



Cutting Force Measurements - LAB 4

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Objective Measure the cutting tool forces in turning operation. Compare the data to analytical estimations. Interpret the data in the machining process.

I. Turning

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. During the material removal, forces occur at the interaction of the cutting tool and the workpiece. With orthogonal assumption, cutting force and thrust force can be calculated. Below equations are for the turning operation:

$$\text{Cutting speed, } v_c = \frac{\pi \cdot D \cdot n}{1000} \quad (m / min)$$

$$\text{Spindle speed, } n = \frac{1000 \cdot v_c}{\pi \cdot D} \quad (rev / min)$$

$$\text{Material removal rate, } Q = v_c \cdot a_p \cdot f \quad (cm^3 / min)$$

Legend

v_c = Cutting speed (m/min)

n = Spindle speed (rev/min)

f = Feed per rev (mm/rev)

a_p = Axial depth of cut (mm)

D = Workpiece diameter (mm)

Q = Material removal rate (cm^3/min)

Total Specific Energy

$$u_t = \frac{F_c \cdot V}{w \cdot t_o \cdot V}$$

Cutting ratio

$$r = \frac{t_o}{t_c}$$

II. Equipment

Experiments will be conducted at Technology Faculty C building, lab C 002. CNC turning machine (Figure 1) will be used for the force measurements. Machine has a piezoelectric dynamometer that measures three force components; cutting force, feed force, and passive (radial) force as can be seen in Figure 2.

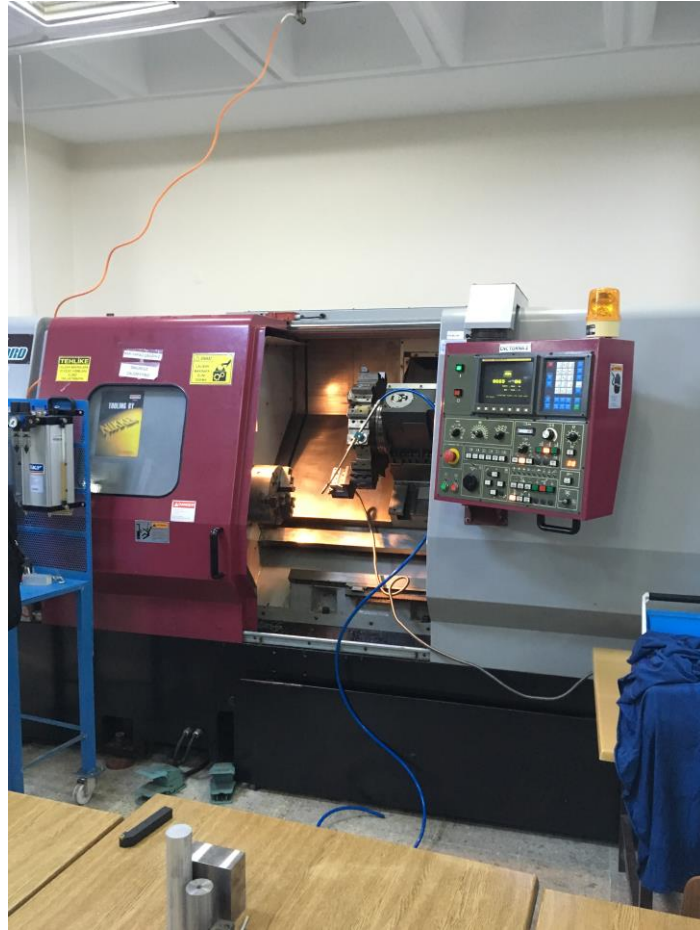


Figure 1. Turning machine

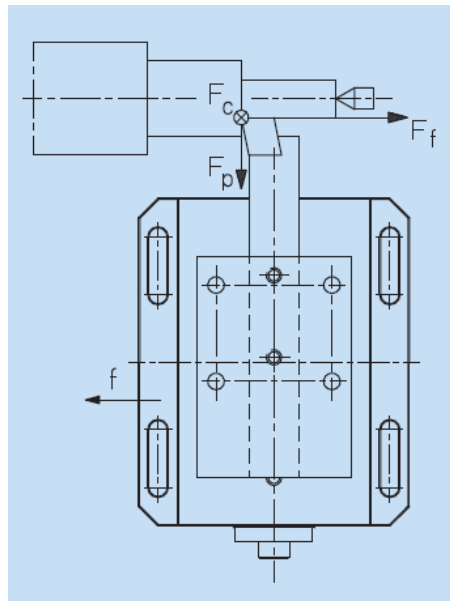


Figure 2. Forces during longitudinal cutting.

Figure 3 shows the cutting tool geometric details. It is **Zigong Cemented Carbide Cutting Tool Insert**

CNMG-ZM : Negative relief ang., M class, 80deg rhombic insert, for finishing to medium cutting. Recommended operation values are $V \leq 200 \text{ m/min}$ and $Feed = 0.2 - 0.4 \text{ mm/rev}$.



Designation	Stock	l	d	s	re	d1	ap (min)	ap (max)	ft (min)	ft (max)
CNMG120408-ZM	Available	12.90	12.700	4.76	0.80	5.16	0.70	2.00	0.20	0.40

Figure 3. Cutting tool geometric details.

Workpiece will be Ç1060 (carbon steel) shaft with a diameter of 40 mm.

III. Procedure

Test will start with a single cut 25 mm long experiment. During the cut, force data will be captured. Following cases will be experimented as shown in Table 1. 4 different cases will give 4 different sets of force data.

Table 1. Process parameter of the turning force measurement experiment

Case	N (rpm)	D (mm)	Length (mm)	depth of cut (mm)	f (mm/rev)	V (m/min)	MRR (cm ³ /min)
1.0	1000.0	40.0	25.0	1.0	0.4	125.7	50.3
2.0	1500.0	38.0	20.0	1.0	0.3	179.1	50.1
3.0	1600.0	36.0	15.0	1.0	0.2	181.0	36.2
4.0	2500.0	34.0	10.0	1.0	0.2	267.0	53.4

IV. Assignments

- For the given workpiece and the cutting tool, pick an average specific cutting energy. Then estimate cutting force for each case. Compare your estimate to the experimental data. What are your comments?
- From the experimental data find out the percentage of the friction energy loss for each case.



Hint. You need to measure the chip thickness for each case. You need to know the rake angle during the operation.

- Comment on different case parameter effects on forces and energy losses.

V. Acknowledgment

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