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Study the Chip Tool Interactions & Tool Life in Plain Turining with High Velocity Air Jet as the Cooling Medium

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Abstract
Introduction of green concepts in machining operations is being envisaged by introducing different echo friendly cooling systems in the modern machine shops. The role of cutting fluids usage in metal cutting is predominant as it influences the surface quality and production cost. The current work mainly focuses on the study of chip tool interactions viz. contact pressure, temperature and chip flow pattern on the rake surface in plain turning operation for different cutting parameters without any cooling medium and analyze the influence of high pressure air jet as the cooling medium on the chip tool interactions like contact pressure reducing the tool wear, cutting temperatures thereby increasing tool life.
Keywords— Modelling, Machining, Compressor, Air Jets, Nozzle

I. Introduction

The use of high speed air jet as a coolant in machining is a challenging scenario in environmental friendly machining. Despite the extensive literature, air jet cooling in machining is an area of ongoing research. Until now, the jet cooling technique has been studied only from a thermal point of view. The new aspect investigated in this work is the chip bending ability of the jet. The idea of chip-bending and its beneficial effects in cooling the cutting area is not related to maximizing the heat transfer, but to avoid the temperature increase. The heat generation in the chip-tool interface is due to the contribution of deformation in the shear zone and to the frictional contact between the chip and the rake face of the cutting tool. The importance of the frictional contact is proportional to the friction coefficient and to the pressure of the chip on the rake face. The traditional way of reducing this contribution is using a cutting fluid (flooding) or, more recently, injecting a coolant in the chip-tool interface. The new approach with high speed air jet shows the temperature reduction is strongly dependant on the position of the nozzle. By directing the jet onto the top face of the chip it is possible to reduce the pressure on the rake face, responsible of temperature increase in the chip-tool interface. The pressure on the top face of the chip generates a stress on the bottom face of the chip close to the constraint and in the chip-tool interface. The global stress is due to air jet pressure and cutting pressure on the rake face. When the air jet is directed on the top face of the chip (overhead position) the global stress is less than the cutting stress in dry machining.

A fully thermo-mechanical model has been developed with DEFORM-3D and a mechanical only model with DEFORM-2D, in order to investigate the chip bending. From an analytical point of view the chip can be modelled as a structural cantilevered beam with uniform load. The results from finite element modelling show the displacement of the chip is mainly due to the chip-breaker. The displacement due to the air jet bending moment is minimized by the stiffness close to the constraint point, but the mechanical effect of the air jet has a significant impact on the energy in the tool.

II. DRY CUTTING MODE

1.1Objective

Analysis of effect of the cutting parameters like cutting speed, feed rate and depth of cut on cutting force components which influence the contact pressure, temperature and chip flow pattern on the rake surface during turning operation

1.2Equipment

Lathe machine, Lathe Tool Dynamometer, Amplifier, Cutting tool, PC, Job piece.

III. Experimental Setup

Figure 1 shows the schematic of the experimental setup for carrying out the experiment. Work piece is mounted in the chuck of the lathe headstock. The tool dynamometer is mounted on the carriage at the place of tool holder. The tool holder is mounted on the dynamometer as shown in figure 2. Output of the dynamometer is amplified by charge amplifier (Kistler 5070A) and data are collected in the PC by using data acquisition system

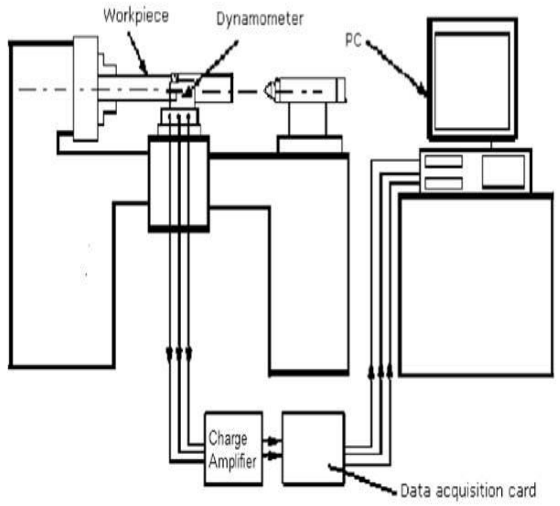


Figure 1 Schematic diagram of the experimental setup

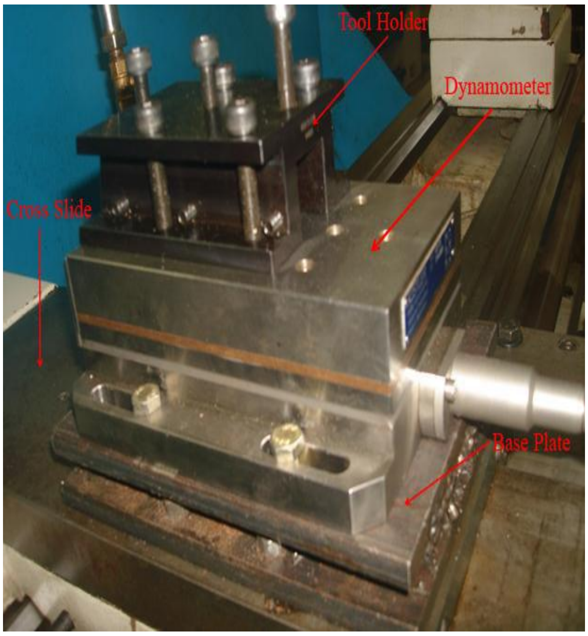


Figure 2 Schematic diagram of the experimental setup

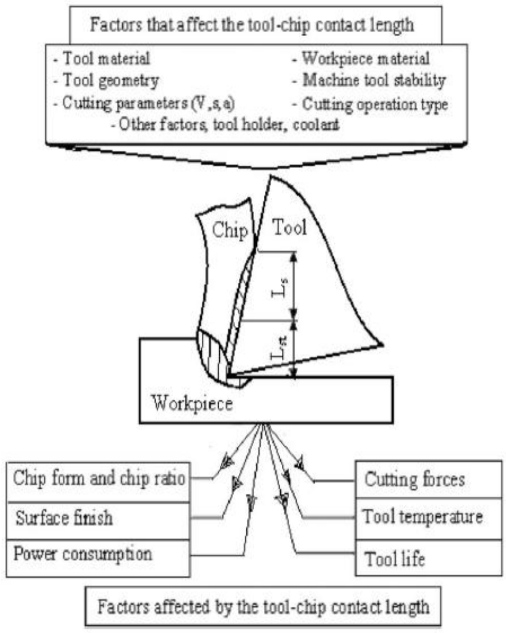
IV. OBSERVATION TABLE

Initial diameter of the bar = 25mm
Bar material = MS
Cutting tool material = HSS

File Name	Speed (rpm)	Feed (mm/rev.)	Depth of Cut (mm)	Cutting Force (N)
ins1	550	0.1	0.1	23.88
ins2	440	0.1	0.1	17.73835
ins3	330	0.1	0.1	13.9618
ins4	220	0.1	0.1	22.2015
ins5	118	0.1	0.1	14.57215
ins6	118	0.2	0.1	20.82825
ins7	220	0.2	0.1	21.293
ins8	330	0.2	0.1	19.0354
ins9	440	0.2	0.1	30.9735
ins10	550	0.2	0.1	16.86095
ins11	550	0.3	0.1	67.5965
ins12	440	0.3	0.1	44.5175
ins13	330	0.3	0.1	36.3159
ins14	220	0.3	0.1	23.68925
ins15	118	0.3	0.1	62.866
ins16	118	0.4	0.1	46.0434
ins17	220	0.4	0.1	44.632
ins18	330	0.4	0.1	24.719
ins19	440	0.4	0.1	28.8391

V. MATERIAL PROPERTIES

Material: High Speed Steel
Young's modulus : 190-210Gpa
Poisson's ratio:0.27
Density : 7800 kg/m3
Work piece: Mild steel



VI. ESTIMATION OF CONTACT LENGTH

A number of theoretical and experimental estimators have been proposed for the contact length in the orthogonal cutting process Based on the experiments conducted on different types of steel using a tool with an unrestricted rake face, a relationship between the chip–tool contact length, chip thickness, the chip compression ratio and the friction coefficient has been developed. It suggests that the length of the sticking region is approximately equal to the deformed chip thickness hc, and in accordance with Tay's assumption the

Total chip–tool contact length Lc is given as
Lc = 2hc
Thickness of the chip=1.5mm
Width of the chip=4mm
Contact Length=2*1.5=3mm
Area of the chip contacting the tool=3*4=12mm2
Pressure acting on the contact area=F/A
P1=23.88/12=1.99 N/MM2
Similarly for the remaining forces
P2=1.419 N/MM2
P3=1.163 N/MM2
P4=1.85012 N/MM2
P5=1.214 N/MM2

VII. ANALYSIS OF CUTTING TOOL WITH OUT COOLENT

7.1 For the Speed (N) =550 rpm, Feed=0.1mm/rev, Depth
of cut=0.1mm

a. *Meshing*

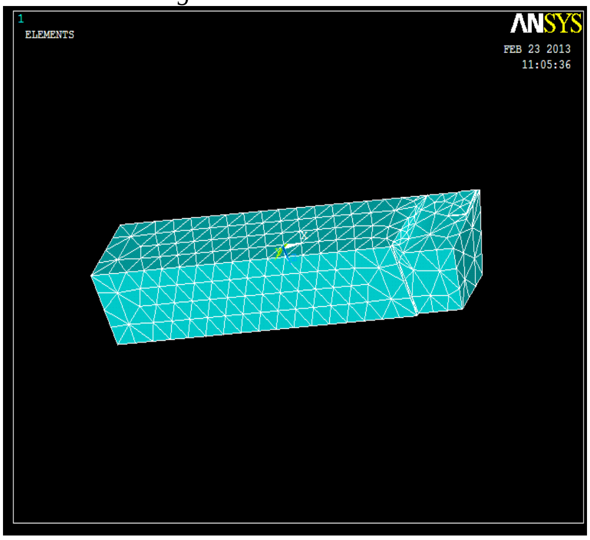


Fig 3

b. *Area Selection For Applying The Load*

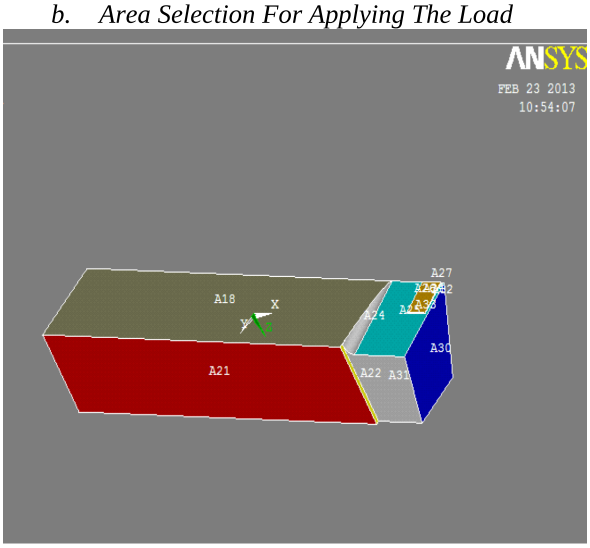


Fig 4

C .VonMises Stress

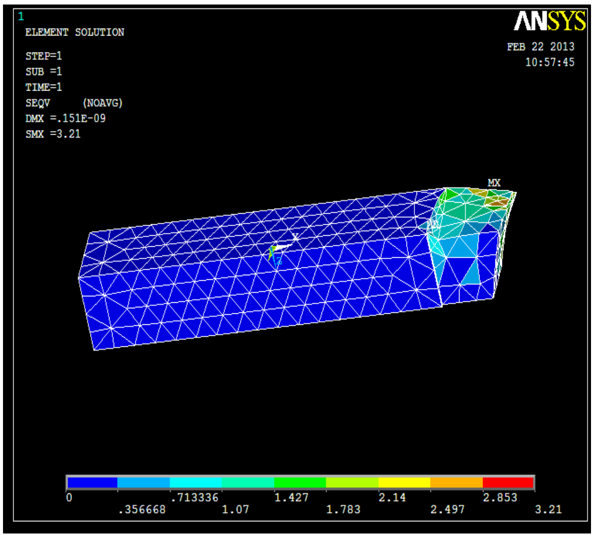


Fig-5

Maximum deflection is 0.151e-09
Maximum Stress is 3.21 N/MM2

7.2 For the Speed (N) =440 rpm, Feed=0.1mm/rev, Depth
of cut=0.1mm ,pressure=1.419N/MM^2

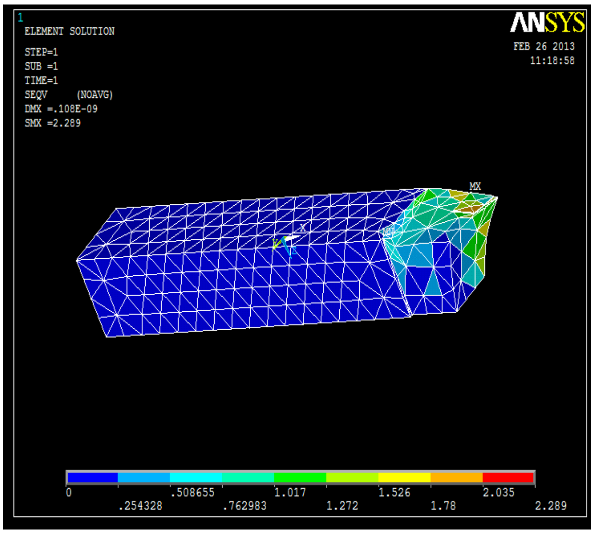


Fig-6

7.3 For the Speed (N) =440 rpm, Feed=0.1mm/rev, Depth
of cut=0.1mm,

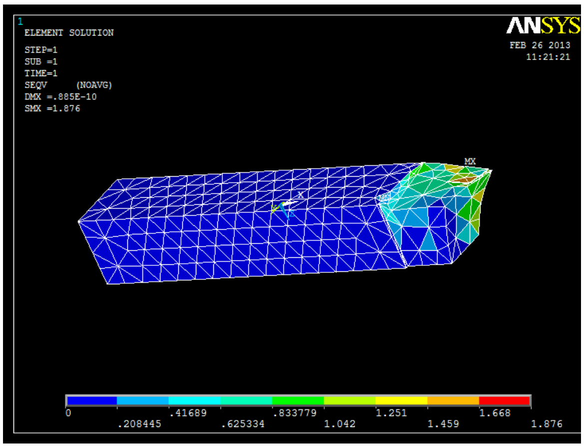


FIG -7 maximum stress is

VIII. PRESSURE VS. STRESS GRAPH

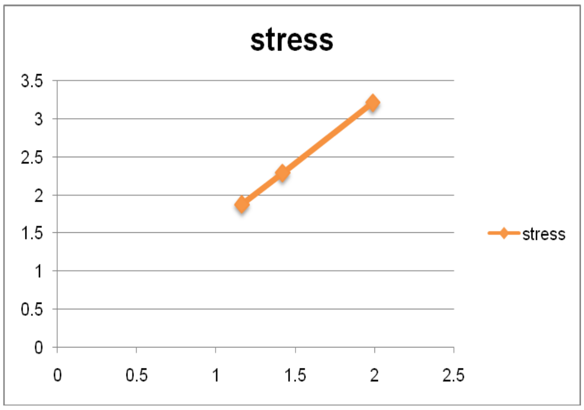


FIG-8

IX. TOOL LIFE

Taylor Tool Life Equation

$VT^n=C$

Where v = cutting speed, m/min;
T = tool life, min; and
n and C are parameters that depend on feed, depth of cut ,work material, and tooling material but mostly on material (work and tool).

Typical Values of n and C

Tool material	N	C
High Speed Steel Non Steel Work Steel Work	0.125 0.125	120 70
Cemented carbide Non Steel Work Steel Work	0.25 0.25	900 500
Ceramic Steel Work	0.6	3000

X. TOOL LIFE CALCULATIONS

Cutting velocity=πDN/1000 (m/min)
D=Spindle diameter (mm)

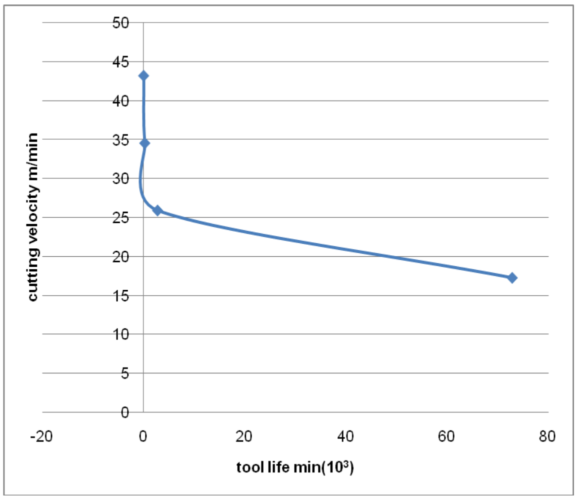
A. Sample calculation

V1=πx25x550/1000
= 43.19 m/min
Similarly
V2= 34.55 m/min
V3=25.19
V4=17.29

B. Tool Life

$VT^n=C$
T1=(70/43.19)(1/0.125)
49.32 min
Similarly
T2=283.92 min
T3= 2838.2 min
T4=72.85x103 min

GRAPH BETWEEN CUTTING SPEEDS VS TOOL LIFE



XI. EXPERIMENTAL SETUP

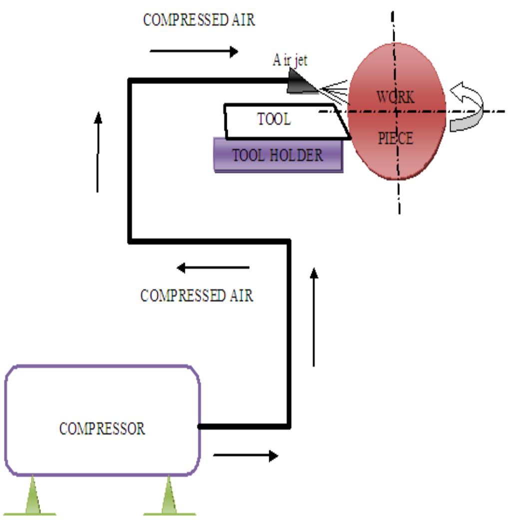


FIG-9

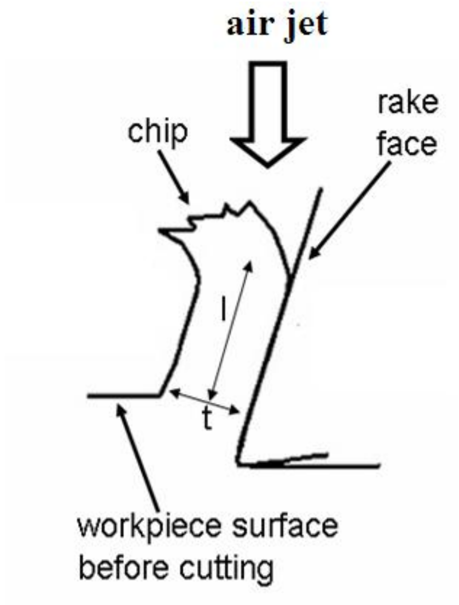


FIG-10

In the Fig 9 shown above, compressed air from the compresses passes through the hose pipe and comes out through nozzle with high velocity.

This high velocity air jet is made impinge between the tool and chip interface so that the contact area is reduce between tool and chip and thereby reducing the frictional force on the tool.

The air jet is made to impinge on the tool and chip interface with different pressures. The main motive of this is to reduce the carter wear.

By eliminating the carter wear tool life can be increased

XII. OBSERVATION TABLE

File Name	Speed (rpm)	Feed (mm/rev.)	Depth of Cut (mm)	Cutting Force (N)
ins1	550	0.1	0.1	18.32
ins2	440	0.1	0.1	14.732
ins3	330	0.1	0.1	10.9618
ins4	220	0.1	0.1	18.2015
ins5	118	0.1	0.1	12.572
ins6	118	0.2	0.1	17.82
ins7	220	0.2	0.1	19.293
ins8	330	0.2	0.1	16.0354
ins9	440	0.2	0.1	28.9735
ins10	550	0.2	0.1	14.86095

Pressure acting on the contact area=F/A
P1=18.32/12=1.52 N/MM2
Similarly for the remaining forces
P2=1.227 N/MM2
P3=0.913 N/MM2
P4=1.516 N/MM2
P5=1.014 N/MM2

For the Speed (N) =550 rpm, Feed=0.1mm/rev, Depth
of cut=0.1mm

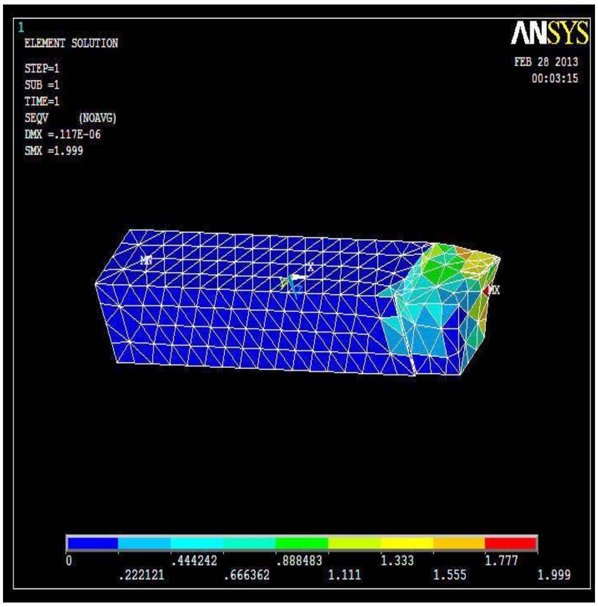


Fig-11

Maximum stress- 1.99N/MM^2

For the Speed (N) =440 rpm, Feed=0.1mm/rev, Depth of cut=0.1mm, pressure=1.227 N/MM2

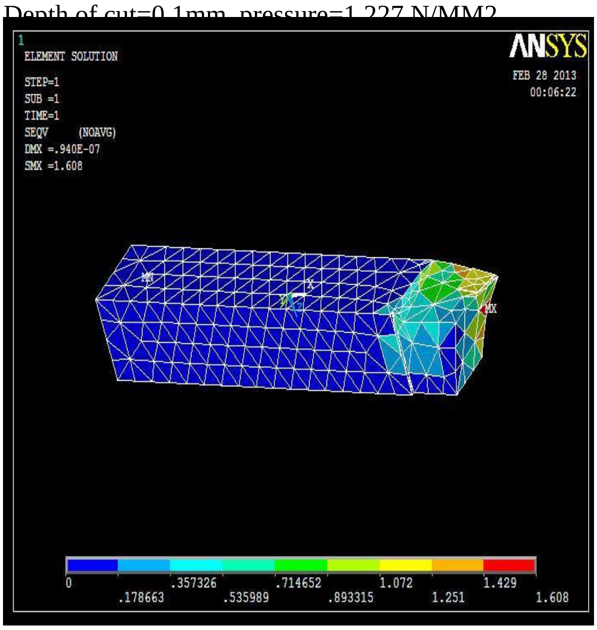
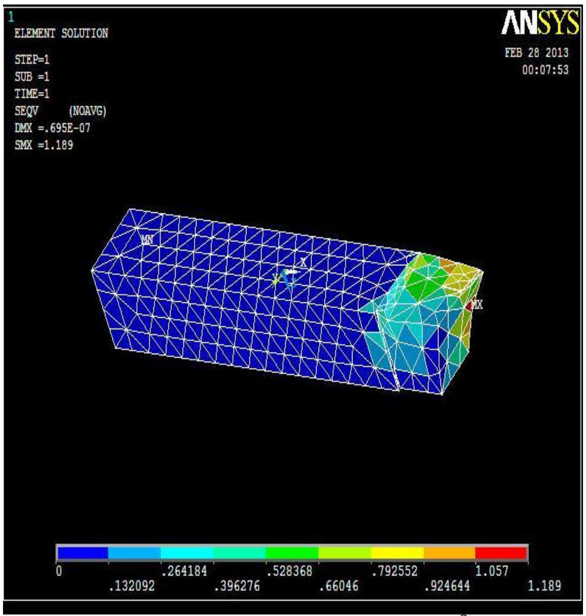


Fig-12 Maximum stress-1.608

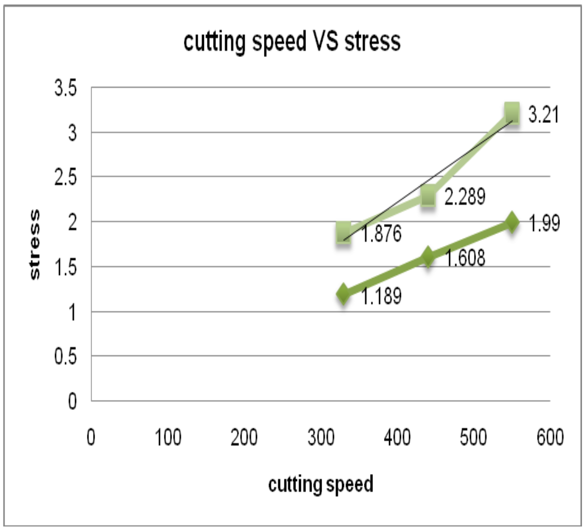
3 For the Speed (N) =440 rpm, Feed=0.1mm/rev, Depth of cut=0.1mm, pressure =0.913 N/MM2



Maximum stress is 1.189 N/MM^2

XIII. RESULTS

COMPARISON OF GRAPHS



By the above graph stress is reduced compared to the dry cutting approximately up t o 38%of stress.

XIV. CONCLUSION AND FURTHER RESEARCH

Mechanical effect of air jet is a new aspect in the world of environmental friendly cooling techniques in metal cutting. Intuition may suggest a positive effect with using the jet in interface position. This displacement of the nozzle is traditionally used for MQL APPLICATIONS.Analysis shows that there is reduction in the cutting force by the introduction of air jet between the tool and chip interface .In further there is a possibility to increase the stress reduction percentage

XV. ACKNOWLEDGMENT

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