INDIAN INSTITUTE OF TECHNOLOGY

DATE 17·3·09 | SHEET NO.

MEASUREMENT OF CUTTING TEMPERATURE

AIM:- i) To determine average chip tool interface temperature using tool-work thermo couple technique

ii) To study the effect of cutting velocity and feed on cutting temperature

APPARATUS:- (i) Machine Tool NH-22

(ii) Work Material AISI 1080

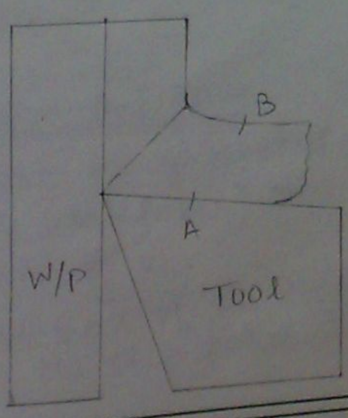
(iii) Multimeter Rish 155

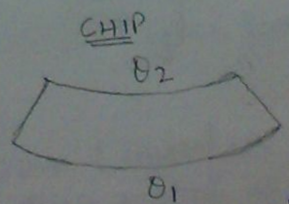
THEORY:-

The determination of the chip tool interface temperature is necessary because of the following reasons:-

1) To identify the limitation of a tool material in machining a workpiece of a particular material at given machining parameters.

2) To study the effect on the surface integrity of the tool. Surface integrity includes hardness, roughness, microstructure properties and also the state of residual stress.





$\theta_1 > \theta_2$

The above figure shows a cross-sectional view of a chip. The surface of the chip in contact with the tool is hotter than the surface in contact with the air or coolant. Thus $\theta_1 > \theta_2$

Due to this temperature difference between the top and the bottom surface, strain will occur in the chip. This is called thermal strain. More bending of the chip will occur if the temperature difference is very high. More bending of the chip leads to the formation of discontinuous chips. On using coolant, the temperature difference is higher and hence more is the strain in the chip.

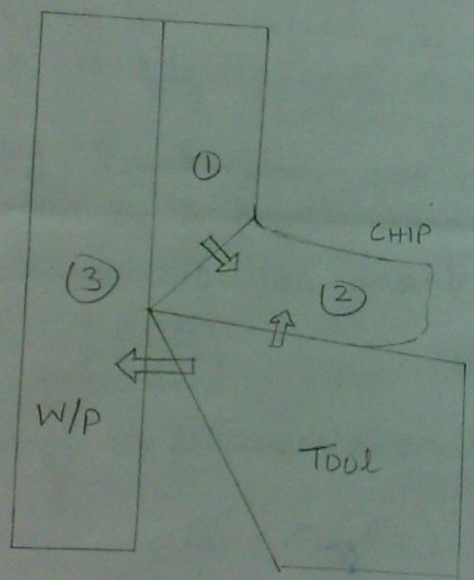


Fig: Zones of heat generation

There are 3 main zones of heat generation

① Primary Shear Zone

Heat generation due to the work done for plastic deformation and chip removal.

② Secondary Shear Zone

Heat is generated due to the friction at the chip tool interface. Greater the value of normal force at the chip tool interface, higher is the friction force & hence higher the temperature

③ Worn Out Zone

Heat is generated at this zone (interface of the tool tip and the workpiece) due to the sliding motion of the tool at cutting velocity V_c.

70%-80% of the total heat generated is taken by the chip as the chip takes heat from 2 out of 3 heat generation zones

EFFECT OF PROCESS PARAMETERS ON CHIP TOOL INTERFACE TEMP.

$V_c \rightarrow$ cutting speed
$a_1 \rightarrow$ true feed
$K \rightarrow$ thermal conductivity
$E_c \rightarrow$ specific energy
$\theta_i \rightarrow$ chip tool interface temp.
$\rho c \rightarrow$ specific heat capacity

Dimensions of all the above mentioned quantities:-

$V_c \rightarrow L/T$ $\quad E_c \rightarrow \frac{M}{LT^2}$
$a_1 \rightarrow L$ $\quad \theta_i \rightarrow \theta$
$K \rightarrow \frac{ML}{T^3\theta}$ $\quad \rho c \rightarrow \frac{M}{LT^2\theta}$

Using Buckingham pie theorem to derive a relation between θ_i & process parameters

2 dimensionless quantities:-

$$Q_1 = \left(\frac{\rho c \theta}{E_c}\right) \qquad Q_2 = \left(\frac{\rho c V_c a_1}{K}\right)$$

Through experimentation relation between Q_1 & Q_2 is

$$Q_1 = c_1 (Q_2)^{2n} \quad \text{where } n = 0.25$$

$$\left(\frac{\rho c \theta_i}{E_c}\right) = c_1 \left(\frac{\rho c V_c a_1}{K}\right)^{0.5}$$

$$\boxed{\theta_i = c_1 E_c \sqrt{\frac{V_c a_1}{\rho c K}}}$$

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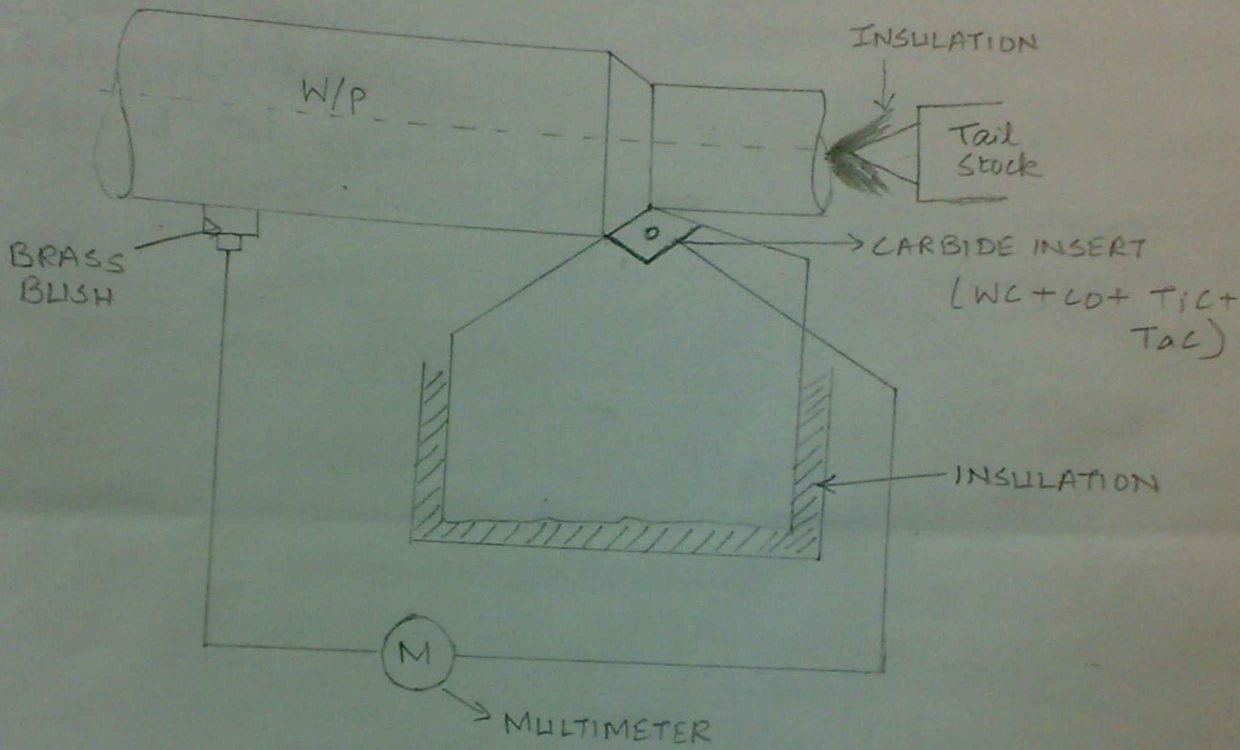
MEASUREMENT PRINCIPLES:- TOOL-WORK THERMOCOUPLE TECHNIQUE



The main principle behind measuring the tool interface temperature is called Seeback Effect. In this effect a voltage (thermoelectric EMF) is created in the presence of a temperature difference between two different metals or semiconductors. This causes a continuous current in the conductors if they form a complete loop. Here the tool (carbide insert) and the W/P forms 2 different metal junctions. On connecting the W/P and the tool via a multimeter, the tool-~~W~~W/P interface temperature gives rise to voltage which is shown in the multimeter. The multimeter is calibrated so that ~~the~~ from the voltage readings we can directly infer the chip tool interface temperature

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OTHER TEMPERATURE MEASUREMEN TECHNIQUES

1) Calorimetric method
2) De coloring agent
3) Photographic technique
4) Infrared technique

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Observations : Experimental conditions –

Machine tool : NH-22

Work material specification : AISI 1080

Work material composition : C – 0.8 %

Cutting tool specification : SPUN 12 03 08

Cutting tool geometry : 0 6 6 6 15 75 0.8 (mm) in ISO

Cutting tool material : Composite carbide (Grade P30)

Multimeter Rish 15S

Table :

Serial	Spindle Speed (rpm)	Cutting velocity	Feed (mm/rev)	emf (mV)	Temperature (°C)	Remark
1	249		0.08	8.14	569.8	
2	249	80	0.12	9.23	646.1	Cutting velocity remains unchanged.
3	249		0.16	9.44	660.8	
4	249		0.20	9.55	668.5	
5	187	60		8.40	588	
6	249	80	0.12	9.09	636.3	Feed remains unchanged
7	312	100		9.52	666.4	
8	374	120		9.95	696.5	

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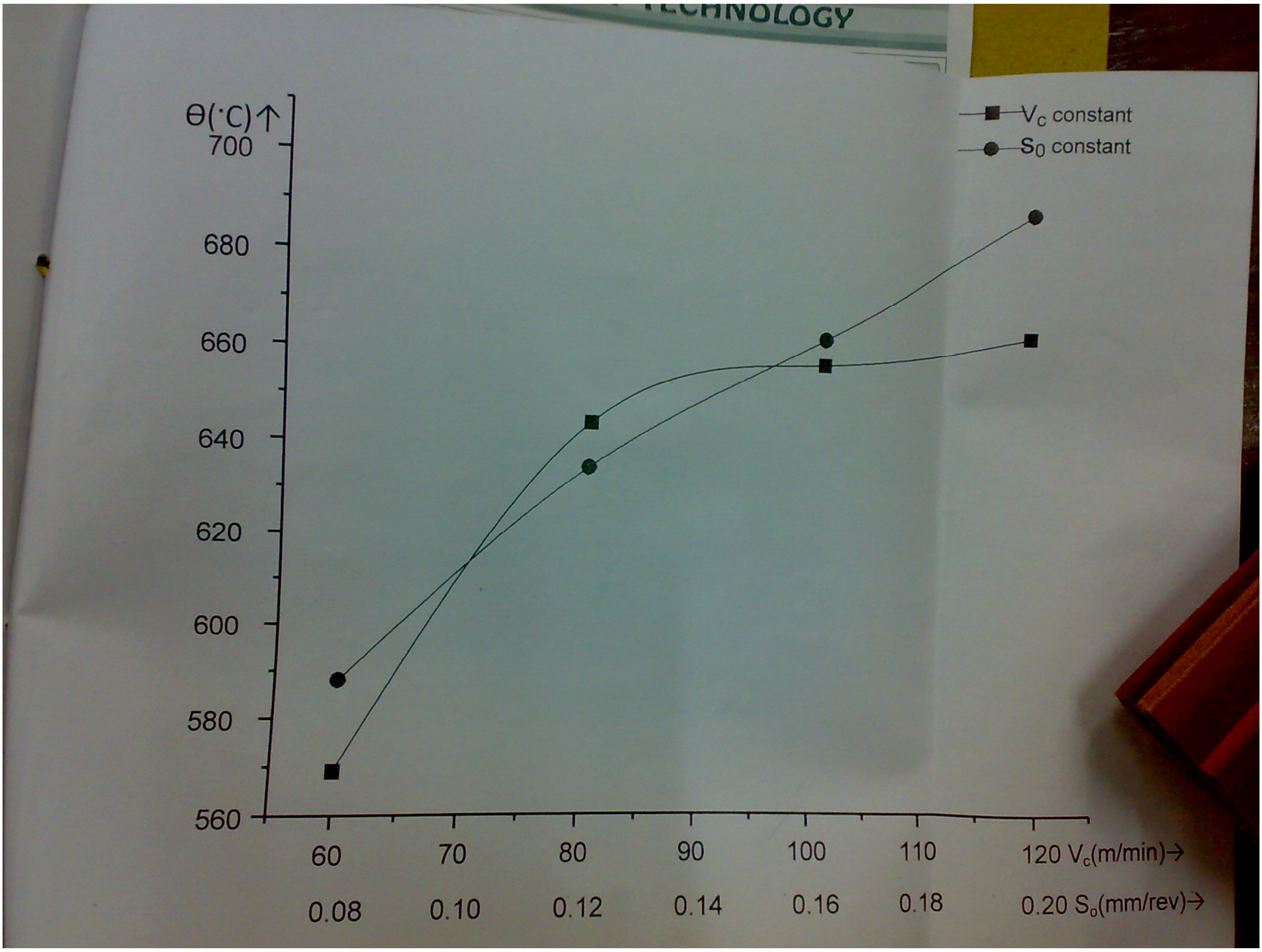

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θ(·C)↑
700
680
660
640
620
600
580
560
60
70
80
90
100
110
120 V_c(m/min)→
0.08
0.10
0.12
0.14
0.16
0.18
0.20 S_o(mm/rev)→
V_c constant
S_0 constant

Discussions : From the graph it can clearly be seen that temperature increases with V_c (cutting velocity) more rapidly than that with feed. The reason for this being, the heat flux in cutting zone Q_c can be written as a function of force P_z, cutting velocity V_c, width ~~b~~ b ~~and~~ and contact length l_c as,

$$Q_c = \frac{P_z V_c}{A_c} = \frac{P_z V_c}{b l_c}$$

Now increasing V_c decreases l_c thus while the numerator increases, the denominator decreases thus resulting Q_c increases rapidly. However when feed increases keeping V_c constant, P_z increases but l_c also increases in the denominator thus resulting Q_c does not increase as much. Thus the graph shows such a nature.