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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

STUDYING THE EFFECT OF TEMPERATURE ON THE
CUTTING MECHANISM FOR LOCAL QUALITY
STEELS

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Thesis submitted for the degree of
Master of Science
in
Metal Cutting

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By

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S u m m a r y .

The present investigation aims to study the effect of temperature on the cutting mechanism for some steels used in local industries. This work includes :

- A study of the cutting forces variation under different cutting conditions at elevated temperature ,
- A study of the tool life behaviour under certain conditions at elevated temperature.

A critical review is given for the literature related to the machining operations with special references to hot machining. The basis for dynamometer design and heating methods is reviewed.

A three component strain gauge dynamometer and its calibration apparatus were designed and constructed to measure the three components of the cutting force in turning operations. An oxy-acetylene heater was also constructed to heat the workpiece material for hot machining.

The experimental work was carried out for different qualities of steels namely mild steel, medium carbon steel, high carbon steel and high speed steel, the tool used was a carbide tool tip.

The tool life experiments were carried out on a projector measuring the flank wear of the carbide tip every one minute.

The results obtained indicated that :

- 1) The cutting forces were found to change with the cutting conditions, the workpiece material properties and temperature as follows :

$$F_t = 350 T^{-0.6} f^{0.8} d^{0.84} H^{0.58} V^{-0.028 + 0.243 \left(\frac{T}{360} - 1\right)}$$

$$F_r = 720 T^{-1.05} f^{0.64} d^{0.76} H^{0.79} V^{-0.014 + 0.301 \left(\frac{T}{360} - 1\right)}$$

$$F_a = 1860 T^{-1.03} f^{0.79} d^{0.77} H^{0.8} V^{-0.014 + 0.372 \left(\frac{T}{360} - 1\right)}$$

It is most beneficial to apply these relations with the range of 170 - 540°C.

- 2) The cutting speed exponent in the cutting force versus cutting speed relation was found to depend on temperature and to follow the relations :

$$\text{Exponent of } V \text{ for } F_t = -0.028 + 0.243 \left(\frac{T}{360} - 1\right)$$

$$\text{Exponent of } V \text{ for } F_r = -0.014 + 0.301 \left(\frac{T}{360} - 1\right)$$

$$\text{Exponent of } V \text{ for } F_a = -0.014 + 0.273 \left(\frac{T}{360} - 1\right)$$

3) Increasing the workpiece temperature caused a reduction of about 37 - 62 % in the cutting force components.

4) The tool life - cutting speed relation in hot machining of the workpiece materials used were found to be in the exponential form :

$$v_T^{0.92 + 0.0018 t - 25 \times 10^{-7} t^2} = 268 + 4.7t - 0.0062 t^2$$

for high carbon steel (H.C.S.)

$$v_T^{1.335 + 0.0018t - 25 \times 10^{-7}} = 300 + 4.7t - 0.0062 t^2$$

for high speed steel (H.S.S.)

5) The tool life was found to be optimum in the range 170 to 470°C for H.S.S. and 170-420 for H.C.S.

6) The workpiece material properties under the layer removed was found to be unaffected by hot machining in the selected range of temperature with regard to surface micro hardness, grain growth and micro structure.

7) The best heating range was found to be 170 - 470°C. from the point of view of maximum tool life and minimum cutting forces for the materials tested (high carbon steel and high speed steel).

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