ME 361 LAB REPORT

Experiment number : 01

Sub-Group number : C3

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Date & Day experiment was conducted on : 05/09/2017 (Tuesday)

Date of submission of report : 12/09/2017 (Tuesday)

Objective(s):

To measure cutting forces; identify cutting force coefficients; estimate cutting force coefficient from estimated chip thickness ratio; and study influence of cutting speed on cutting forces.

Answers to questions asked in the report:

Calculation Parameters:

Work piece Material: Aluminium (Shear Strength: 3.03e8 N/m_2)
Outside diameter (D): 75 mm
Depth of Cut: 1mm

Tool: SCLCR2020K12 (SECO make, oblique angle = 5_o, rake angle = 13_o)
Insert: CCGT120408F-AL, KX (SECO make, Side cutting edge angle ($\psi = 5_o$)

Table 1: Cutting Parameters:

Run	Feed rate (mm/rev)	Cutting Speed (V, m/min)	Spindle speed (RPM = $V\pi D$) D=73mm	Avg. Fx (N)	Avg. Fy (N)	Avg. Fz (N)
1	0.075	200	872	33.3904	41.9947	69.4399
2	0.125	200	872	37.8490	47.72253	100.6991

3	0.175	200	872	46.8402	75.1482	127.1293

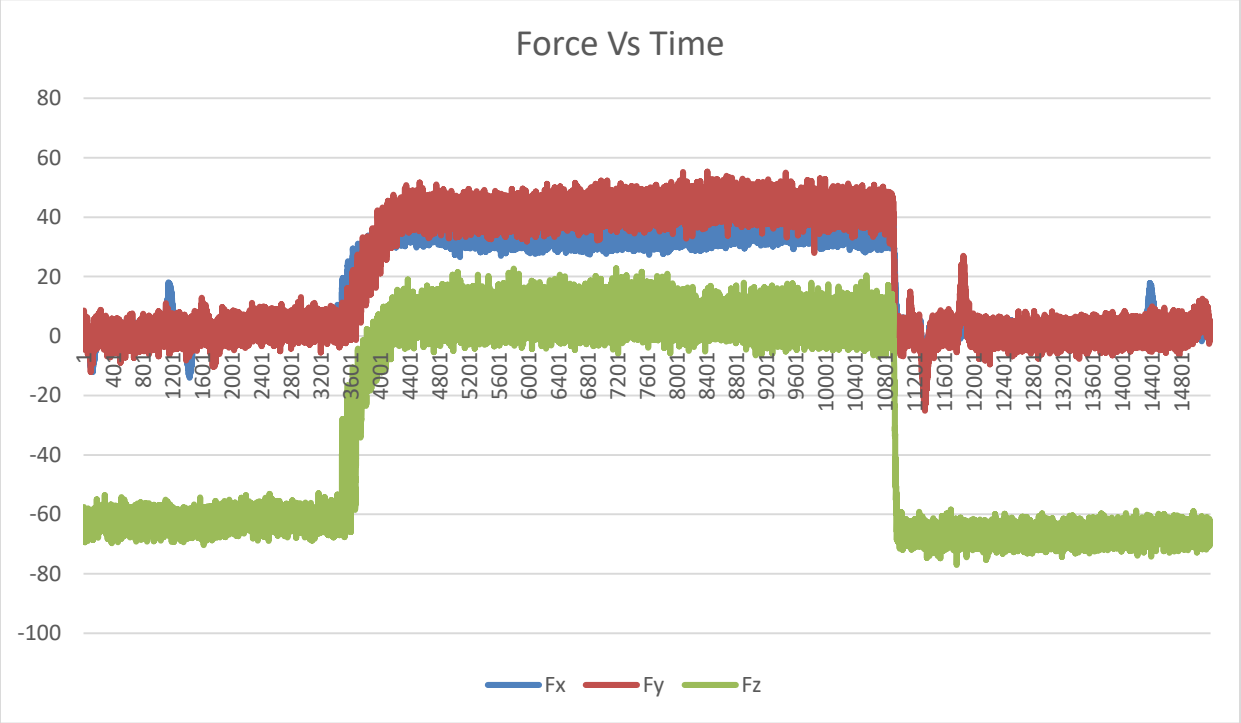
Table 2: Cutting Parameters

Run	Feed rate (mm/rev)	Cutting Speed (V, m/min)	Spindle speed (RPM = $V\pi D$) D=71mm	Avg. Fx	Avg. Fy	Avg. Fz
1	0.125	100	448	65.0736	85.8925	127.6189
2	0.125	150	672	48.8540	72.0396	113.3370
3	0.125	200	897	39.8075	55.5516	97.2639
4	0.125	250	1121	32.3943	48.1278	91.2927

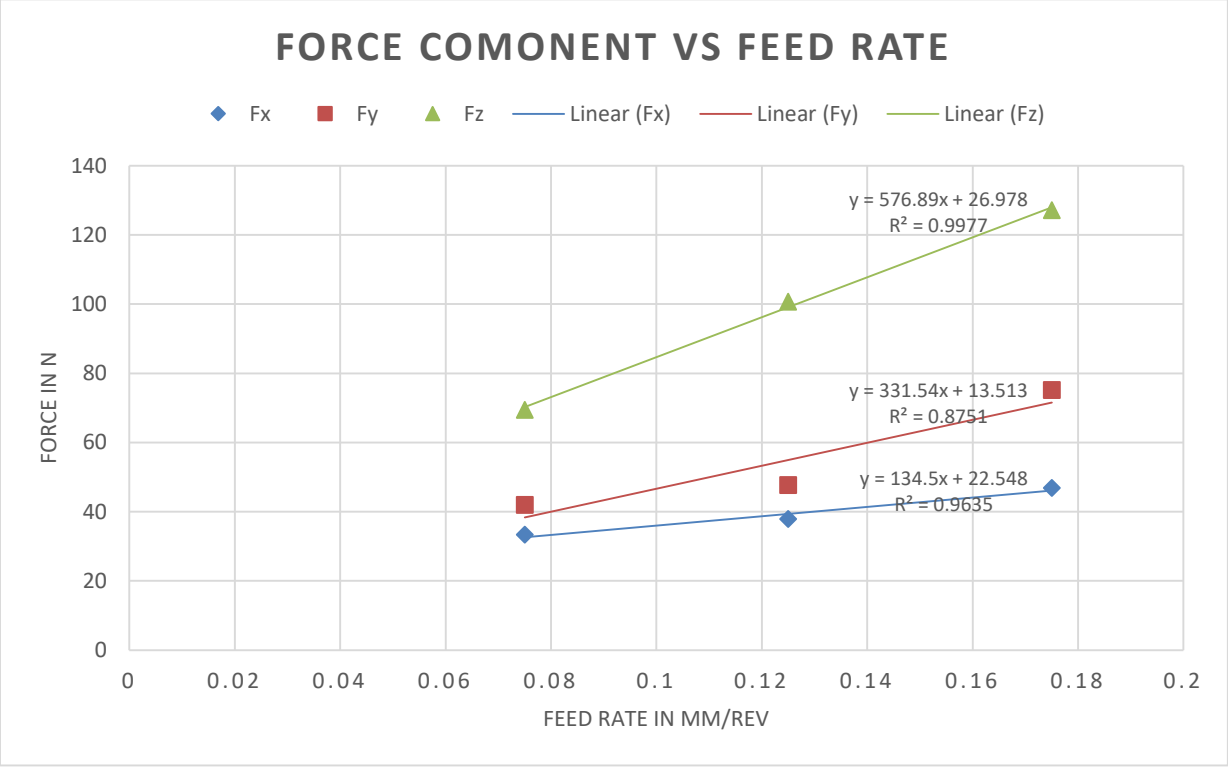
Answers to questions asked in the report:

1. Plot measured cutting forces in all directions in one figure.

Feed rate =0.075mm/rev and Cutting speed =200m/min



2. **Plot the averaged force data (averaged over the stable cutting regime) fit using linear regression modelling (eg. Plot shown in Fig 5) and show the value of R2.**



3. **Experimentally identify the cutting force coefficients (eq. 5) through given force data and report the values.**

- Chip thickness $h=f\cos(\psi)$ = f*cos(5) = 0.1245mm
- Chip width (b) = 1.304mm

$Kx=Fx/bh$ $Ky=Fy/bh$ $Kz=Fz/bh$

From experimental data :-

Feeed rate(mm/rev)	**Fx(N)**	**Fy(N)**	**Fz(N)**	**Kx(N/m2)**	**Ky(N/m2)**	**Kz(N/m2)**
0.125	16.74	41.27	71.82	103.14	254.25	442.40

4. **Calculate chip thickness ratio using the measured chip length and weight. Identify βn, using Armarego's assumptions, Stabler's rule ($\eta=i$). Use these identified values to find cutting force coefficients.**

Calculations for feed rate=0.125mm/rev

Kx=Kt, Ky=Kf, Kz=Kr

Chip width (b) = 1.304mm
Chip cut Thickness (hc) = 0.263mm
Uncut chip thickness (h) = f*cos(5) = 0.1245mm (f = 0.125mm/rev)
Using eq. 8
Rc = h/hc = 0.47

Using eq. 7

$$\tan(\phi_n + \beta_n) = \frac{\cos(45)\tan i}{\tan i - \sin(45)\tan i} = \frac{1.414}{0.414} = 3.415$$

$\phi_n + \beta_n = 73.68$

$\phi_n = \tan^{-1}\{(0.47/1.41)/(1-0.47*1.41)\}$
$= 26.43$
$\beta_n = 47.25$
$\tau_s = 3.03e8$ N/m2

Using equation s for Ks:

$$K_t = \left[\frac{\tau_s}{\sin\phi_n}\frac{\cos(\beta_n - \alpha_n) + \tan i \tan\eta \sin\beta_n}{\sqrt{cos^2(\phi_n + \beta_n - \alpha_n) + tan^2\eta sin^2\beta_n}}\right]$$

$$K_f = \left[\frac{\tau_s}{\sin\phi_n \cos i}\frac{\sin(\beta_n - \alpha_n)}{\sqrt{cos^2(\phi_n + \beta_n - \alpha_n) + tan^2\eta sin^2\beta_n}}\right]$$

$$K_r = \left[\frac{\tau_s}{\sin\phi_n}\frac{\cos(\beta_n - \alpha_n)\tan i - \tan\eta \sin\beta_n}{\sqrt{cos^2(\phi_n + \beta_n - \alpha_n) + tan^2\eta sin^2\beta_n}}\right]$$

Calculated values are :
K_t = 71.25
K_f= 217.16
K_z= 401.33

5. **Compare the experimentally identified and estimated cutting force coefficients. Comment on the difference, if any.**

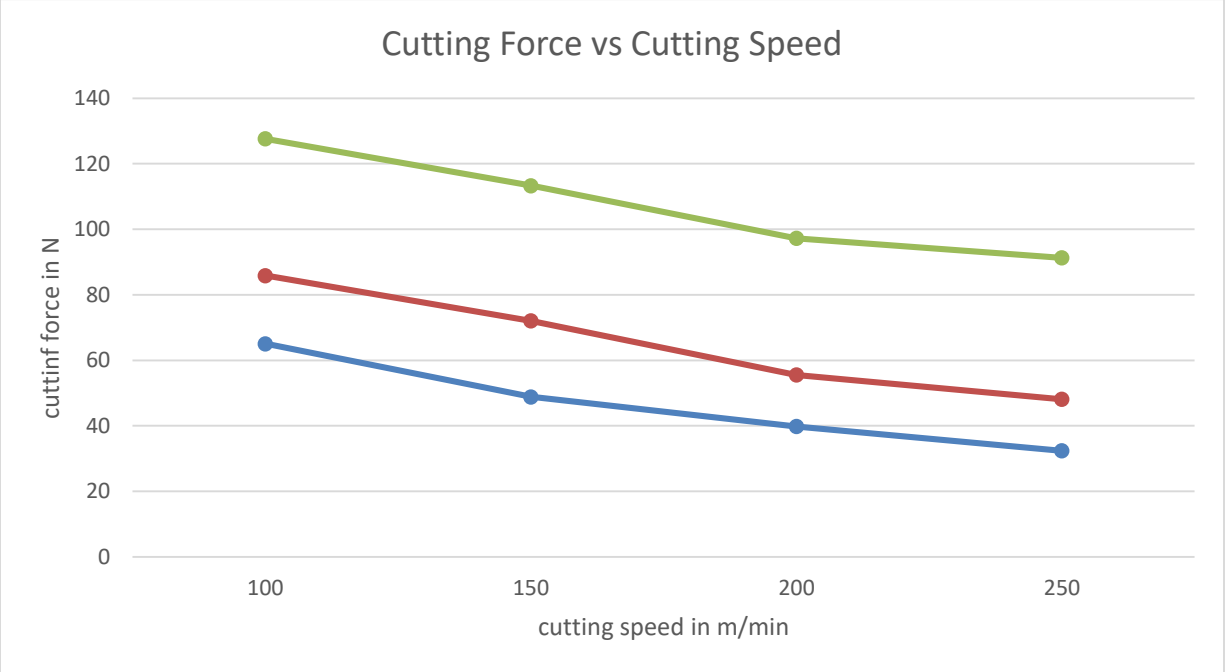
Force Coefficients	Experimental	Theoretical	% Error
Kx	103.14	71.25	30.91

Ky	254.25	217.16	14.58
Kz	442.4	401.33	9.28

The difference in the experimentally identified and estimated cutting force coefficients is mainly because of following reasons :

- It may be due to approximate reading of chip thickness for the measurement had been taken by putting the chip under the microscope instead of the procedure specified
- The possible sources of error were accuracy while calculating the thickness of chip using the electron microscope. Also, the nose of the tool was neglected while doing calculations.
- Sources of error also includes: friction, higher shear deformation rate, higher temperature in the cutting region, BUE formation. These factors might result in variation in material property.

6. **Plot the average cutting forces with respect to cutting speed and comment on the trend.**



Reason and Conclusion:

This is due to the reason that energy required for material removal per unit volume is a material property, it remains constant. As Power = Force ×Velocity, cutting forces in all directions decrease as the cutting speed. As we increase velocity, friction decreases, temperature in cutting region increases, shear deformation rate increases. High temperature in the flow region and a

decrease of the contact area and the chip thickness cause the cutting force to decrease depending on the cutting speed. All these factors lead to decreases in cutting forces.