is as follows:

- Greater nose radius clears up the feed marks caused by the previous shearing action and provides better surface finish.
- All finish turning tool have greater nose radius than rough turning tools.
- It increases the strength of the cutting edge, tends to minimize the wear taking place in a sharp pointed tool with consequent increase in tool life.
- Accumulation heat is less than that in a pointed tool which permits higher cutting speeds.

1.8CUTTING TOOL: 1.8.1Tool Life: Tool life improvement is essential to reduce the cost of production as much as possible. Cutting tools have a limited life due to inevitable wear and consequent failures and avenues must be found to increase tool life.
1.8.2Tool Failure: The failure of cutting tools may be a result of

1. wear and the flank of the tool
2. wear at the tool chip interface
3. a combination of flank wear and catering
4. the sapling and crumbling of the cutting edge
5. the loss of hardness
6. Fracture by a process of mechanical breakage.

1.8.3 Factors Affecting Tool Life

The life of a tool is affected by many factors such as cutting speed, feed depth of cut, chip thickness tool geometry, material of the cutting fluid and rigidity of the machine. The physical and chemical properties of work materials influence tool life by affecting from stability and rate of wear of tools. The nose radius also tends to affect the tool life.
Cutting Speed:

Cutting tool has the greatest influence on the tool life. As the cutting speed increases temperature increases. The heat is more concentrated on the tool than on the work and the hardness of the tool matrix changes so the relative increase in the hardness of the work accelerates he abrasive action. The criterion of wear may be wear for flank or crater if cutting speed is increased. It has been found that the cutting speeds greater than 100 m/min in carbide turning of steel, crater wear may become predominant.The relation of the cutting speed to the tool life expressed by the formula:

$$VT^n = C$$

V = cutting speed in m/min

T = tool life in min
N = exponent which depends on the tool and the work piece. The value of the exponent n is about 0.1 for high speed tools, 0.20 to 0.25 for carbide tools and 0.4 to 0.55 for ceramic tools.
C = constant which is numerically equal to cutting speed that gives a tool life of one minute.
The relation indicates that as cutting tools speed increases, tool life decreases.

Feed and Depth of cut: The tool life is influenced by the feed rate also. With a fine feed area of chip passing over the tool face is greater than that of course feed of a given volume of swarf removal, but to offset this chip will be greater. The effect of feed and depth of cut on tool life is given below:

$$\mathbf{V = \frac{257}{T^{0.19} \times S60.36 \times t}}$$

Where S = feed in mm/min
T = depth of cut in mm

Another relation between cutting speed for a given tool life, depth of cut and feed is given by,

$$\mathbf{Vt = \frac{CV}{T^{\wedge} x \; * \; S^{\wedge}}}$$

Where Vt = cutting speed m/min
CV = a coefficient depending upon machine and work piece variables
X, Y = exponents which depend on mechanical properties of the material being machined.
The above relation shows that for a constant tool life cutting speed decreases with the increase of feed and depth of cut.

1.9 HARDNESS

Hardness refers to various properties of matter in the solid phase that gives it high resistance to various kinds of shape change when force is applied. Hard matter is contrasted with soft matter.Microscopic hardness is generally characterized by strong intermolecular bonds. However, the behavior of solid materials under force is complex, resulting in several different scientific definitions of what might be called “hardness” in everyday usage.In materials science, there are three principal operational definitions of hardness:

Scratch hardness : Resistance to fracture or plastic deformation is due to friction from a sharp object.
Indentation hardness : Resistance to plastic deformation is due to a constant load from a sharp object.
Rebound hardness: Height of the bounce of an object dropped on the material, related to elasticity.

In physics, hardness encompasses:

- Elasticity, plasticity, viscosity and viscoelasticity
- Strength and strain
- Brittleness/ductility and toughness

1.9.1 Hardness Testing

Hardness: Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

Measurement of Hardness: Hardness is not an intrinsic material property dedicated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure.

Hardness of the materials has probably long been assessed by resistance to scratching or cutting. An example would be material B scratches material C, but not material A. Alternatively, material A scratches material B slightly and scratches material C heavily. Relative hardness of minerals can be assessed by reference to the Mohs scale that ranks the ability of materials to resist scratching by another material. The above relative hardness tests are limited in practical use and do not provide accurate numeric data or scales particularly for modern day metals and materials. The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and intender geometry.

Hardness Testing Methods:

1. Rockwell hardness test
2. Brinell hardness test
3. Vickers hardness test
4. Micro hardness test
5. Mohs hardness test

1.9.2 Rockwell hardness test: The Rockwell hardness test method consists of indenting the test material with a diamond cone or hardened steel boll intender. The intender is forced into the test material under a preliminary minor load F0 (Fig. 1A) usually 10 kgf. When equilibrium has been reached, an indicating device which follows the movements of the intender and so responds to changes in depth of penetration of the indenter, is set to a datum position. While the preliminary minor load is still applied an additional major load is applied with resulting increase in penetration (Fig. 1B). When equilibrium has again been reach, the additional major load is removed but the preliminary major load allows a partial recovery, so reducing the depth of penetration (Fig.1C). The permanent increase in depth of penetration, resulting from the application and removal of the additional major load is used to calculate the Rockwell hardness number.
F0= preliminary minor load in kgf
F1= additional major load in kgf
F= total load in kgf
e= permanent increase in depth of penetration due to major load F1 measured in units of 0.002 mm
E= a constant depending on form of indenter: 100 units for diamond indenter, 130 units for steel ball indenter
HR= Rockwell hardness number
D= diameter of steel ball
Typical Application of Rockwell Hardness Scales
HRA----Cemented carbides, thin steel and shallow case hardened steel
HRB----Copper alloys, soft steels, aluminium alloys, malleable irons, etc..
HRC---- Steel, hard cast irons, case hardened steel and other materials harder than 1000 HRB

1.10MATERIALS
Engineering Materials

A metal may be described as a material which is solid at room temperature has relatively high density, high melting temperature, low specific heat, good electrical and thermal conductivity, strength, stiffness, hardness, toughness, etc.By engineering materials, we mean materials used for manufacturing engineering components in industry. Materials form one of four M's (Men, Material, Machines and Money) which plays a vital role for the development and flourishment of a country. The study of engineering materials, namely ferrous and non ferrous metals, metal alloys, non metals, their grain structure, properties and applications etc. is termed as material science.

General Material Classifications:

There are thousands of materials available for use in engineering applications. Most materials fall into one of three classes that are based on the atomic bonding forces of a particular material. These three classifications are metallic, ceramic and polymeric. Additionally, different materials can be combined to create a composite material. Within each of these classifications, materials are often further organized into groups based on their chemical composition or certain physical or mechanical properties. Composite materials are often grouped by the types of materials combined or the way the materials are arranged together. Below is a list of some of the commonly classification of materials within these four general groups of materials.

Metals • Ferrous metals and alloys (irons, carbon steels, alloy steels, stainless steels, tool and die steels) • Nonferrous metals and alloys (aluminum, copper, magnesium, nickel, titanium, precious metals, refractory metals, super alloys)	**Polymeric** • Thermoplastics plastics • Thermoset plastics • Elastomers
Ceramics • Glasses • Glass ceramics • Graphite • Diamond	**Composites** • Reinforced plastics • Metal-matrix composites • Ceramic-matrix composites • Sandwich structures • Concrete

In this different types materials we are selected ferrous metals to machine with the treated HSS tool.There are different types of ferrous metals, in that we have chosen EN8 and EN19 steels which have high carbon content as its property to machine.

1.11.Properties of Machining Steels

EN8: EN8 is an unalloyed medium carbon steel with good tensile strength. It is normally supplied in cold drawn or as rolled. Tensile properties can vary but are usually between 500-800 N/mm2.

Table 1.1Properties of EN8

TYPICAL ANALYSIS				
C.	Si.	Mn.	S.	P.
0.40%	0.25%	0.80%	0.015%	0.015%

Hardening Heat uniformly to 830/860C until heated through. Quench in oil or water. Can also be induction or flame hardened.

Tempering: Heat uniformly and thoroughly at the selected tempering temperatures, between 550C to 660C and hold at heat for one hour per inch of total thickness.

Normalising: Normalise at 830-860C, and cool in air.

Fig. 1.4 available sections of EN8

EN19: EN19 is a high quality, high tensile alloy steel usually supplied readily machineable in 'T' condition, giving good ductility and shock resisting properties combined with resistance to wear.

Table 1.2 Properties of EN19

TYPICAL ANALYSIS				
C.	Si.	Mn.	Cr.	Mo.
0.40%	0.25%	0.70%	1.20%	0.30%

Hardening: Heatuniformlyto820/840°Cuntilheatedthrough.Quenchinoil.

Tempering: Heat uniformly and thoroughly at the selected tempering temperature, and hold at heat for one hour per inch of total thickness.

Fig. 1.5 Available sections of EN19

1.12definition Of Cryogenic: In physics, cryogenics is the study of the production of very low temperature (below −150 °C, −238 °F or 123 K) and the behavior of materials at those temperatures. Rather than the familiar temperature scales of Fahrenheit and Celsius, cryogenicists use the Kelvin (and formerly Rankine) scales. A person who studies elements under extremely cold temperature is called a cryogenicist.

It is derived from the Greek word as, Cryo -- Cooling

Genic -- Generation.

Cryogenic Solution: The different types of cryogenic solutions used for the treatment of high speed steels. They are,

- Liquid Nitrogen (-196°c)

- Liquid Helium (-297°c)

Liquid helium

Fig. 1.6 Liquid helium in a cup.

Helium exists in liquid form only at extremely low temperatures. The boiling point and critical point depend on the isotope of the helium; see the table below for values. The density of liquid helium-4 at its boiling point and 1 atm is approximately 0.125 g/mL .Helium-4 was first liquefied on 10 July 1908 by Dutch physicist Heike Kamerlingh Onnes. Liquid helium-4 is used as a cryogenic refrigerant; it is produced commercially for use in superconducting magnets such as those used in MRI or NMR. It is liquefied using the Hampson-Linde cycle.

The temperatures required to liquefy helium are low because of the weakness of the attraction between helium atoms. The inter atomic forces are weak in the first place because helium is a noble gas, but the inter atomic attraction is reduced even further by quantum effects, which are important in helium because of its low atomic mass. The zero point energy of the liquid is less if the atoms are less confined by their neighbors; thus the liquid can lower its ground state energy by increasing the inter atomic distance. But at this greater distance, the effect of inter atomic forces is even weaker. Because of the weak inter atomic forces, helium remains liquid down to absolute zero; helium solidifies only under great pressure. At sufficiently low temperature, both helium-3 and helium-4 undergo a transition to a super fluid phase (see table below).

Liquid helium-3 and helium-4 are not completely miscible below 0.9 K at the saturated vapor pressure. Below this temperature a mixture of the two isotopes undergoes phase separation into a lighter normal fluid that is mostly helium-3, and a denser superfluid that is mostly helium-4. (This occurs because the system can lower its enthalpy by separating.) At low temperatures, the helium-4 rich phase may contain up to 6% of helium-3 in solution, which makes possible the existence of the dilution refrigerator, capable of reaching temperatures of a few milli kelvin above absolute zero.

Properties of Liquid Helium	**Helium-4**	**Helium-3**
Critical temperature	5.2 K	3.3 K
Boiling point at 1 atm	4.2 K	3.2 K
Minimum melting pressure	25 atm	29 atm at 0.3 K
Superfluid transition temperature at saturated vapor pressure	2.17 K	1m K in zero magnetic field

Liquid Nitrogen

Fig. 1.7

Liquid nitrogen is a cryogenic liquid. At atmospheric pressure, it boils at −195.8 °C. When insulated in proper containers such as Dewar flasks, it can be transported without much evaporative loss. Like dry ice, the main use of liquid nitrogen is as a refrigerant. Among other things, it is used in the cryopreservation of blood, reproductive cells (sperm and egg), and other biological samples and materials. It is used in cold traps for certain laboratory equipment and to cool x-ray detectors. It has also been used to cool central processing units and other devices in computers which are over clocked, and which produce more heat than during normal operation.

Properties of Liquid Nitrogen

Density 1.251 g/L
Melting point 63.153K (210°c)
Boiling point 77.36K (-195.79°c)
Critical point 126.19K
Heat of vapourization 5.56KJ/mol

In these two types of cryogenic solutions, we are selected to do our project in Liquid Nitrogen. Since it can be get from Veterinary hospital and easily available than liquid helium. The liquid nitrogen is used as a preservative to preserve the semen distributing injection in it.

1.13BRAINSTORMED IDEAS

We four discussed each other to do a project on production field and finally decided to do machine hardened materials using high speed steel tool. Each one gave an idea to machine using different HSS tool due to the drawbacks we finally decided to do cryogenic treatment. The various ideas are,

1. Carbide tipped tool
2. Diamond tipped tool
3. Ceramic tool
4. Cryogenic treatment of too

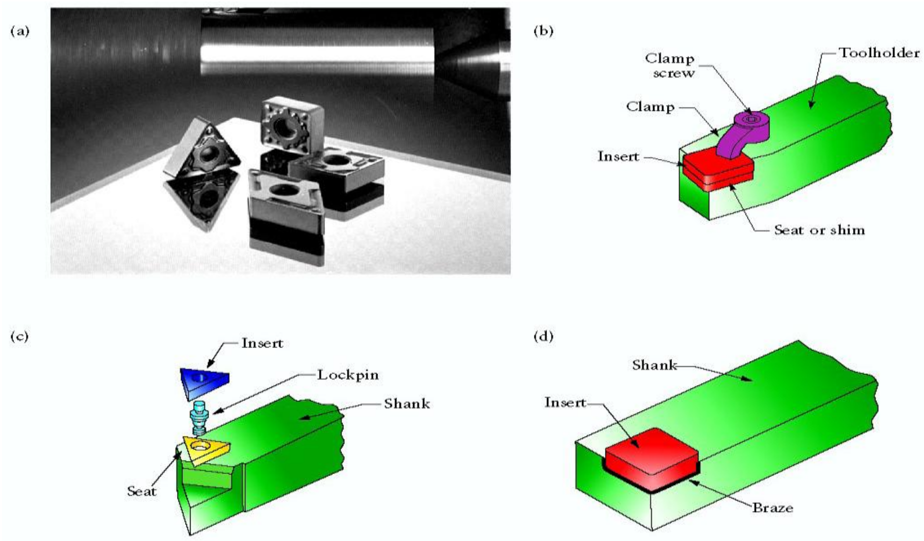


Fig.1.8 Types of Tool

Evaluation Of Alternatives

- **Carbide tipped tool**:The tool is costly, suitable for high feed rate and material removal. Not suitable for low speed application.
- **Diamond tipped tool**: Not economical for machining low carbon steels.
- **Ceramic tool**: Suitable for harder material. For machining high carbon steel work pieces only, tool material would suffice. Not for low speed operation or interrupted cutting, not for machining Al, Ti alloys**.**
- **Cryogenic treatment of tool:** A novel method which improves the hardness of the tool material, thereby the machining time can be reduced.

II. Literature Review:

A.Akhbarizadeh, M.A.Golozar on " Effects of cryogenic treatment on wear behavior of D6 tool steel" two temperatures were used: −63 °C as shallow cryogenic temperature and −185 °C as deep cryogenic temperature. The effects of cryogenic temperature (Shallow and deep), cryogenic time (kept at cryogenic temperature for 20 and 40 h) and stabilization (kept at room temperature for 1 week) on the wear behavior of D6 tool steel were studied. Wear tests were performed using a pin-on-disk wear tester to which two different loads(120 and 180 N) and three different velocities (0.05, 0.1 and 0.2 m/s) were applied. The findings showed that the cryogenic treatment decreases the retained austenite and hence improves the wear resistance and hardness

S.Zhirafara, M.Pugha on " Effect of cryogenic treatment on the mechanical properties of 4340 steel" study investigated the effects of cryogenic treatment on the mechanical properties and microstructures of AISI 4340 steel. Mechanical tests, including rotating fatigue, impact and hardness were carried out, after various heat treating conditions and the results were compared. Fracture features of specimens were also compared. It was shown that in general, hardness and fatigue strength of the cryogenically treated specimens were a little higher whereas the toughness of the cryogenically treated specimens was lower when compared to that of the conventionally treated steel. Neutron diffraction showed that the transformation of retained austenite to martensite occurred which, along with possible carbide formation during tempering, is a key factor in improving hardness and fatigue resistance of the cryogenically treated specimens.

M. ArockiaJaswinD. MohanLal on " Effect of cryogenic treatment on the tensile behaviour of En 52 and 21-4N valve steels at room and elevated temperatures" investigates the effects of cryogenic treatment on the tensile behaviour of En 52 and 21-4N valve steels at room and elevated temperatures. The materials are subjected to shallow cryogenic treatment (SCT) at 193 K and deep cryogenic treatment (DCT) at 85 K and the tensile behaviour is compared with that of the conventional heat treatment (CHT). On comparing the results of the percentage elongation, the cryo-treated samples show a smaller reduction in the elongation than that of the CHT samples. It is concluded that the precipitation of fine secondary carbide through cryogenic treatment is the reason for the improved strength and the reduction in elongation.

Flávio J Da Silva, Sinésio D Franco, Álisson R Machado, Emmanuel O Ezugwu, Antônio M Souza Jr Wear on " Performance of cryogenically treated HSS tools" Studies on cryogenically treated high speed steel tools show microstructural changes in the material that can influence tool lives and productivity significantly. Results in the literature show tool life improvements from 92% to 817% when using the cryogenically treated HSS tools in the industry. However, the real mechanisms which guarantee better tool performance are still dubious. This implies in the need of further investigation in order to control the technique more scientifically.

JY Huang, YT Zhu, XZ Liao, IJ Beyerlein, MA Bourke, TE Mitchell on " Microstructure of cryogenic treated M2 tool steel" Cryogenic treatment has been claimed to improve wear resistance of certain steels and has been implemented in cutting tools, autos, barrels etc. Although it has been confirmed that cryogenic treatment can improve the service life of tools, the underling mechanism remains unclear. In this paper, we studied the microstructure changes of M2 tool steel before and after cryogenic treatment. We found that cryogenic treatment can facilitate the formation of carbon clustering and increase the carbide density.

Mr. Chitrang A. Dumasia, Dr. V. A. Kulkarni, Mr. Kunal Sonar on "A Review on the Effect of Cryogenic Treatment on Metals" s. Cryogenic treatments are proved to be a good way to reduce the retained austenite content and improve the performance of materials by improving its martensite structure. Objectives of cryogenic treatments are to increase material's strength, hardness, wear resistance, ductility, & toughness, to obtain fine grain size, to remove internal stresses, to improve machinability, cutting properties of tools, to improve surface properties, electrical properties & magnetic properties.

M. Sakthivel, G. Rajeshkannan, : M. Naveenkumar & Dr. M. Muralimanokar on "Design And Analysis of Twin Shaft shreader using PRO-E And HYPERWORKS SOFTWARE" The model of the twin shaft shredder is designed using PRO E CREO software, and the systematic analysis of the designed model is done using HYPERWORKS/ANSYS software. The model selected is twin shaft shredder from heavy machinery equipments manufacturing industries. In this model 16 blades are been used and material is used commonly for the blades is heat threatened alloy steels-20MnCr5 steel. Now we are replacing the material to EN8, EN31, EN19& EN36. Then the model is analysis for the deflection, max stress induced and shear stress for both all materials under same load.

III. Chapter-3: Design Of Tool: Catia: An Overview.

3.1 CATIA: CATIA is one of the world's leading CAD/CAM/CAE package. Being a solid modelling tool, it not only unites 3D parametric features with 2D tools, but also addresses every design through manufacturing process. **CATIA**- **C**omputer **A**ided **D**imensional **I**nteractive **A**pplication **.**CATIA, developed by Desalt systems, France, is a completely re-engineered, next generation family of CAD/CAM/CAE software solution. CATIA serves the basic design task by providing different workbenches, some of the workbenches available in this package are

- Part design workbench
- Assembly design workbench
- Drafting workbench
- Wireframe and surface design workbench
- Generative shape design workbench
- DMU kinematics
- Manufacturing
- Mold design

PART DESIGN WORKBENCH : The part workbench is a parametric and feature-based environment, in which we can create solid models. In the part design workbench, we are provided with tool those convert sketches into other features are called the sketch-based features.

ASSEMBLY DESIGN WORKBENCH The assembly design workbench is used to assemble the part by using assembly constraints. There are two type of assembly design,

Bottom –up ,Top- down

In bottom –up assembly, the parts are created in part workbench and assembled in assembly workbench.

In the top-down workbench assembly, the parts are created in assembly workbench itself.

WIREFRAME AND SURFACE DESIGN WORKBENCH: The wire frame and surface design workbench is also parametric and feature based environment. The tools available in this workbench are similar to those in the part workbench, with the only difference that the tool in this environment are used to create basic and advance surfaces

DRAFTING WORKBENCH: The drafting workbench is used for the documentation of the parts or the assemblies created in the form of drafting.

There are two types of drafting techniques:

- Generative drafting
- Interactive drafting

The generative drafting technique is used to automatically generate the drawing views of parts and assemblies.

In interactive drafting, we need to create the drawing by interactive with the sketcher to generate the views.

DMU KINEMATICS : this workbench deals with the relative motion of the parts.DMU kinematics simulator is an independent CAD product dedicated to simulating assembly motions. It addresses the design review environment of digital mock-ups (DMU) and can handle a wide range of products from customer goods to very large automotive or aerospace projects as well as plants, ships and heavy machinery.

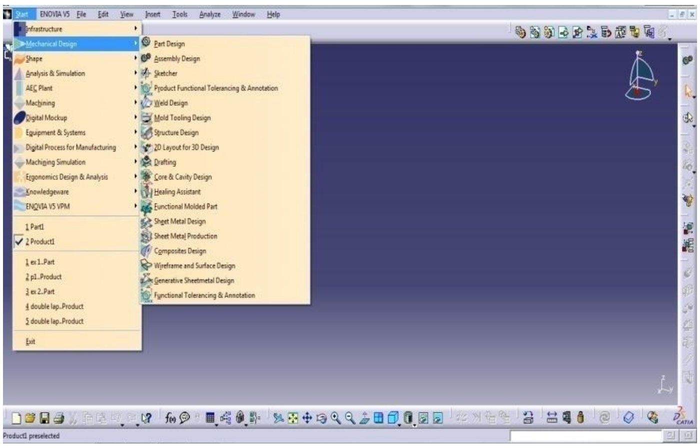


Fig. 3.1 CATIA

We created model of joints (bonded, riveted and hybrid) by using CATIA software. The models are shown below.

3.2 DRAWINGS & MODELS

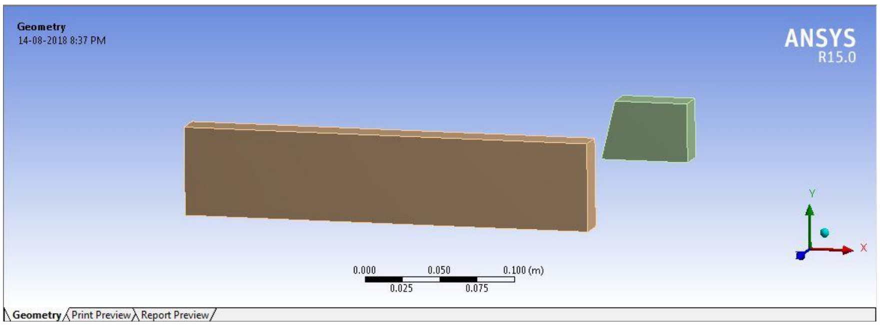


Fig. 3.2

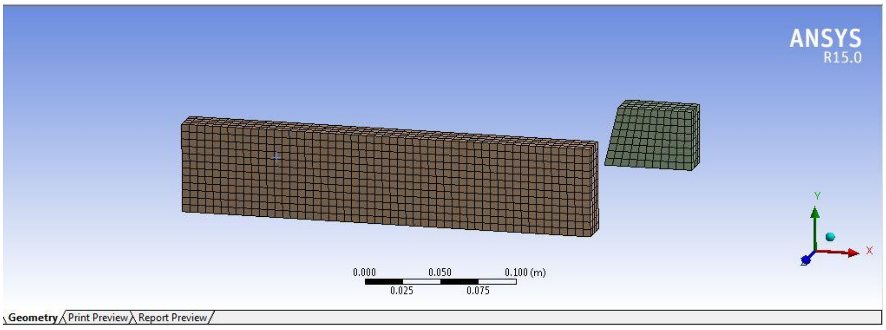


Fig. 3.3

IV. Chapter-4:Modelling Analysis:

4.1 ANSYS EVALUATION :ANSYS is a complete FEA simulation software package developed by ANSYS Inc – USA. It is used by engineers worldwide in virtually all fields of engineering.

- Structural A
- Thermal
- Fluid (CFD, Acoustics, and other fluid analyses)
- Low-and High-Frequency Electromagnetic.

PROCEDURE : Every analysis involves three main steps:

- Pre-processor
- Solver
- post processor

STRUCTURAL ANALYSIS: Structural analysis is probably the most common application of the finite element method. The term structural (or structure) implies not only civil engineering structures such as bridges and buildings, but also naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools.

TYPES OF STRUCTURAL ANALYSIS: The seven types of structural analyses available in the ANSYS family of products are explained below. The primary unknowns (nodal degrees of freedom) calculated in a structural analysis are displacements. Other quantities, such as strains, stresses, and reaction forces, are then derived from the nodal displacements. Structural analyses are available in the ANSYS Multiphysics, ANSYS Mechanical, ANSYS Structural, and ANSYS Professional programs only.

STATIC ANALYSIS--Used to determine displacements, stresses, etc. under static loading conditions. Both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

MODAL ANALYSIS--Used to calculate the natural frequencies and mode shapes of a structure. Different mode extraction methods are available.

HARMONIC ANALYSIS--Used to determine the response of a structure to harmonically time-varying loads.

TRANSIENT DYNAMIC ANALYSIS--Used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

SPECTRUM ANALYSIS--An extension of the modal analysis, used to calculate stresses and strains due to a response spectrum or a PSD input (random vibrations).
BUCKLING ANALYSIS--Used to calculate the buckling loads and determine the buckling mode shape. Both linear (eigenvalue) buckling and nonlinear buckling analyses are possible.
EXPLICIT DYNAMIC ANALYSIS--This type of structural analysis is only available in the ANSYS LS-DYNA program. ANSYS LS-DYNA provides an interface to the LS-DYNA explicit finite element program. Explicit dynamic analysis is used to calculate fast solutions for large deformation dynamics and complex contact problems.In addition to the above analysis types, several special-purpose features are available:

- Fracture mechanics
- Composites
- Fatigue
- p-Method
- Beam Analyses

ELEMENTS USED IN STRUCTURAL ANALYSES: Most ANSYS element types are structural elements, ranging from simple spars and beams to more complex layered shells and large strain solids. Most types of structural analyses can use any of these elements.

Table Elements used in Structural Analysis

Category	Element Name(s)
Spars	LINK1, LINK8, LINK10, LINK180
Beams	BEAM3, BEAM4, BEAM23, BEAM24, BEAM44, BEAM54, BEAM188, BEAM189
Pipes	PIPE16, PIPE17, PIPE18, PIPE20, PIPE59, PIPE60
2-D Solids	PLANE2, PLANE25, PLANE42, HYPER56, HYPER74, PLANE82, PLANE83, HYPER84, VISCO88, VISCO106, VISCO108, PLANE145, PLANE146, PLANE182, PLANE183
3-D Solids	SOLID45, SOLID46, HYPER58, SOLID64, SOLID65, HYPER86, VISCO89, SOLID92, SOLID95, VISCO107, SOLID147, SOLID148, HYPER158, SOLID185, SOLID186, SOLID187, SOLID191
Shells	SHELL28, SHELL41, SHELL43, SHELL51, SHELL61, SHELL63, SHELL91, SHELL93, SHELL99, SHELL150, SHELL181
Interface	INTER192, INTER193, INTER194, INTER195
Contact	CONTAC12, CONTAC52, TARGE169, TARGE170, CONTA171, CONTA172, CONTA173, CON-TA174, CONTA175
Coupled-Field	SOLID5, PLANE13, FLUID29, FLUID30, FLUID38, SOLID62, FLUID79, FLUID80, FLUID81, SOLID98, FLUID129, INFIN110, INFIN111, FLUID116, FLUID130
Specialty	COMBIN7, LINK11, COMBIN14, MASS21, MATRIX27, COMBIN37, COMBIN39, COMBIN40, MATRIX50, SURF153, SURF154
Explicit Dynamics	LINK160, BEAM161, PLANE162, SHELL163, SOLID164, COMBI165, MASS166, LINK167, SOLID168

MATERIAL MODEL INTERFACE: If we are using the GUI, we must specify the material we will be simulating using an intuitive material model interface. This interface uses a hierarchical tree structure of material categories, which is intended to assist in us choosing the appropriate model for our analysis.
TYPES OF SOLUTION METHODS:Two solution methods are available for solving structural problems in the ANSYS family of products: the h-method and the p-method. The h-method can be used for any type of analysis, but the p-method can be used only for linear structural static analyses. Depending on the problem to be solved, the h-method usually requires a finer mesh than the p-method. The p-method provides an excellent way to solve a problem to a desired level of accuracy while using a coarse mesh. In general, the discussions in this manual focus on the procedures required for the h-method of solution.
4.2 STRUCTURAL STATIC ANALYSIS: A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes). Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading that can be applied in a static analysis include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (nonzero) displacements
- Temperatures (for thermal strain)
- Fluences (for nuclear swelling)

PERFORMING A STATIC ANALYSIS: The procedure for a static analysis consists of these tasks:
- Build the Model
- Set Solution Controls
- Set Additional Solution Options
- Apply the Loads
- Solve the Analysis
- Review the Results

LOAD TYPES: All of the following load types are applicable in a static analysis.
DISPLACEMENTS (UX, UY, UZ, ROTX, ROTY, ROTZ): These are DOF constraints usually specified at model boundaries to define rigid support points. They can also indicate symmetry boundary conditions and points of known motion. The directions implied by the labels are in the nodal coordinate system.
FORCES (FX, FY, FZ) AND MOMENTS (MX, MY, MZ): These are concentrated loads usually specified on the model exterior. The directions implied by the labels are in the nodal coordinate system.
PRESSURES (PRES): These are surface loads, also usually applied on the model exterior. Positive values of pressure act towards the element face (resulting in a compressive effect).
TEMPERATURES (TEMP): These are applied to study the effects of thermal expansion or contraction (that is, thermal stresses). The coefficient of thermal expansion must be defined if thermal strains are to be calculated. We can read in temperatures from a thermal analysis [LDREAD], or we can specify temperatures directly, using the BF family of commands.
FLUENCES (FLUE): These are applied to study the effects of swelling (material enlargement due to neutron bombardment or other causes) or creep.
GRAVITY, SPINNING, ETC.: These are inertia loads that affect the entire structure. Density (or mass in some form) must be defined if inertia effects are to be included.
APPLY LOADS TO THE MODEL: Except for inertia loads, which are independent of the model, we can define loads either on the solid model (key points, lines, and areas) or on the finite element model (nodes and elements). We can also apply boundary conditions via TABLE type array parameters. Applying Loads Using TABLE Type Array Parameters) or as function boundary conditions
APPLYING LOADS USING FUNCTION BOUNDARY CONDITIONS "Loads Applicable in a Static Analysis" summarizes the loads applicable to a static analysis. In an analysis, loads can be applied, removed, operated on, or listed.

Load Type	**Category**	**For details on commands and menu paths for defining these loads**
Displacement (UX,UY,UZ,ROTX,ROTY,ROTZ)	Constraints	DOF Constraints in the ANSYS Basic Analysis Guide
Force,Moment (FX,FY,FZ,MX,MY,MZ)	Forces	Forces(concentrated loads) in the ANSYS Basic Analysis Guide
Pressures(PRES)	Surface loads	Surface loads in the ANSYS basic Analysis Guide
Temperature(TEMP),Fluence (FLUE)	Body loads	Body Loads in the ANSYS Basic Analysis Guide
Gravity, Spinning ,and so on	Inertia loads	Inertia Loads in the ANSYS Basic Analysis Guide

COMPOSITES IN ANSYS: Composite materials have been used in structures for a long time. In recent times composite parts have been used extensively in aircraft structures, automobiles, sporting goods, and many consumer products. Composite materials are those containing more than one bonded material, each with different structural properties.The main advantage of composite materials is the potential for a high ratio of stiffness to weight. Composites used for typical engineering applications are advanced fiber or laminated composites, such as fiberglass, glass epoxy, graphite epoxy, and boron epoxy.ANSYS allows us to model composite materials with specialized elements called layered elements. Once we build our model using these elements, we can do any structural analysis (including nonlinearities such as large deflection and stress stiffening).
MODELING COMPOSITES: Composites are somewhat more difficult to model than an isotropic material such as iron or steel. We need to take special care in defining the properties and orientations of the various layers since each layer may have different orthotropic material properties. In this section, we will concentrate on the following aspects of building a composite model:
- Choosing the proper element type
- Defining the layered configuration
- Specifying failure criteria
- Following modeling and post-processing guidelines

CHOOSING THE PROPER ELEMENT TYPE: The following element types are available to model layered composite materials: SHELL99, SHELL91, SHELL181, SOLID46, and SOLID191. Which element we choose depends on the application, the type of results that need to be calculated, and so on. Check the individual element descriptions to determine if a specific element can be used in our ANSYS product. All layered elements allow failure criterion calculations.

SHELL99 - Linear Layered Structural Shell Element:SHELL99 is an 8-node, 3-D shell element with six degrees of freedom at each node. It is designed to model thin to moderately thick plate and shell structures with a side-to-thickness ratio of roughly 10 or greater. For structures with smaller ratios, we may consider using SOLID46. The SHELL99 element allows a total of 250 uniform-thickness layers. Alternately, the element allows 125 layers with thicknesses that may vary bilinearly over the area of the layer. If more than 250 layers are required, we can input our own material matrix. It also has an option to offset the nodes to the top or bottom surface.

SHELL91 - Nonlinear Layered Structural Shell Element:SHELL91 is similar to SHELL99 except that it allows only up to 100 layers and does not allow us to input a material property matrix. However, SHELL91 supports plasticity, large-strain behavior and a special sandwich option, whereas SHELL99 does not. SHELL91 is also more robust for large deflection behavior.

SHELL181 - Finite Strain Shell:SHELL181 is a 4-node 3-D shell element with 6 degrees of freedom at each node. The element has full nonlinear capabilities including large strain and allows 255 layers. The layer information is input using the section commands rather than real constants. Failure criteria are available using the FC commands.

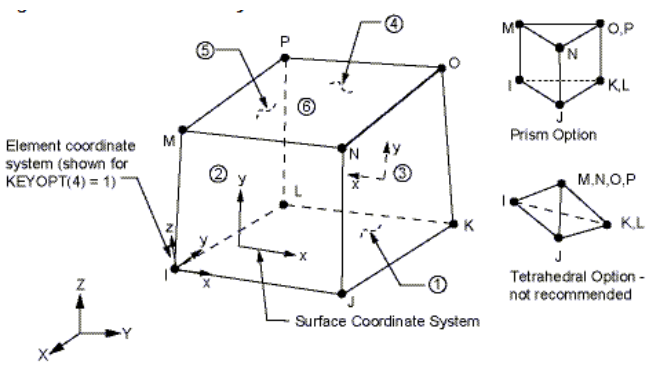
SOLID46 - 3-D Layered Structural Solid Element:SOLID46 is a layered version of the 8-node, 3-D solid element, SOLID45, with three degrees of freedom per node (UX, UY, UZ). It is designed to model thick layered shells or layered solids and allows up to 250 uniform-thickness layers per element. Alternately, the element allows 125 layers with thicknesses that may vary bilinearly over the area of the layer. An advantage with this element type is that you can stack several elements to model more than 250 layers to allow through-the-thickness deformation slope discontinuities. The user-input constitutive matrix option is also available. SOLID46 adjusts the material properties in the transverse direction permitting constant stresses in the transverse direction. In comparison to the 8-node shells, SOLID46 is a lower order element and finer meshes may be required for shell applications to provide the same accuracy as SHELL91 or SHELL99.

SOLID191 - Layered Structural Solid Element:SOLID191 is a layered version of the 20-node 3-D solid element SOLID95, with three degrees of freedom per node (UX, UY, UZ). It is designed to model thick layered shells or layered solids and allows up to 100 layers per element. As with SOLID46, SOLID191 can be stacked to model through-the-thickness discontinuities. SOLID191 has an option to adjust the material properties in the transverse direction permitting constant stresses in the transverse direction. In spite of its name, the element does not support nonlinear materials or large deflections.In addition to the layered elements mentioned above, other composite element capabilities exist in ANSYS, but will not be considered further in the chapter:

- ✓ **SOLID95,** the 20-node structural solid element, with KEYOPT(1) = 1 functions similarly to a single layered
- ✓ **SOLID191** including the use of an orientation angle and failure criterion. It allows nonlinear materials and large deflections.
- ✓ **SHELL63,** the 4-node shell element, can be used for rough, approximate studies of sandwich shell models.

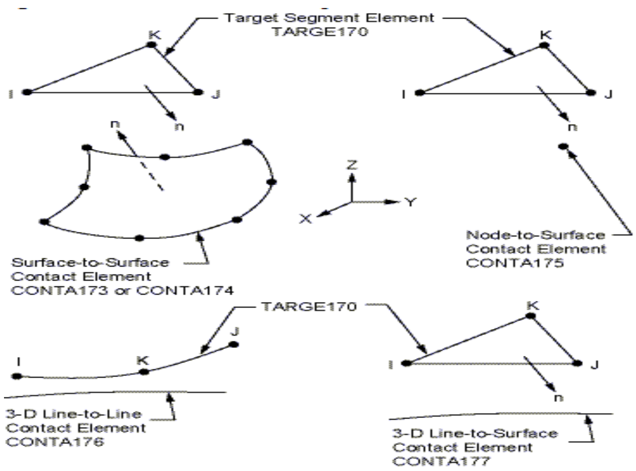
A typical application would be a polymer between two metal plates, where the bending stiffness of the polymer would be small relative to the bending stiffness of the metal plates. The bending stiffness can be adjusted by the real constant RMI to represent the bending stiffness due to the metal plates, and distances from the middle surface to extreme fibers (real constants CTOP, CBOT) can be used to obtain output stress estimates on the outer surfaces of the sandwich shell. It is not used as frequently as SHELL91,SHELL99, or SHELL181, and will not be considered for anything other than sandwich structures in this section.

- ✓ **SOLID65,** the 3–D Reinforced Concrete Solid Element, models an isotropic medium with optional reinforcing in 3 different user-defined orientations.
- ✓ **BEAM188** and **BEAM189,** the 3–D finite strain beam elements, can have their sections built up with multiple materials.
- ✓ **ELEMENT TYPE USED IN THE PROJECT**:**SOLID45 Element Description :**SOLID45 is used for the 3-D modeling of solid structures. The element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities.



SOLID45 Geometry

TARGE170 Element Description :TARGE170 is used to represent various 3-D "target" surfaces for the associated contact elements (CONTA173, CONTA174, CONTA175, CONTA176 & CONTA177). The contact elements themselves overlay the solid, shell, or line elements describing the boundary of a deformable body and are potentially in contact with the target surface, defined by TARGE170. This target surface is discredited by a set of target segment elements (TARGE170) and is paired with its associated contact surface via a shared real constant set. We can impose any translational or rotational displacement, temperature, voltage, and magnetic potential on the target segment element. we can also impose forces and moments on target elements. For rigid target surfaces, these elements can easily model complex target shapes. For flexible targets, these elements will overlay the solid, shell, or line elements describing the boundary of the deformable target body.



TARGE170 Geometry

STRUCTURAL ANALYSIS OF EN8 & EN19 STEELS:
EN8 STEEL UNTREATED:

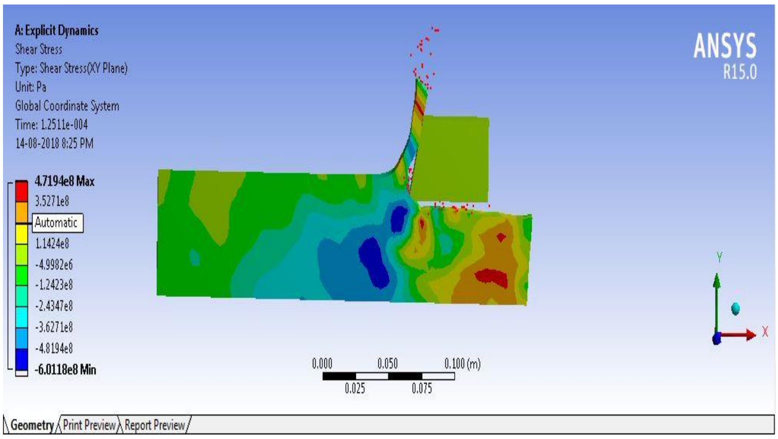


Fig. 4.1

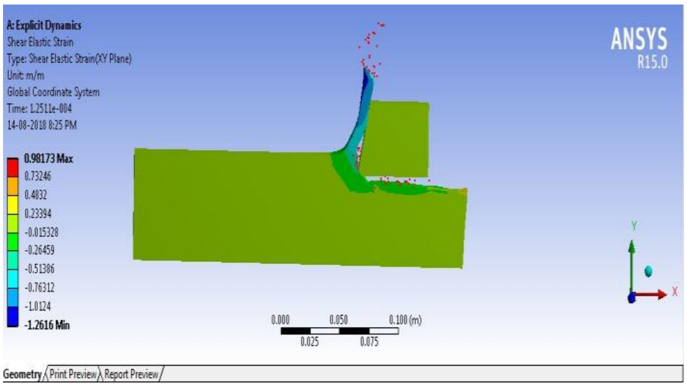


Fig. 4.2

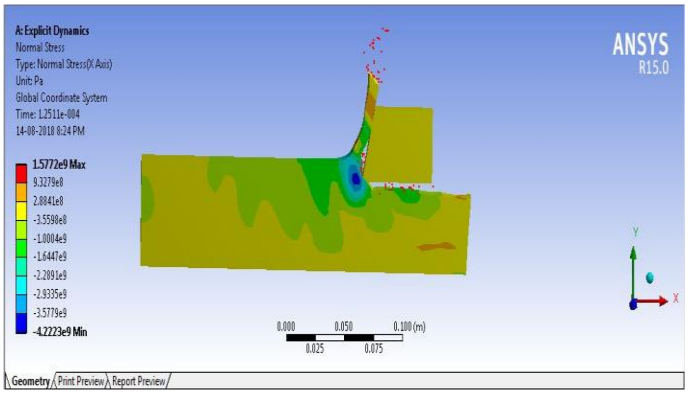


Fig. 4.3

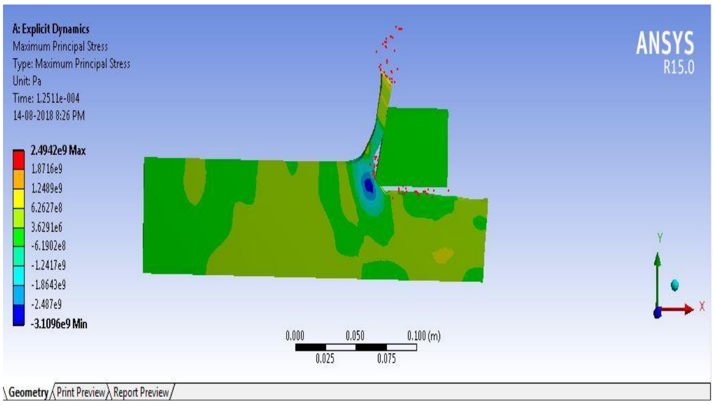


Fig.4.4

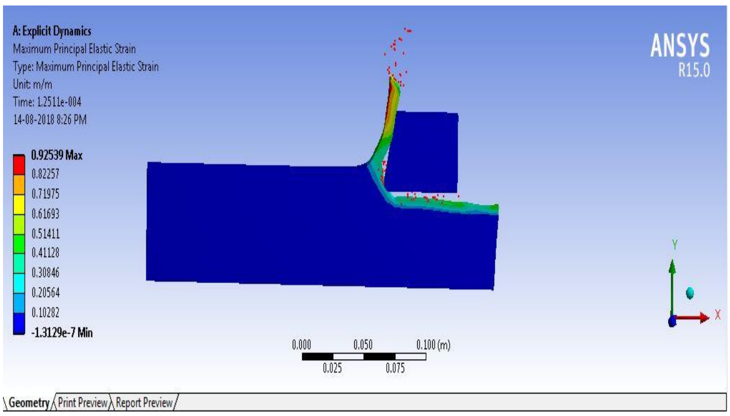


Fig. 4.5

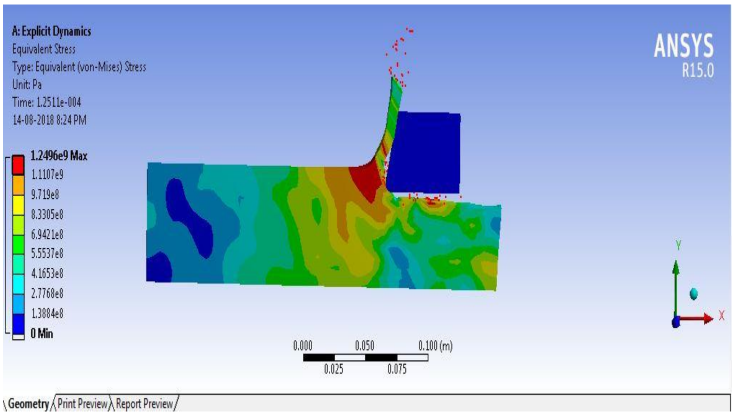


Fig. 4.6

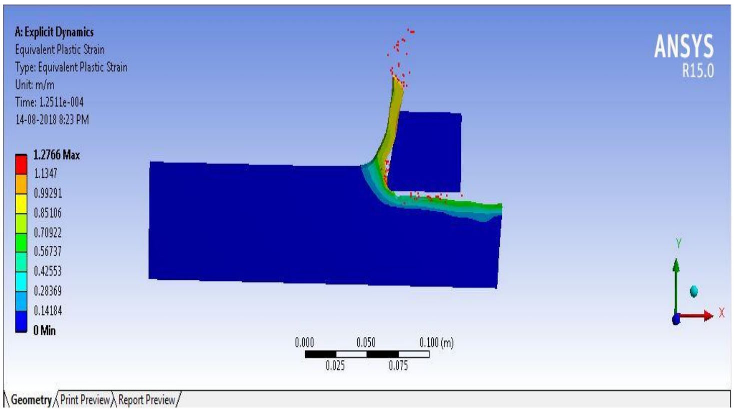


Fig. 4.7

EN8 STEEL TREATED:

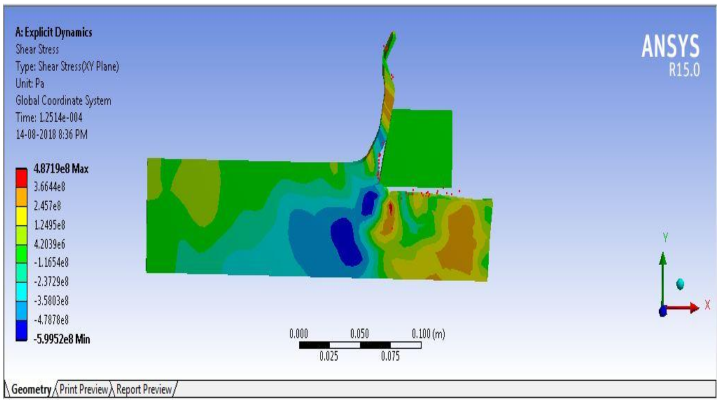


Fig. 4.8

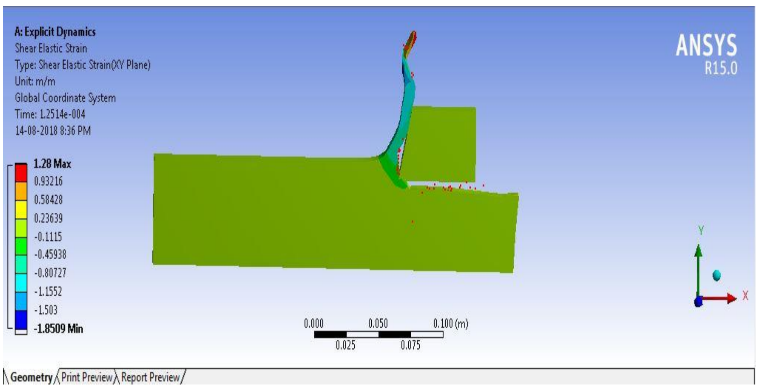


Fig. 4.9

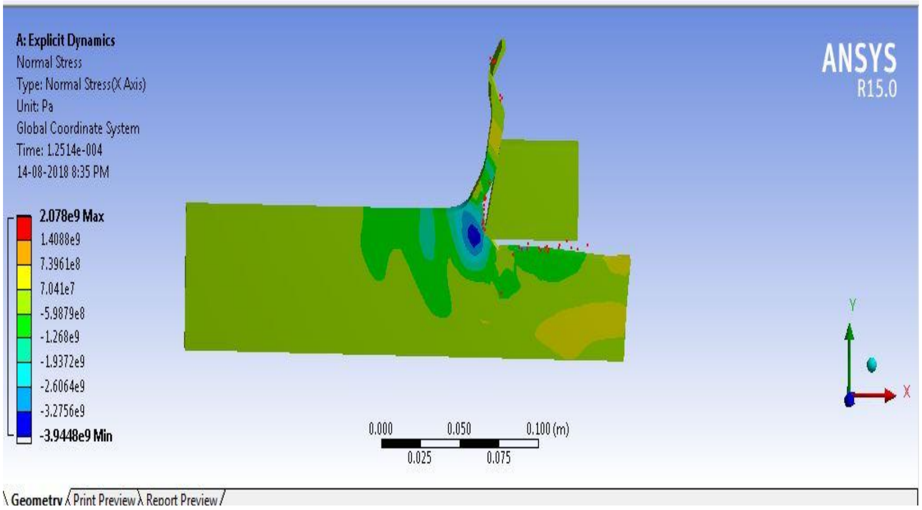


Fig. 4.10

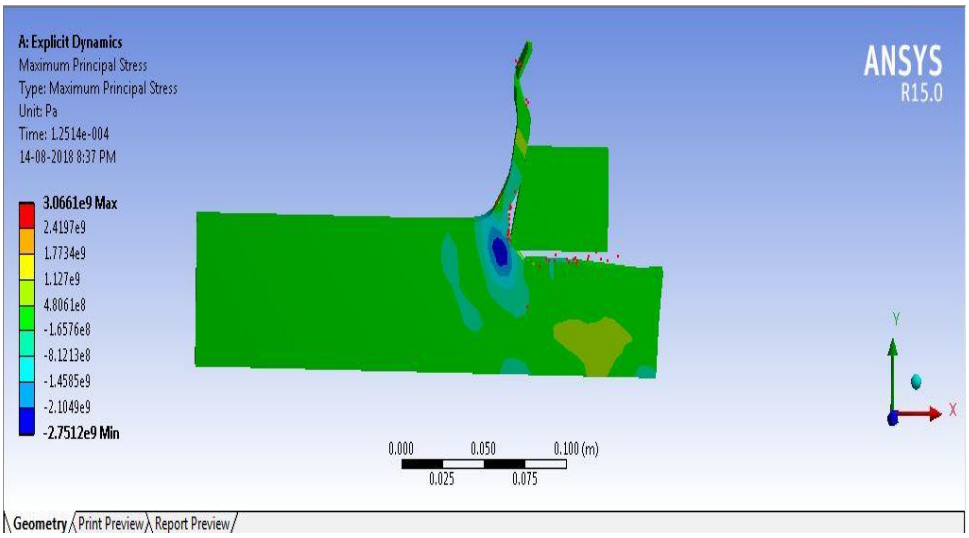


Fig. 4.11

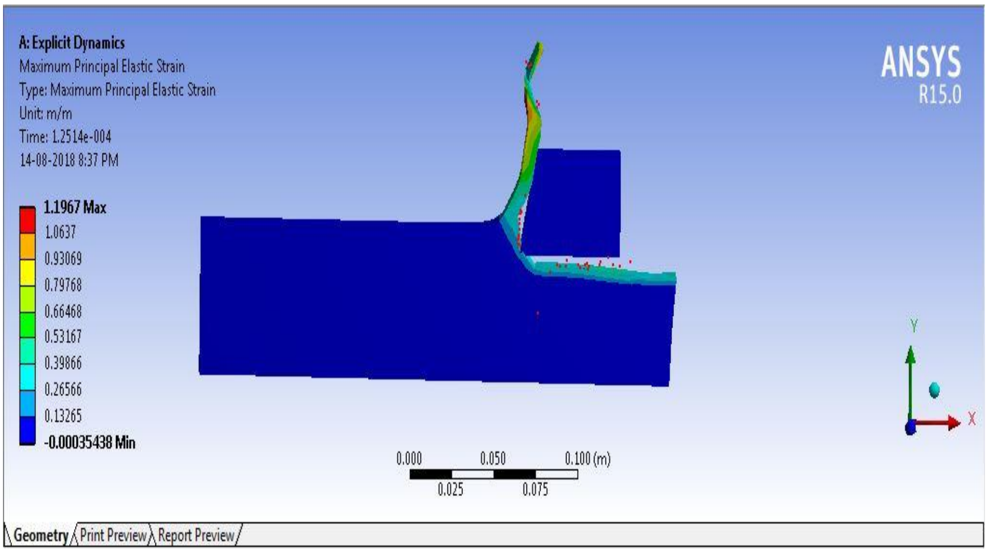


Fig. 4.12

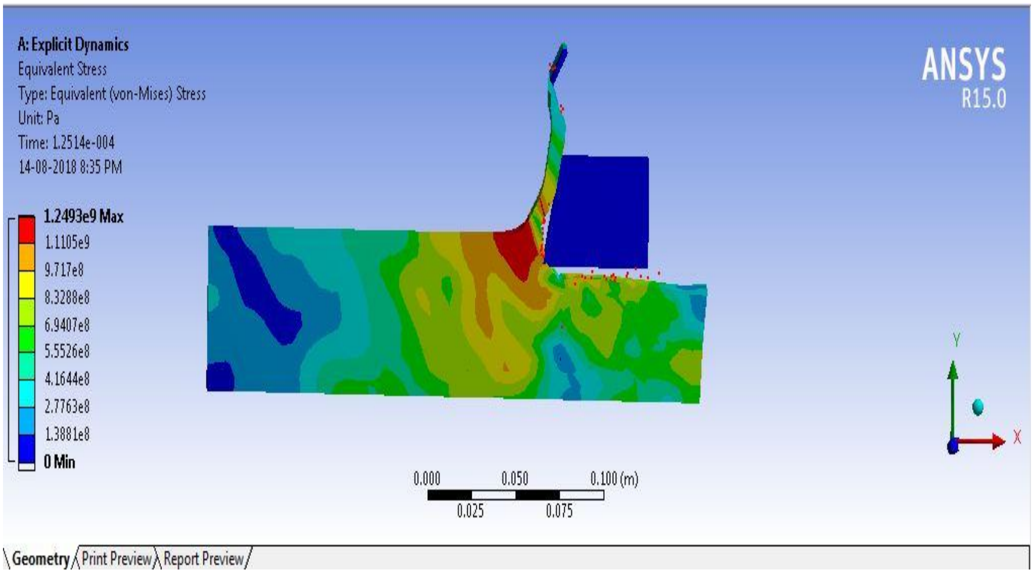


Fig. 4.13

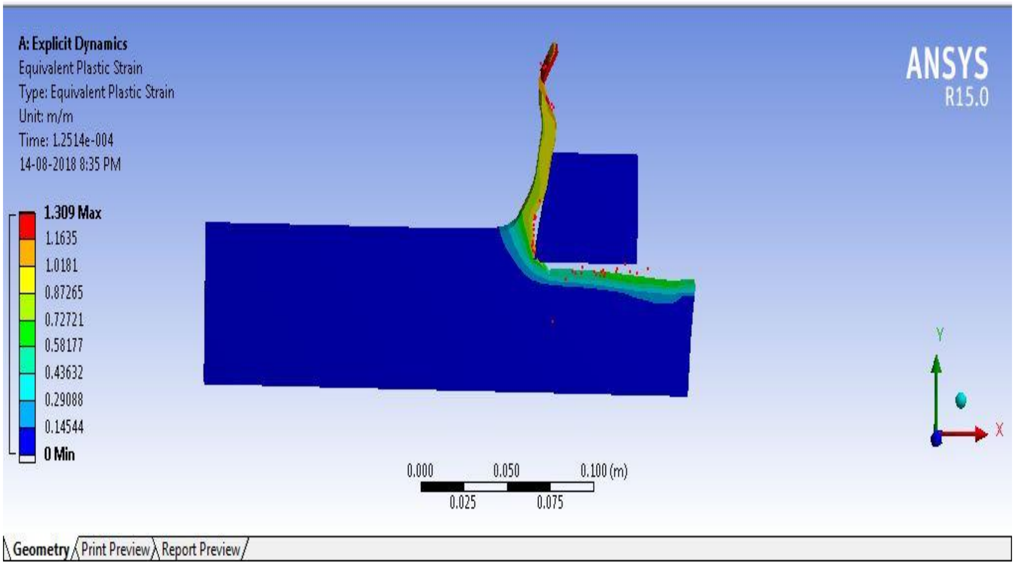


Fig. 4.14

EN19 STEEL UNTREATED:

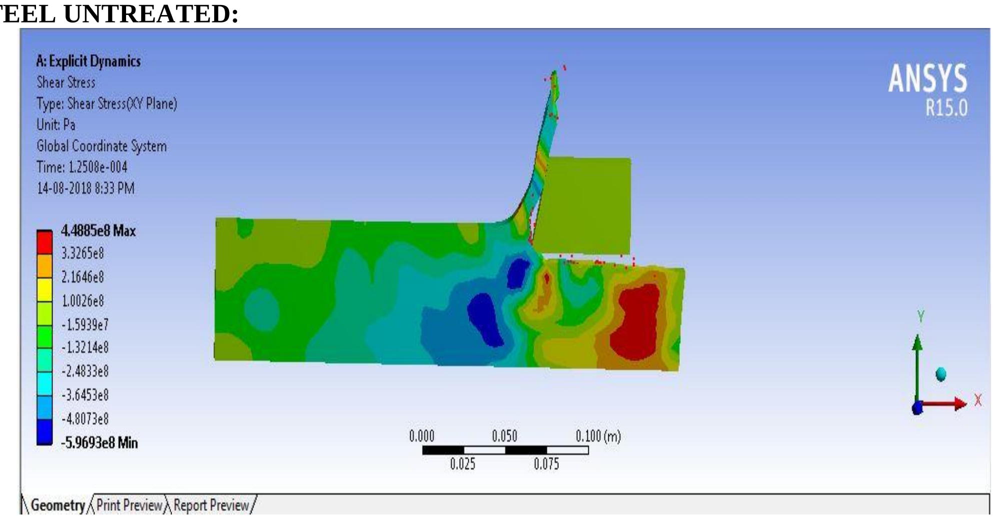


Fig. 4.15

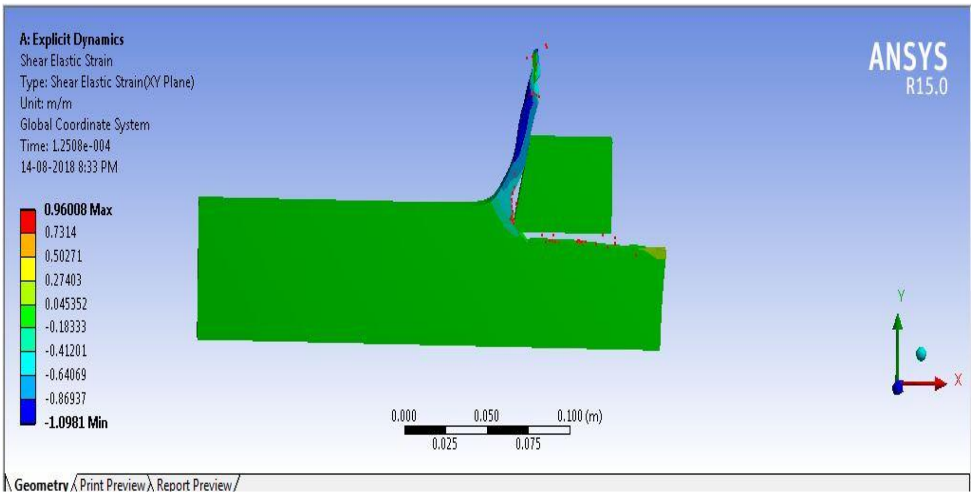


Fig. 4.16

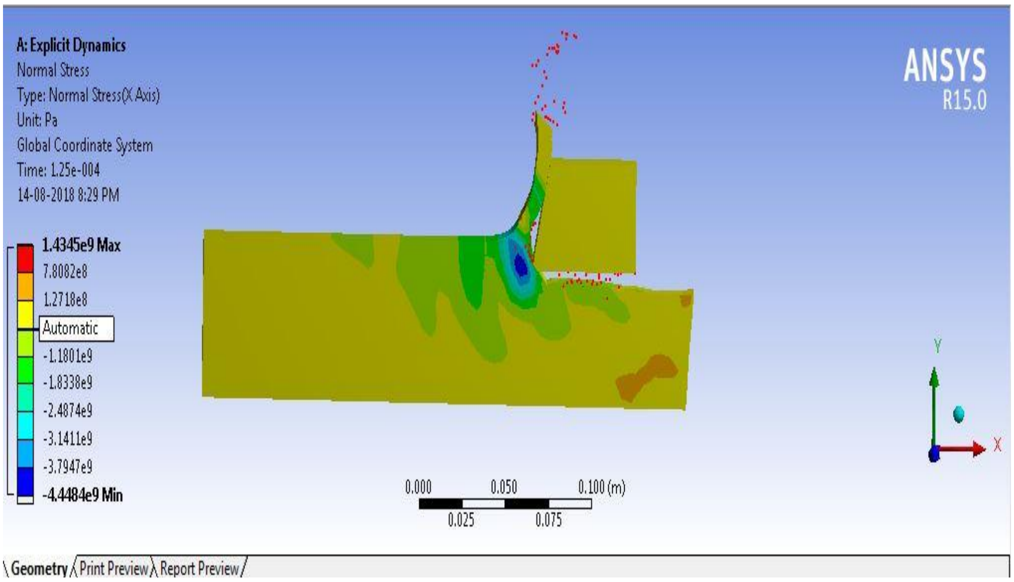


Fig. 4.17

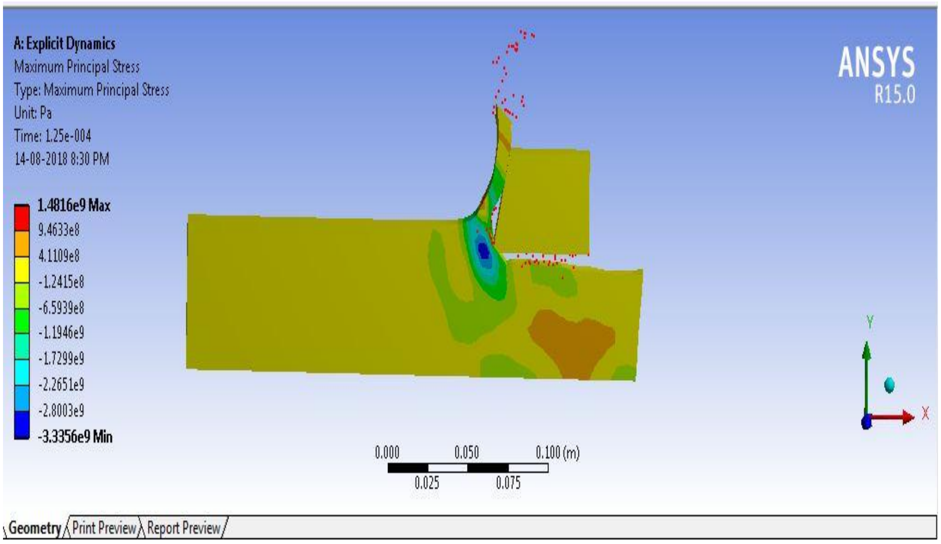


Fig. 4.18

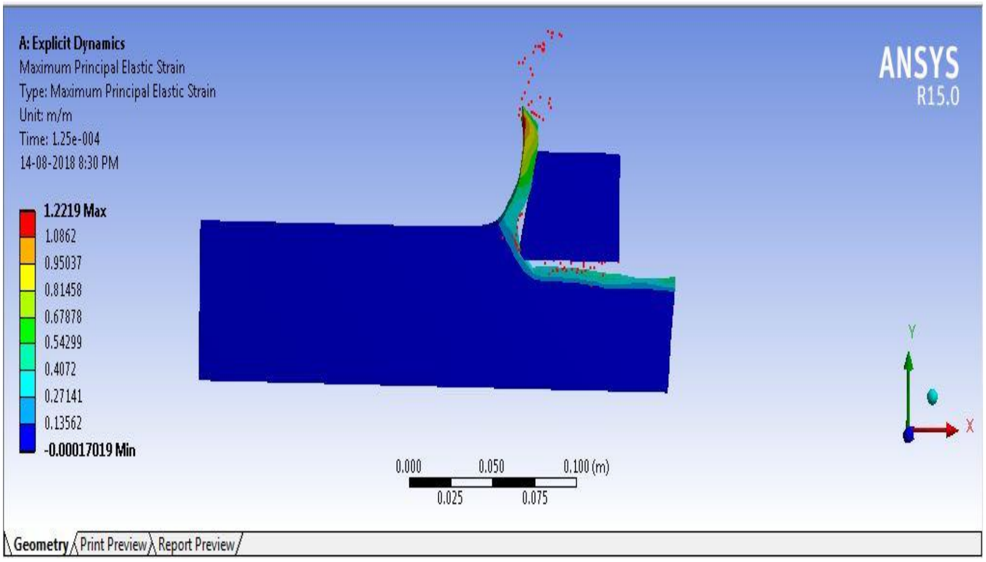


Fig. 4.19

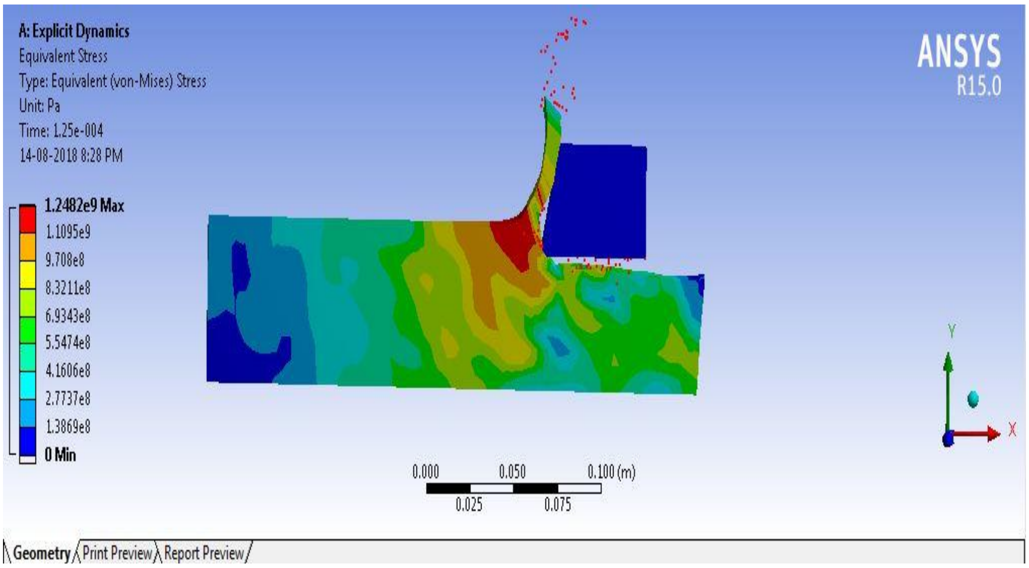


Fig. 4.20

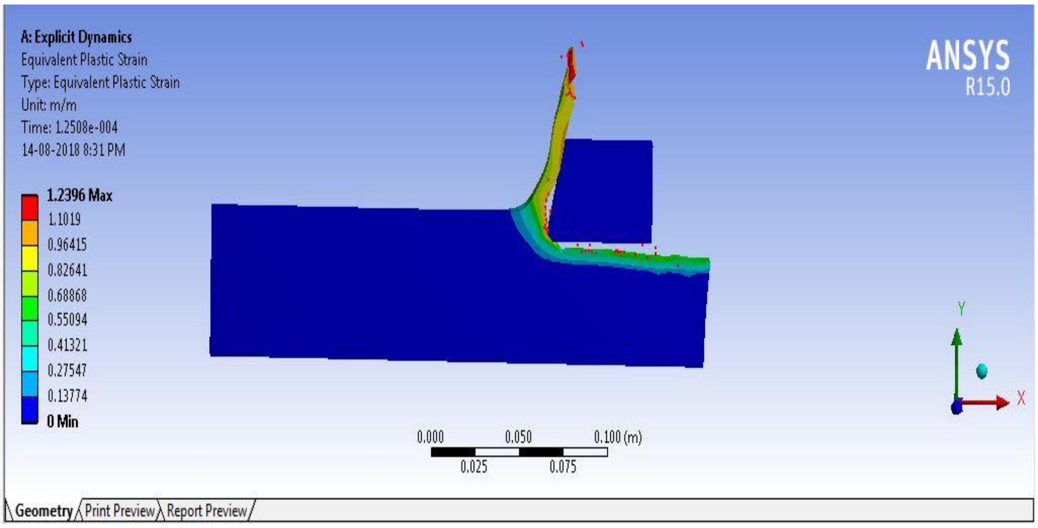


Fig. 4.21

EN19 STEEL TREATED:

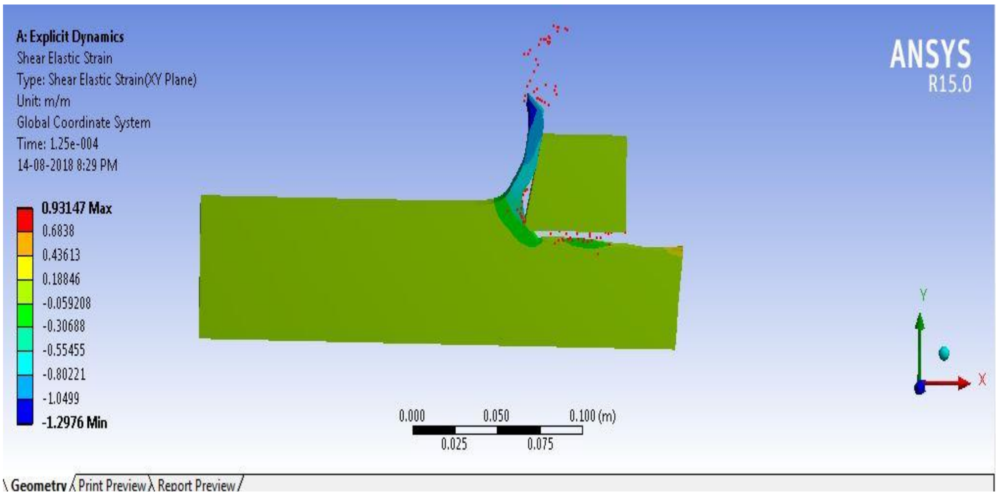


Fig. 4.22

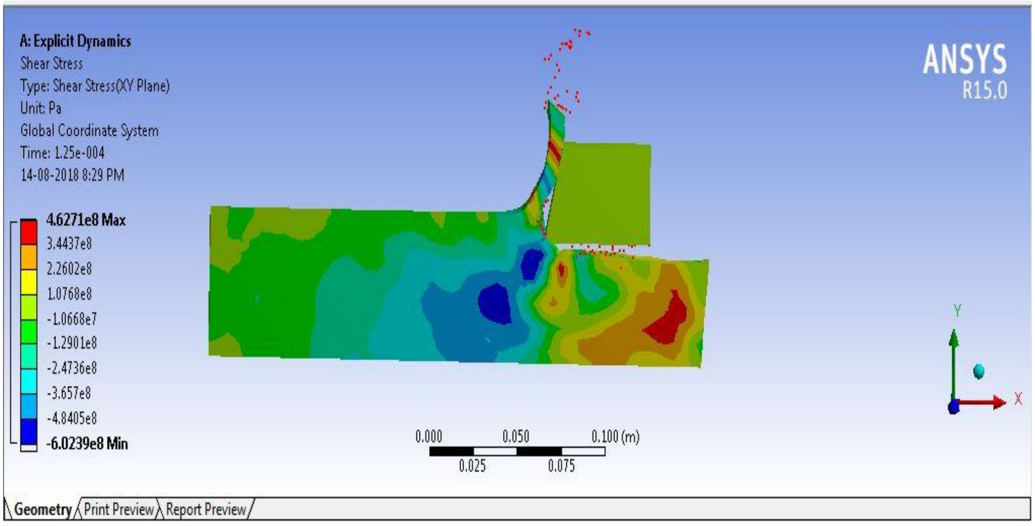
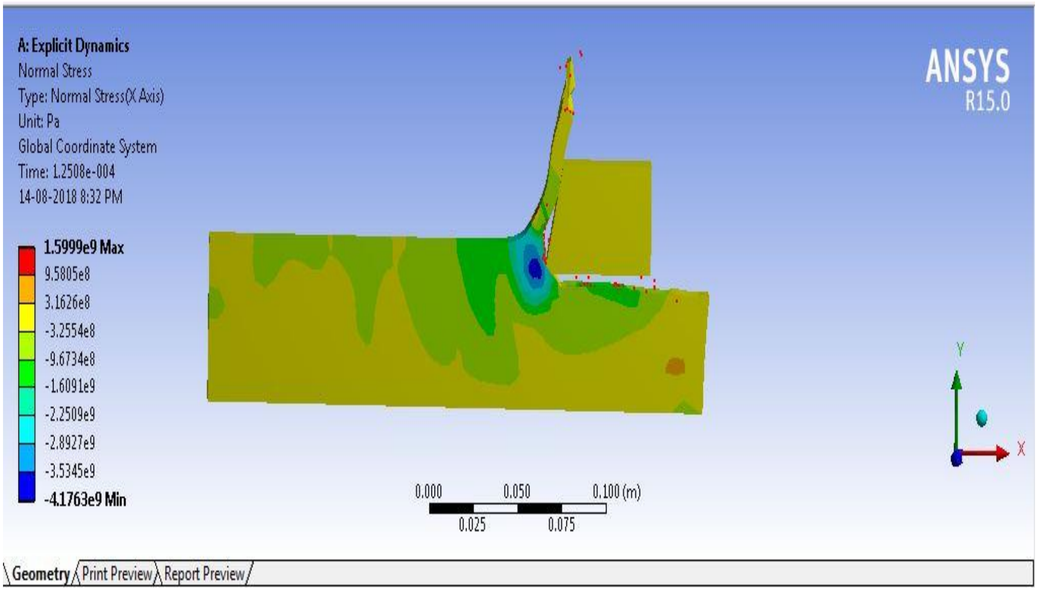


Fig. 4.23



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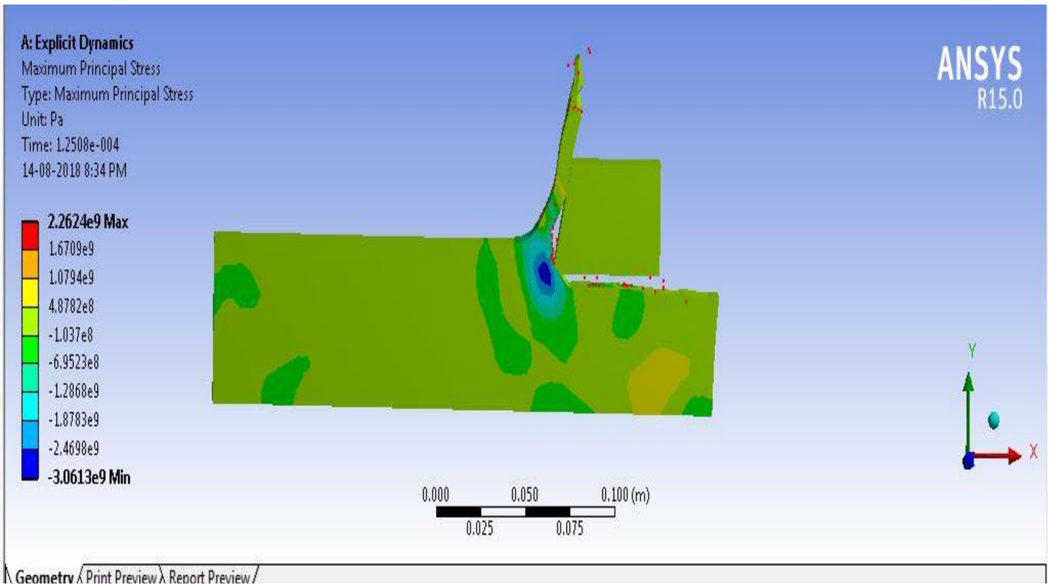


Fig. 4.25

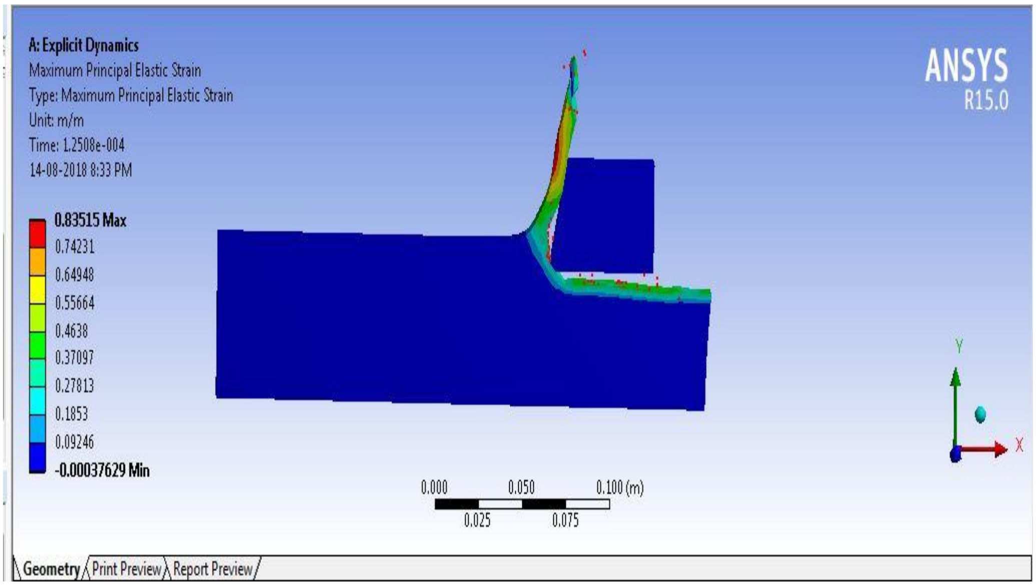


Fig. 4.26

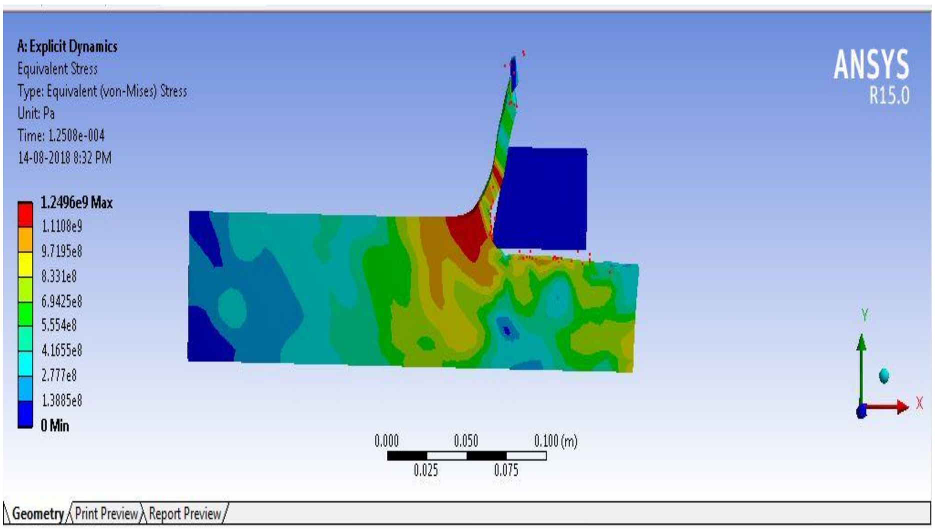


Fig. 4.27

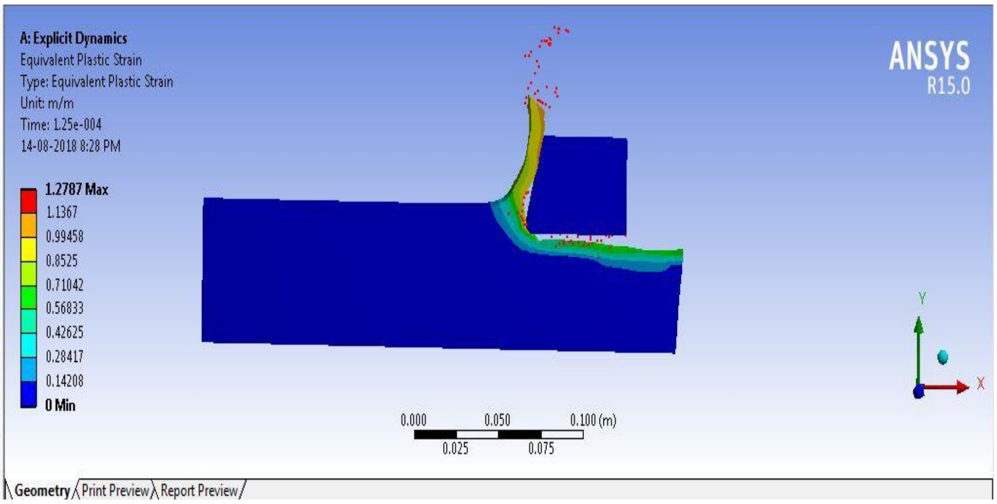


Fig. 428

V. Chapter:5 Results & Discussions:

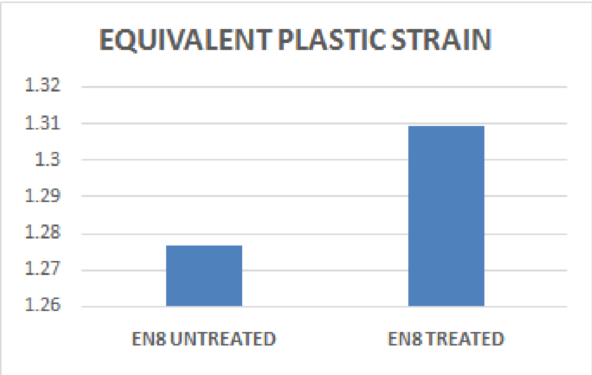
5.1 STRUCTURAL ANALYSIS RESULTS & BAR CHARTS:

MATERIAL (X-AXIS)	EQUIVALENT PLASTIC STRAIN (Y-AXIS)
EN8 UNTREATED	1.2766
EN8 TREATED	1.309

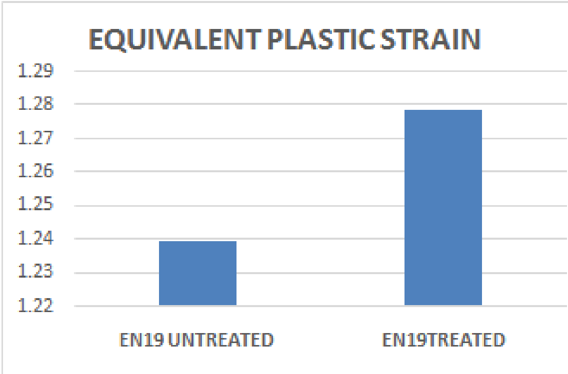
Table.5.1

MATERIAL (X-AXIS)	EQUIVALENT PLASTIC STRAIN (Y-AXIS)
EN19 UNTREATED	1.2396
EN19TREATED	1.2787

Table-5.2



Graph. 5.1



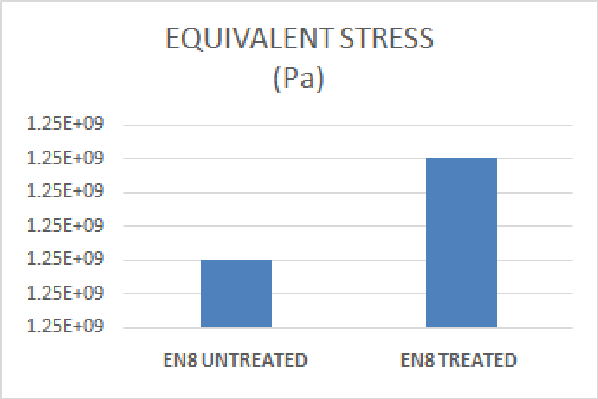
Graph.5.2

MATERIAL (X-AXIS)	EQUIVALENT STRESS (Pa) (Y-AXIS)
EN8 UNTREATED	1.25E+09
EN8 TREATED	1.25E+09

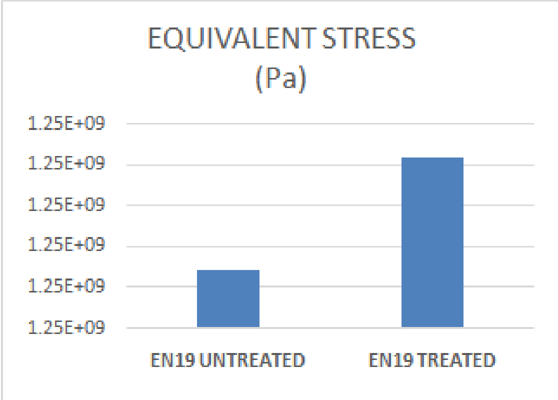
Table.5.3

MATERIAL (X-AXIS)	EQUIVALENT STRESS (Pa) (Y-AXIS)
EN19 UNTREATED	1.25E+09
EN19 TREATED	1.25E+09

Table-5.4



Graph-5.3



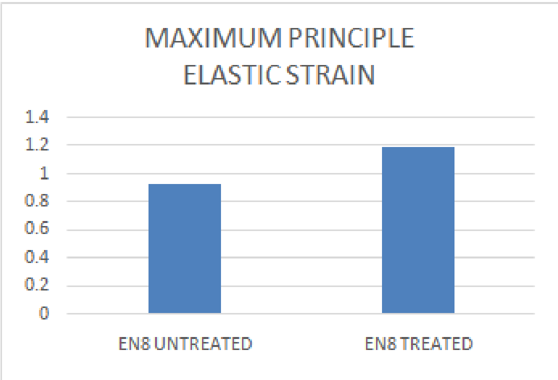
Graph-5.4

MATERIAL (X-AXIS)	MAXIMUM PRINCIPLE ELASTIC STRAIN (Y-AXIS)
EN8 UNTREATED	0.92539
EN8 TREATED	1.1967

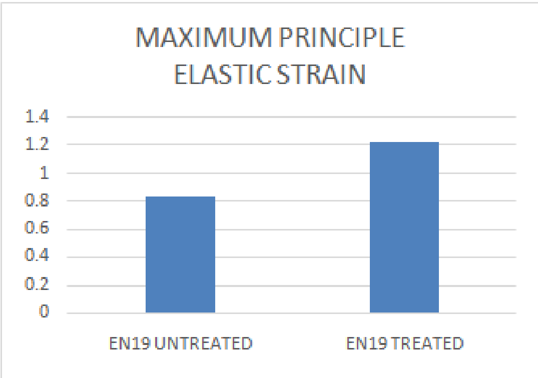
Table-5.5

MATERIAL (X-AXIS)	MAXIMUM PRINCIPLE ELASTIC STRAIN (Y-AXIS)
EN19 UNTREATED	0.83515
EN19 TREATED	1.2219

Table-5.6



Graph-5.5



Graph-5.6

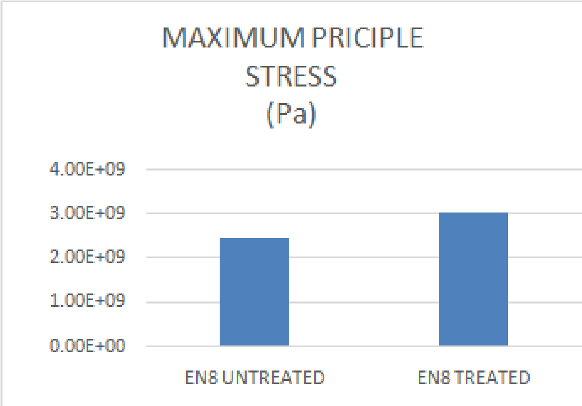
MATERIAL (X-AXIS)	MAXIMUM PRICIPLE STRESS (Pa) (Y-AXIS)
EN8 UNTREATED	2.49E+09
EN8 TREATED	3.07E+09

Table-5.7

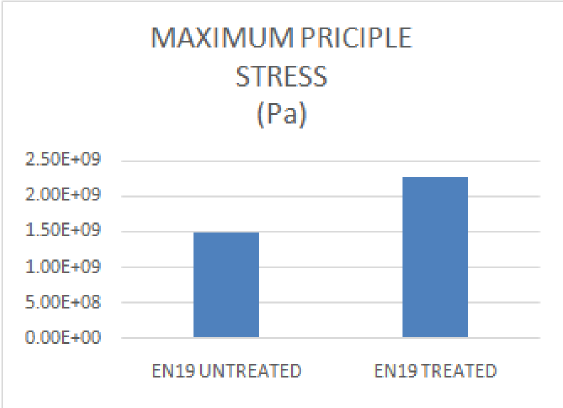
MATERIAL (X-AXIS)	MAXIMUM PRICIPLE STRESS (Pa) (Y-AXIS)
EN19 UNTREATED	1.48E+09
EN19 TREATED	2.26E+09

Table-5.8

DOI: 10.9790/1684-1504054484



Graph-5.7



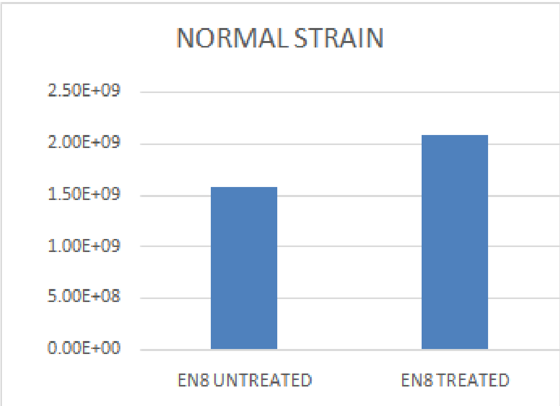
Graph-5.8

MATERIAL (X-AXIS)	NORMAL STRAIN (Y-AXIS)
EN8 UNTREATED	1.58E+09
EN8 TREATED	2.08E+09

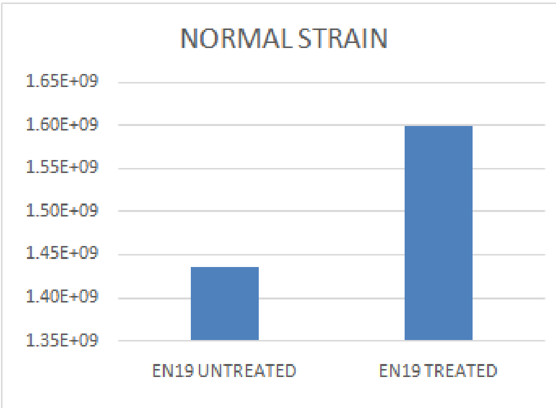
Table-5.9

MATERIAL (X-AXIS)	NORMAL STRAIN (Y-AXIS)
EN19 UNTREATED	1.43E+09
EN19 TREATED	1.60E+09

Table-5.10



Graph-5.9



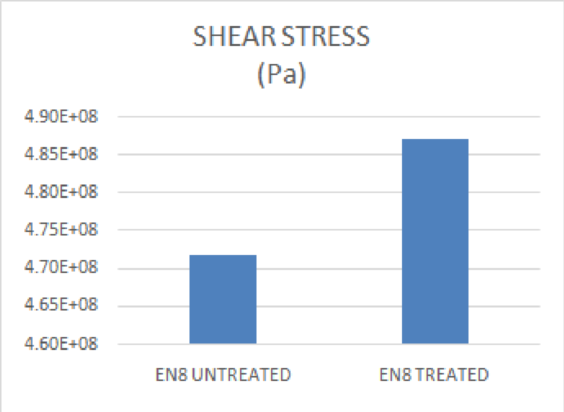
Graph-5.10

MATERIAL (X-AXIS)	SHEARSTRESS (Pa) (Y-AXIS)
EN8 UNTREATED	4.72E+08
EN8 TREATED	4.87E+08

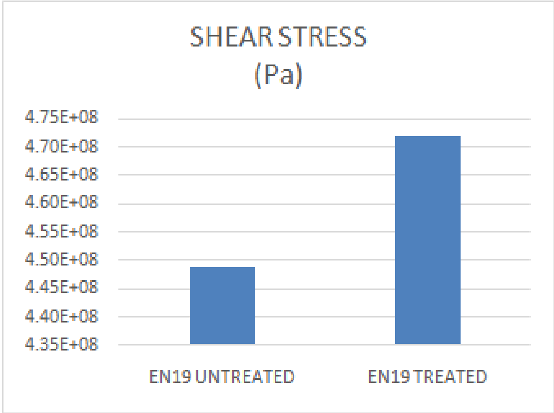
Table-5.11

MATERIAL (X-AXIS)	SHEARSTRESS (Pa) (Y-AXIS)
EN19 UNTREATED	4.49E+08
EN19 TREATED	4.72E+08

Table-5.12



Graph-5.11



Graph 5.12

5.2 EXPERIMENT DETAILS

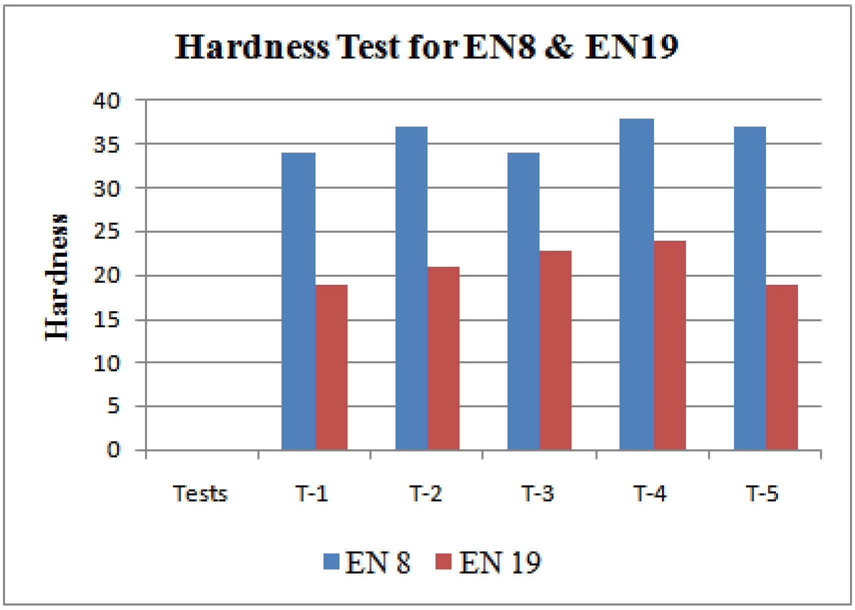
5.2.1 SAMPLE MATERIAL:There are different types of materials are used for machining purposes due to the requirements. We have selected the hardened steels for machining. They are EN8 and EN19.For these two sample work pieces the hardness test is performed at various sections using Rockwell Hardness testing machine. Therefore the test readings are tabulated and it is shown.

Rockwell Hardness Test for EN8 and EN19 Steel

TESTS	EN8	EN19
T-1	34	19
T-2	37	21
T-3	34	23
T-4	38	24
T-5	37	19

Table-5.15

Rockwell Hardnes



Graph-5.15

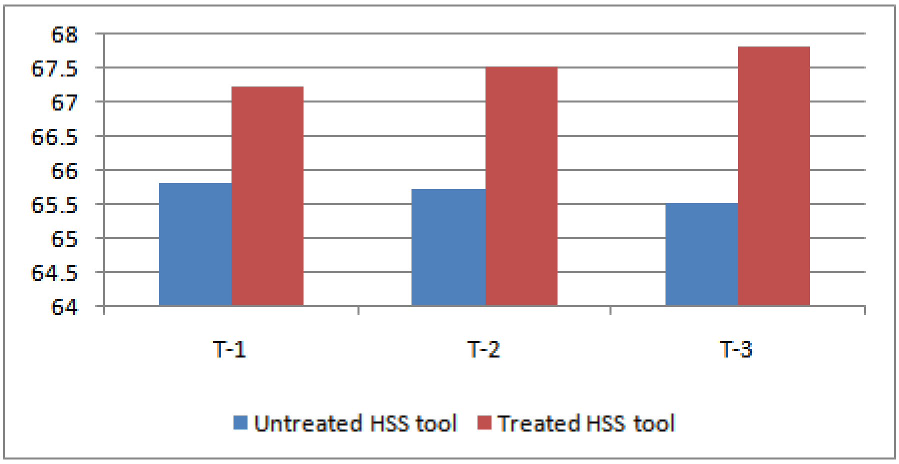
5.2.2 PREPARATION OF TOOL: Although we have selected the normal high speed steel tool for machining, it is not possible to machine the hardened materials. Due to this drawback we prepared to dip the tool in the cryogenic solution for certain minutes. The hardness is tested for the tool before dipping and after dipping it in the solution.The hardness tests are done for an untreated single point cutting tool at various sections is: 65.8, 65.7 & 65.5. The average is 65.6 HRC.The hardness tests are done for a treated single point cutting tool at various sections is: 67.2, 67.5 & 67.8. The average is 67.5 HRC. therefore the hardness is increased by 1.9 HRC than the untreated tool.

Rockwell Hardness Test for Treated and Untreated Tool

TESTS	**Untreated HSS tool**	**Treated HSS tool**
T-1	65.8	67.2
T-2	65.7	67.5
T-3	65.5	67.8

Table-5.16

ROCKWELL TESTS Vs HARDNESS:



Graph-5.16

5.3 TOOL TREATMENT

5.3.1 Cryogenic tool treatment: Although its effects on metal composition are subtle, deep cryogenic tempering can yield dramatic improvements in tool performance.In the search for cutting tool engineering that can increase productivity, prolong cutting life, and decrease costs, gains of 15% to 20% are considered significant. One recently developed tool treatment is showing far greater promise, in some cases improving tool life by 200% to 400%. The method called deep cryogenic tempering, subjects tools placed in a specially constructed tank to temperatures below -300F for a number of hours using liquid nitrogen as the refrigerant. The process supplements standard heat/quench tempering, completing metallurgical changes that heat treating begins.According to the literature of United States some machine elements, such as progressive dies used in metal working, have lasted six times longer after deep cryogenic treatment. Drills, End mills have shown significant improvement.Another advantage of deep cryogenic tempering revealed through research is its ability to change the entire structure of the tool material, not just its surface.

Chilly Changes: Slowly cooling the tool steels to deep cryogenic temperatures and soaking it at this low temperature for half an hour changes the material's microstructure. Almost all of the austenite retained in the steel after heat treating is transformed into a harder form martensite by deep cryogenic tempering.

Standard Tempering:Some of these benefits may be achieved through standard tempering, which also transforms austenite into martensite. But standard tempering may not bring about a complete transformation in some tool steels. For example, 8.5% of an O-1 steel remains austenite after it is oil-quenched to 68F. If M-1 is quenched from 2228 F to 212 F, then tempered at 1049 F, the retained austenite is 11%. Additional improvements in tool performance can be achieved if this retained austenite can be transformed to martensite.

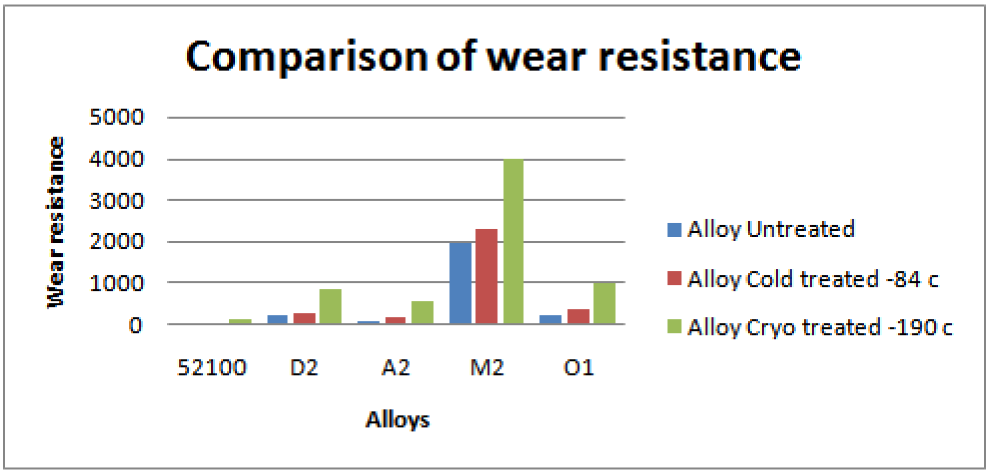
Predicting Effectiveness:Knowing how deep cryogenic tempering works, we can predict which materials will benefit most from treatment. Generally, if an alloy contains austenite and this austenite responds in some degree to heat treatment, further improvements will be seen after deep cryogenic tempering. For instance, ferrite and austenite (430 and 303) stainless steels generally cannot be hardened by heat treatment. Martensite (440) stainless steels, on the other hand, can be hardened by heat treatment. Therefore, the effect of deep cryogenic treatment should be more pronounced for 440 stainless steels than for the other stainless steels.

5.3.2:Researchers in a study conducted at Jassy Polytechnic Institute in Romania used a scanning electron microscope equipped with an automatic particle counter to identify and quantify these smaller particles. Through this examination they found that cryogenic tempering creates a significant change in density throughout the tool.
5.3.3Critics:Some people acknowledge the benefits of 'Cold tempering', but they question the need to use temperatures below -110 F.
5.3.4 Cold Treating:Cold treating of steel is widely accepted within the metallurgical profession as a supplemental treatment that can be used to enhance the transformation of austenite to martensite and to improve stress relif of castings and machined parts. Common practice identifies -84°c as the optimum temperature for cold treatment. Generally, 1 hr of cold treatment for each inch of cross section is adequate to achieve the desired result. It is also used to improve wear resistance in such materials as tool steels, high-carbon martensitic stainless steels, and carburized- alloy steels for applications in which the presence of retained austenite may result in excessive wear. Transformation in service may cause cracking and/or dimensional changes that can promote failure.
5.3.5 Advantages of Cold Treating:Successful transformation through cold treating depends only on the attainment of the minimum low temperature and is not affected by lower temperatures. As long as the material is chilled to -84°C, transformation will occur, additional chilling will not cause reversal.
5.3.6 Case Studies of Cryogenically Treated Steels:Resistance to abrasive wear was investigated in a parametric study. Five tool steels were tested after conventional heat treatment, after cold treatment at -84°C, and after being cryogenically treated at -190°C.

Table-5.17 Tool wear for various metals

Alloy	Untreated	CryoTreated -190°C
52100	25.2	135
D2	224	878
A2	85.6	565
M2	1961	3993
O1	237	996

Graph-5.17 Comparison of wear resistance for five high carbon steels



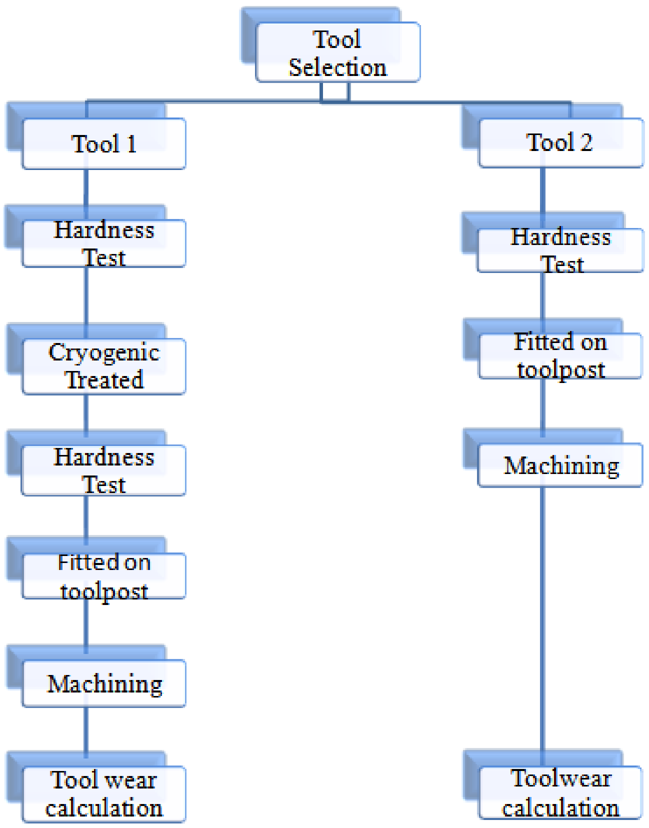
Cold treatment at -84°C improved the wear resistance by 18 to 104%, but the cryogenic treatment results show 104 to 560% improvement.
5.3.7 Reason:So, we discussed with our fellow mates and with the lectures about the cryogenic treatment and with the guidance of them we performed the machining operation.
5.3.8 Cryogenic Treatment and processing promotes three transformations in heat-treated steels.

Crystal structure becomes consistent or homogenous through the conversion of austenite to the desired martensitic crystal. After heat-treating, nearly all steels have a certain percentage of austenite that was not fully transformed into martensite. This is what metallurgists call "retained austenite" or "RA". It is widely accepted in the heat-treating industry that all heat-treated steels will have some percentage of RA and heat treatment recipes routinely specify that RA will "not exceed" a certain percentage. This can vary from processor t to processor, but almost all steels have a certain percentage of RA or retained austenite. Cryogenic treatment promotes the additional transformation of RA into martensite, which is what 90% (or more) of the steel already is and the condition that is most desirable. By eliminating retained austenite (or RA), voids or imperfections in the steel's microstructure are eliminated.

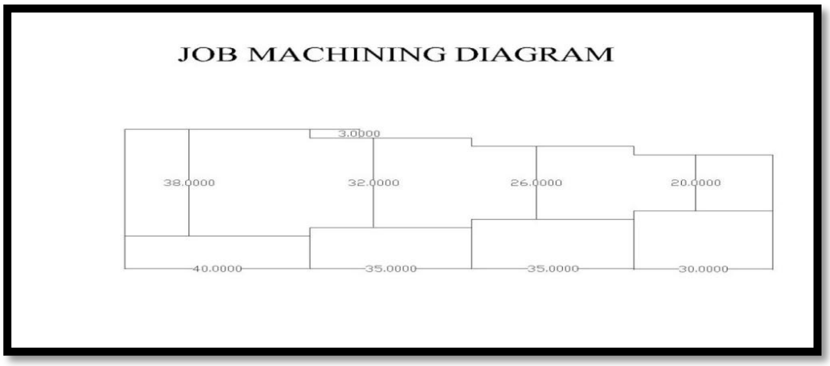
All metals not just steel, but also aluminum, copper, cast alloys, etc. benefit from the residual stress relief that deep cryogenic treatment promotes. All metals have residual stresses; they are created from the moment the metal "freezes" from its molten form into its solid form. Molten metal freezes or transforms from its liquid phase to its solid phase like water or other liquids that we are familiar with. As heat is extracted through cooling, dendrites form from the coolest areas first. Typically, these are the surfaces and edges. This irregular freezing results in natural stress lines where the dendrites collide or along the boundaries of the remaining liquid (molten) metal and the solid metal. After the metal is cast in it's raw stock form, it is heat treated to normalize the material and modify its properties. Once the raw stock is further modified, additional stresses are added by the manufacturing process. When combined, all of these stresses form weak areas that are prone to fail through propagation of the stress lines into cracks. These are often characterized as fatigue failures or more simply "metal fatigue". By attacking the root cause – the residual stresses – cryogenic treatment greatly reduces or eliminates fatigue failures or cracks in metal components

VI. Process Planning & Operations:

6.1 Tool Process



6.3OPERATIONS:DRAWING:



6.4 Operation 1:

In this first operation we selected the machining material as En8 and performed the machining by reducing the material for various diameters of the desired length. The material is removed by turning operation performed in the lathe for a constant speed and feed. The depth of cut is given as 3mm for the metal removal for various diameters. In this shaft of 100mm length, the first 40mm is used for holding the shaft in the lathe.

Dia. Of Shaft (mm)	**Tool Travel length (mm)**	**Tool Wt.**		**M.R.R (g)**	**M/C time (sec)**
		Initial	Final		
38-32	35	49.26	49.25	98.2	143.23
32-26	35	49.25	49.23	87.47	130.07
26-20	30	49.23	49.21	46.48	61.91

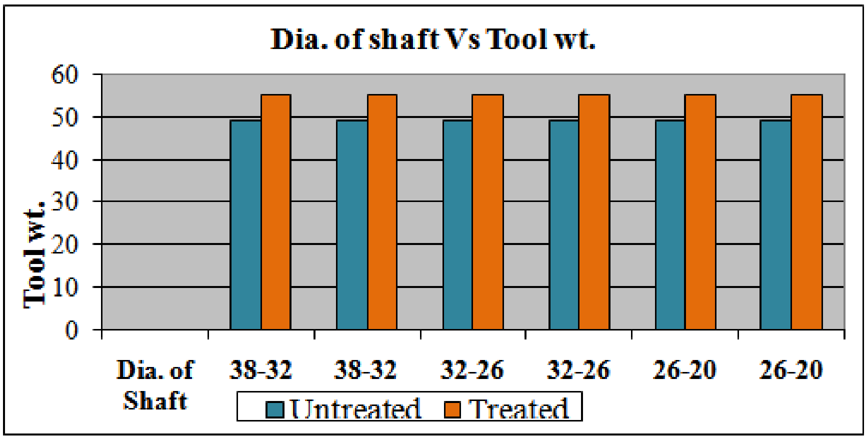
Table -6.1 EN8 Machined with Untreated HSS tool:

Dia. Of Shaft (mm)	**Tool Travel length (mm)**	**Tool Wt.**		**M.R.R (g)**	**M/C time (sec)**
		Initial	Final		
38-32	35	55.27	55.27	156.1	89
32-26	35	55.27	55.27	106.12	82.21
26-20	30	55.27	55.27	83.31	54.86

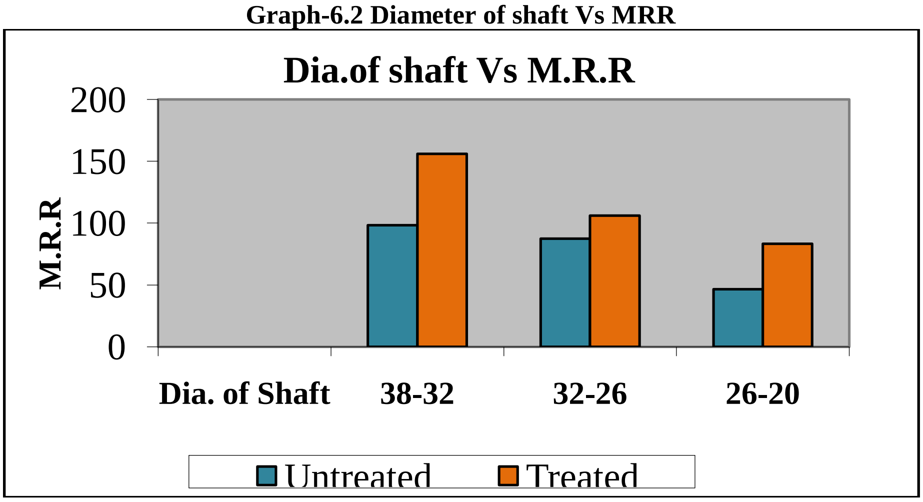
Table- 6.2 EN8 Machined with Treated HSS tool:

Graph:
1. Dia. Of shaft Vs Tool weight
2. Dia. Of shaft Vs MRR
3. Dia. Of shaft Vs Machining Time

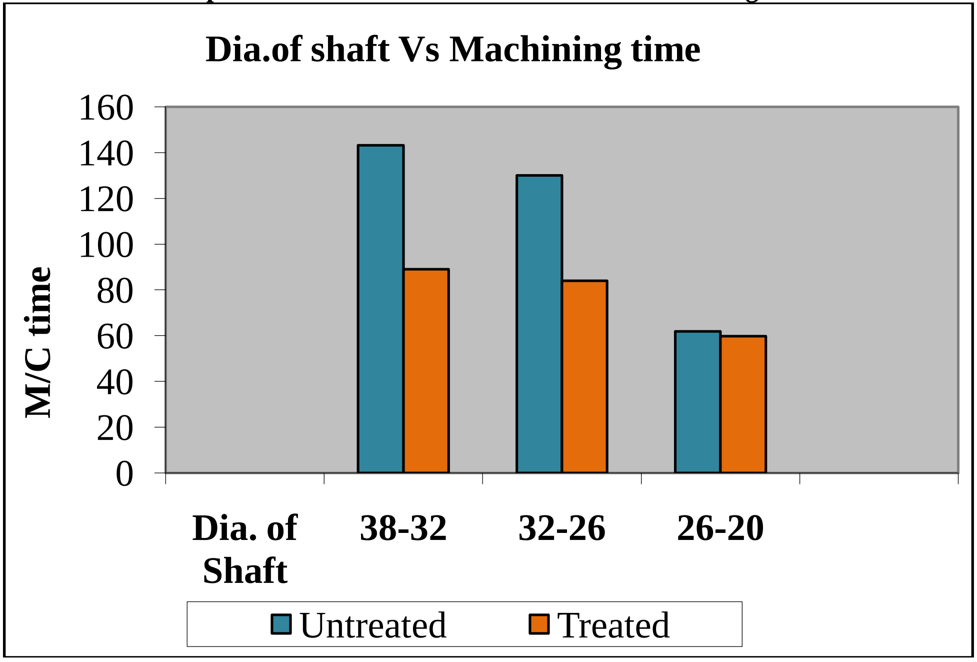
Graph-6.1: Diameter of shaft Vs Tool weight



Graph-6.2 Diameter of shaft Vs MRR



Graph-6.3 Diameter of the shaft Vs Machining time



6.5 Operation 2:

In this second operation we selected the machining material as En48 and performed the machining by reducing the material for various diameters of the desired length. The material is removed by turning operation performed in the lathe for a constant speed and feed. The depth of cut is given as 3mm for the metal removal for various diameters. In this shaft of 140mm length, the first 40mm is used for holding the shaft in the lathe.

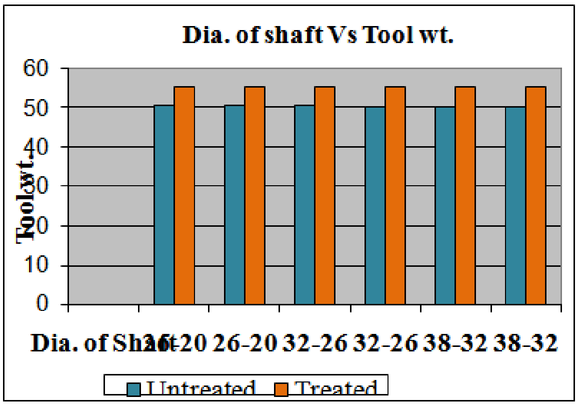
Table-6.3 EN19 Machined with Untreated HSS tool

Dia. Of Shaft (mm)	Tool Travel length (mm)	Tool Wt.		M.R.R (g)	M/C time (sec)
		Initial	Final		
26-20	30	50.40	50.38	59.50	60.46
32-26	35	50.38	50.36	65.92	139.6
38-32	35	50.36	50.35	73.48	146.77

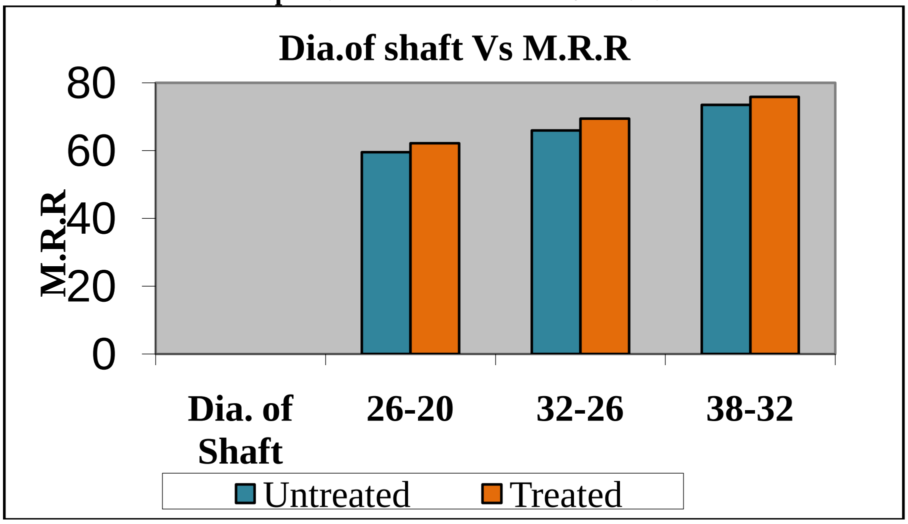
Table-6.4 EN19 Machined with Treated HSS tool

Dia. Of Shaft (mm)	Tool Travel length (mm)	Tool Wt.		M.R.R (g)	M/C time (sec)
		Initial	Final		
26-20	30	55.31	55.31	62.16	55.75
32-26	35	55.31	55.30	69.43	120.18
38-32	35	55.30	55.29	75.88	101.79

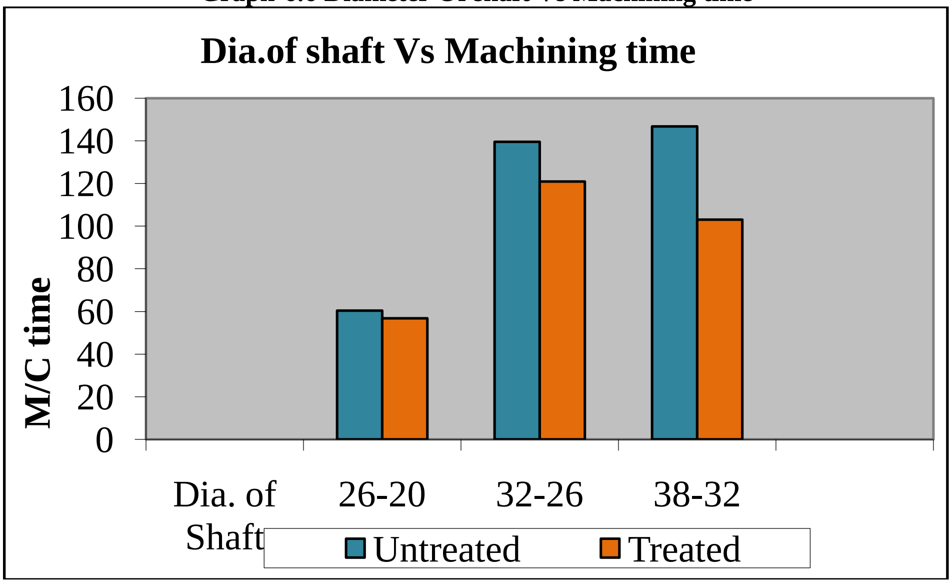
Graph-6.4 Diameter of shaft Vs Tool wt.



Graph-6.5 Diameter Of shaft Vs M.R.R

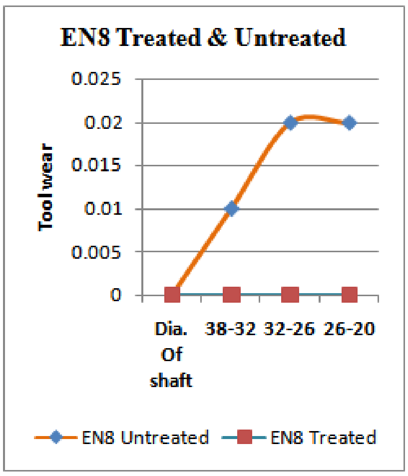


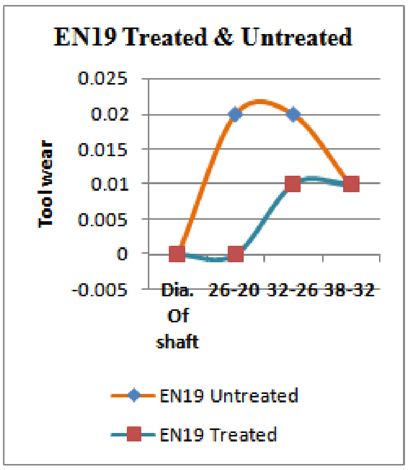
Graph-6.6 Diameter Of shaft Vs Machining time



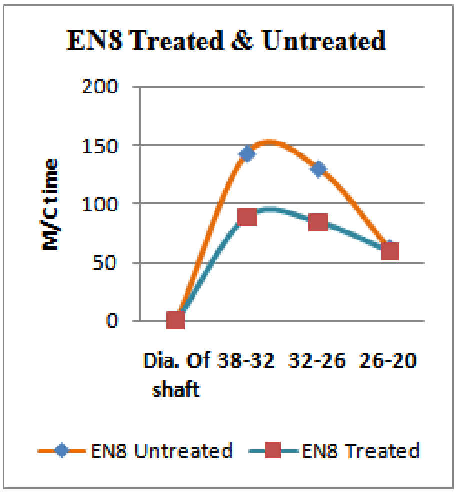
It may be concluded from these tests that treatment at -196°c improves wear resistance and reduces the machining time much more.

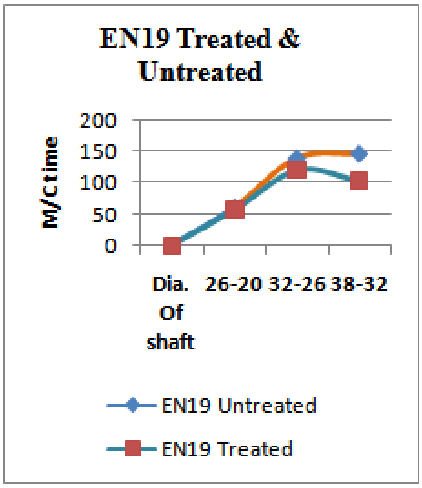
Difference in Tool wear:





Difference in Machining Time:





6.6 Cryogenic Treatment Enhances the Performance of Metals:

Cryogenic treatment, which is sometimes called cryogenic processing, utilizes ultra-cold temperatures to modify the micro-structure of metals and other materials. Cryogenic treatment has been widely adopted as a cost reduction and performance enhancing technology. Cryo treatment is also used as an enabling technology, when its stress relieving benefits are utilized to permit the fabrication (or machining) of critical tolerance parts.The Cryo treatment process uses sub-zero temperatures down to –300ºF to modify the micro-structure of the material. Cryogenic treatment promotes additional transformations in metals. It ultimately improves the performance of the metal..

Cryo treatment is an extension of the heat-treating process that further enhances metals in the following ways:

1. Relieves residual stresses
2. Promotes a more uniform micro-structure
3. Precipitates eta-carbides in steels for increased resistance to wear.
4. Cryo treated metals enjoy the following benefits:
5. Longer life due to reduced wear
6. Less failures due to cracking that result from the propagation of stress lines
7. Improved thermal properties
8. Better electrical properties with reduced electrical resistance
9. Reduced coefficient of friction on polished metals
10. Less creep & walk, and improved flatness for critical tolerance parts
11. Easier machining, polishing and grinding for better edges and finishes.

Cryogenic treatment can make a major contribution to solving these problems:

1. High abrasive wear in cutting tools, molds, dies, brake rotors, gears, engine components, etc.
2. High corrosive wear in chemical, food, and oil equipment applications.
3. High erosive wear from, water, slurries and other abrasive grit carriers.
4. Distortions induced by design, forming, machining or environment.
5. Stress relief in complex tools, components, and welds.
6. Stress relief cracking of weld zones.
7. Surface finishing in any application where long life is needed.
8. Stabilization in parts and components as a result of stresses.
9. Machinability in aluminum and copper parts.
10. Electrode life in copper resistance welding electrodes.

6.7 Advantages:

1. Increases abrasive wear resistance.
2. Requires only one permanent treatment.
3. Creates a denser molecular structure. The result is a larger contact surface area that reduces friction, heat and wear.
4. Eliminates thermal shock through a dry, computer controlled process.
5. Transforms almost all soft retained austenite to hard martensite.
6. Forms micro fine carbide fillers to enhance large carbide structures.
7. Increases durability or wear life.
8. Decreases residual stresses in tool steels.

9. Decreases brittleness.
10. Increases tensile strength, toughness and stability coupled with the release of internal stresses.

VI. Conclusion:

CONCLUSION:
It is came to know that The experimental results are 36.38 seconds decreases in machining time and there is no tool wear when machining EN8 and when machining EN 19 there is 23.02 seconds decrease in machining time and 0.02g increase in tool wear resistance.
Deep cryogenic treatment has shown to result in significant increase in the wear resistance and correspondingly reduces machining time of steels such as EN8 and EN19. The basic mechanisms at work during the cryogenic process helps to control wear by producing a tough surface, which helps to prevent particles from tearing out of the material and resist penetration of the surface by other particles.

Experimental investigation of optimizing EN8 & EN19 Steels are analysed by ANSYS by using Finite Element Analysis. The EN8 & EN19 samples are designed and modelled in CATIA. Structural analysis is done by using ANSYS Work bench. In structural analysis, the properties of the treated EN8 & EN19 Steels are enhanced than the untreated EN8 & EN19 Steels.

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