Evaluation of role of Machining parameters on variation in Cutting forces.

Objective:

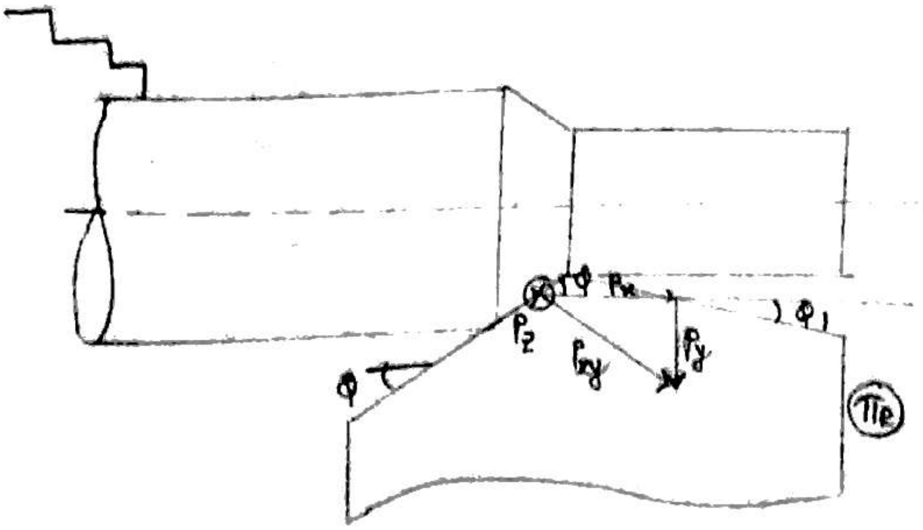
To study the effect of cutting velocity and feed on cutting forces in turning steel with uncoated carbide inserts (positive rake).

Measurement principle:

Piezo-electric dynamometer.

piezo-electricity:

Ability of some materials (mainly crystals) to generate electric potentials in response to mechanical stress. This may take the form of a ~~discharge~~ separation of electric charge across the crystal lattice.



P_x = longitudinal cross force (X_m)

P_y = Radial feed force (Y_m)

P_z = tangential force / main cutting force

P_{xy} = feed force

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Experimental Conditions :→

Sl. no.	Item	Description
1.	Machine Tool	H22 HMT center lathe
2.	Work material - specification	17 Cr Ni Mo 6 / 32 NiCrMo 14.5
3.	Work material - composition	C = 0.8%
4.	Cutting tool - specification	SPUN 120308
5.	Cutting tool - geometry	$\lambda = 0, \gamma_0 = 6^\circ, \alpha_0 = 6^\circ, \alpha_n = 6^\circ, \varphi_1 = 16^\circ, \varphi = 75^\circ$ $r = 0.8$ mm
6.	Cutting tool - material	composite carbide (grade = P30

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Observations and results :-

By performing this experiment we have got the value of the tangential force (P_z) and the value of ξ from 'chip morphology' experiment. (in this experiment the value of ξ is given.

we know that,

$$P_z = ts\,\tau_s(\xi - \tan\gamma_o + 1)$$

for orthogonal machining of ductile materials,

$$P_{xy} = ts\,\tau_s\,(\xi - \tan\gamma_o - 1).$$

$$\therefore\ P_{xy} = \frac{P_z\,(\xi - \tan\gamma_o - 1)}{(\xi - \tan\gamma_o + 1)}$$

for orthogonal machining of ductile materials,

P_{xy} makes an angle $(\frac{\pi}{2} - \phi)$ with the machine longitudinal direction.

$$\therefore\ P_x = P_{xy}\cos(\frac{\pi}{2} - \phi) = P_{xy}\sin\phi$$

$$\text{and, } P_y = P_{xy}\cos\phi.$$

the detail observations are presented in a table in the next page,

OBSERVATION TABLE :-

Serial no.	Spindle speed (rpm)	cutting velocity (m/min)	Feed (mm/rev)	P_{xy} (N)	P_z (N)	ξ	P_x (N)	P_y (N)	τ_s (N/mm²)
1.	190		0.08	232.6	543.8	2.6	224.7	60.2	972.5
2.	190	cutting velocity remains unchanged	0.12	290.2	706.2	2.5	280.3	75.1	866.7
3.	190	$\boxed{96}$	0.16	336.5	856.2	2.4	325.0	87.1	812.1
4.	190		0.20	400.5	1043.8	2.35	386.9	103.7	804.2
5.	113	57		310.1	725	2.6	299.5	80.3	864.4
6.	147	76	feed remains unchanged	298.9	712.6	2.55	288.7	77.4	861.9
7.	190	96	$\boxed{0.12}$	292.8	712.8	2.5	282.8	75.8	874.8
8.	247	125		289.1	719	2.45	279.2	74.8	895.6

Variation of main cutting force (P_z) with feed and cutting velocity

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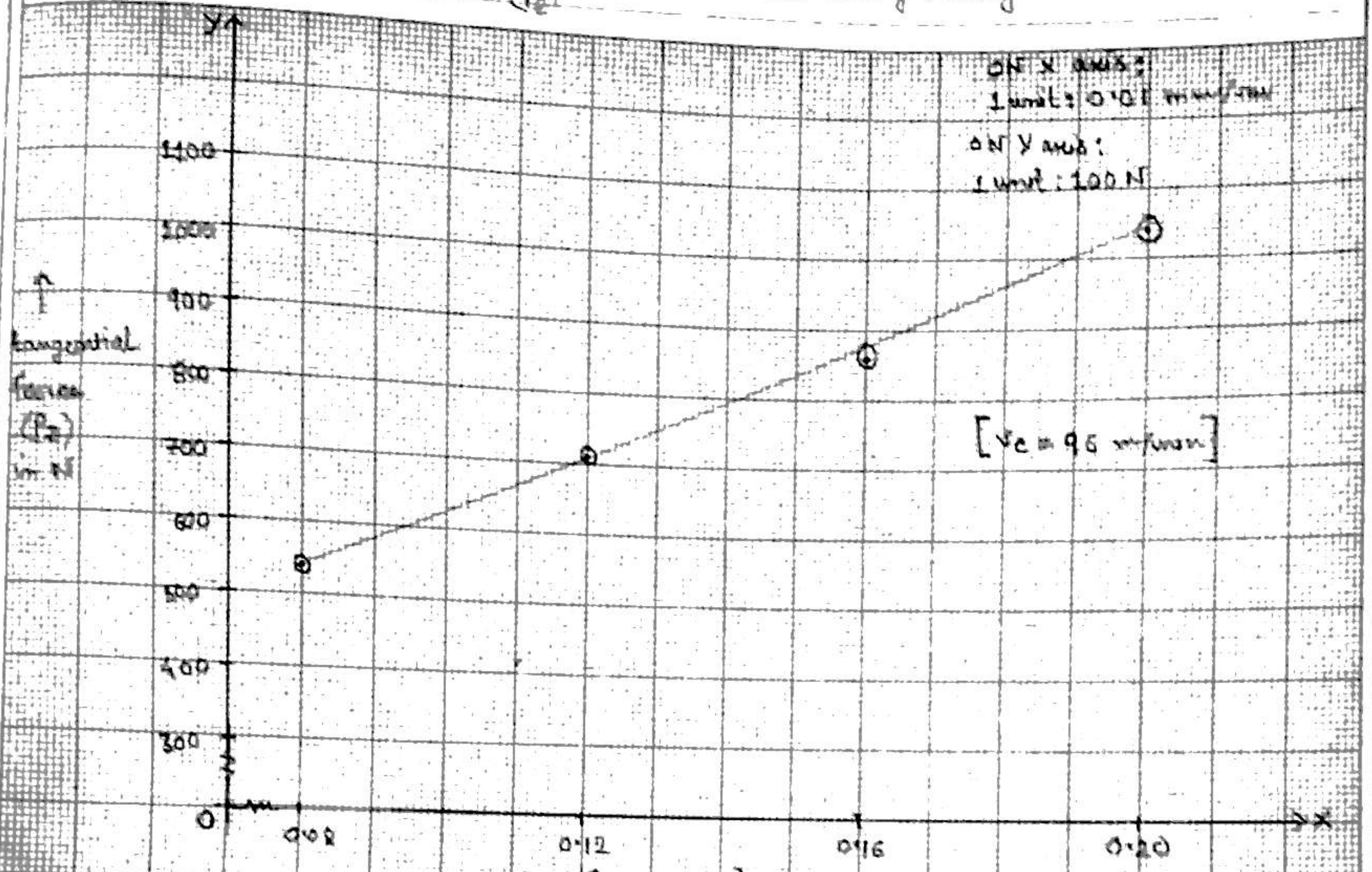
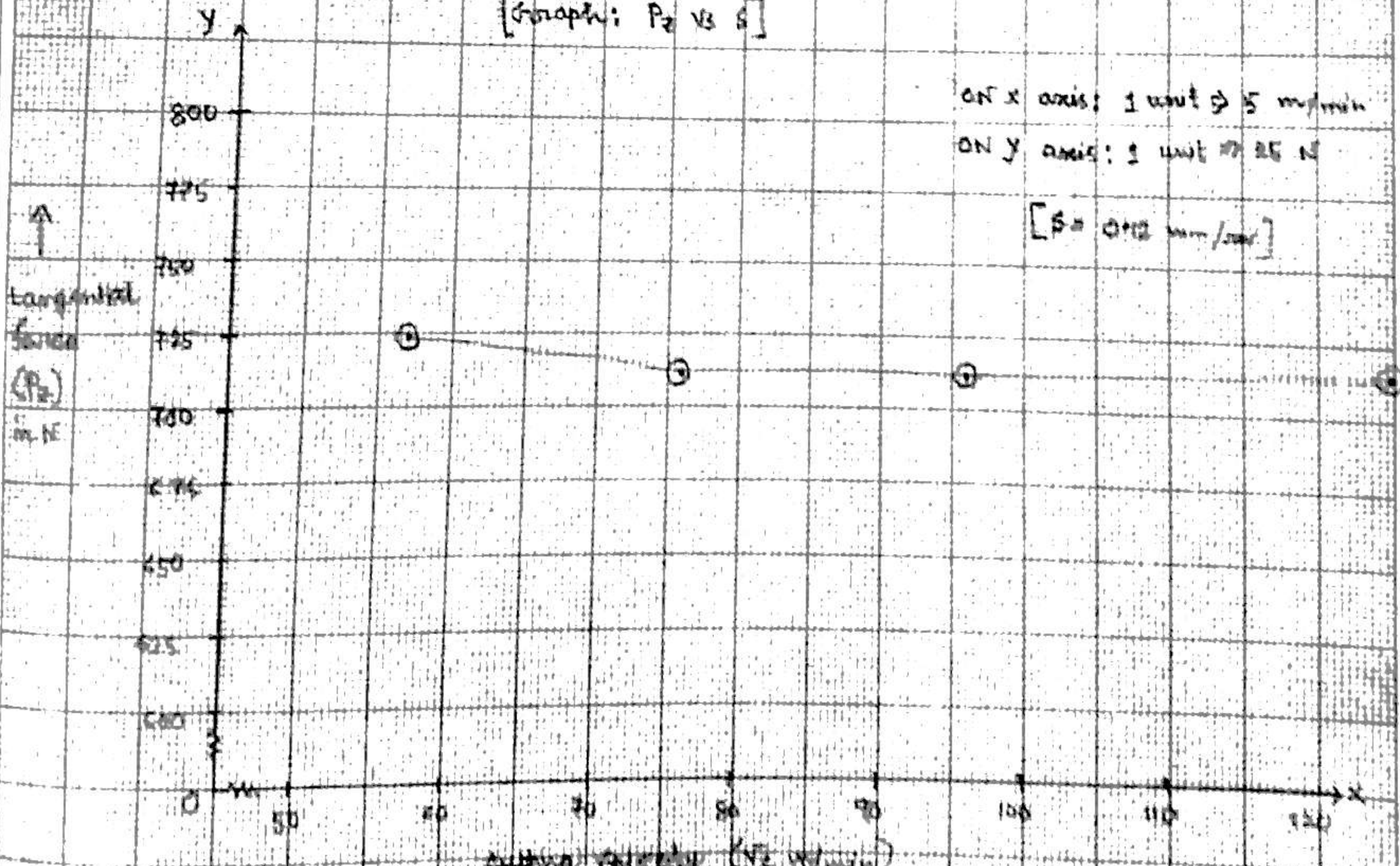
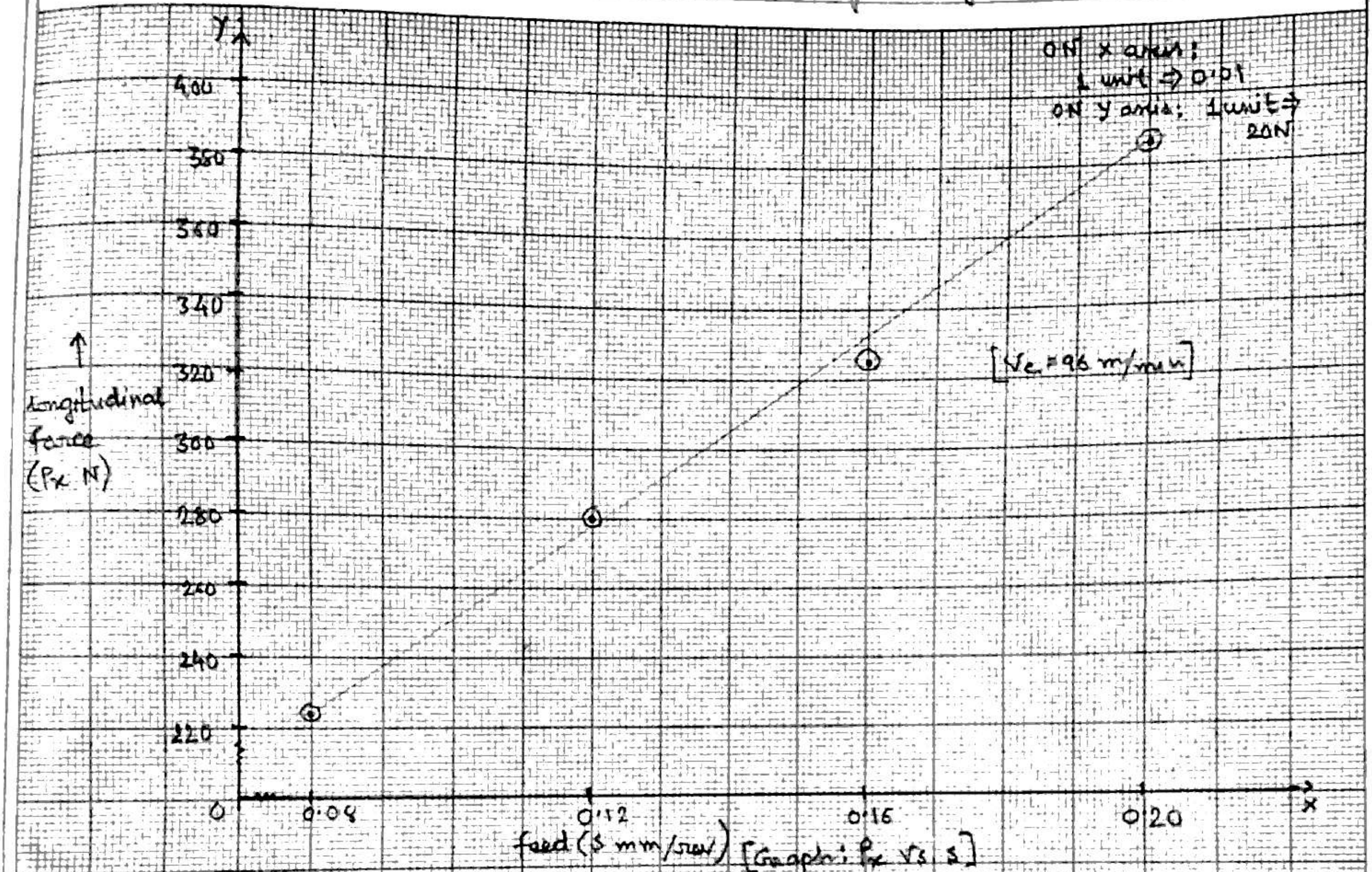


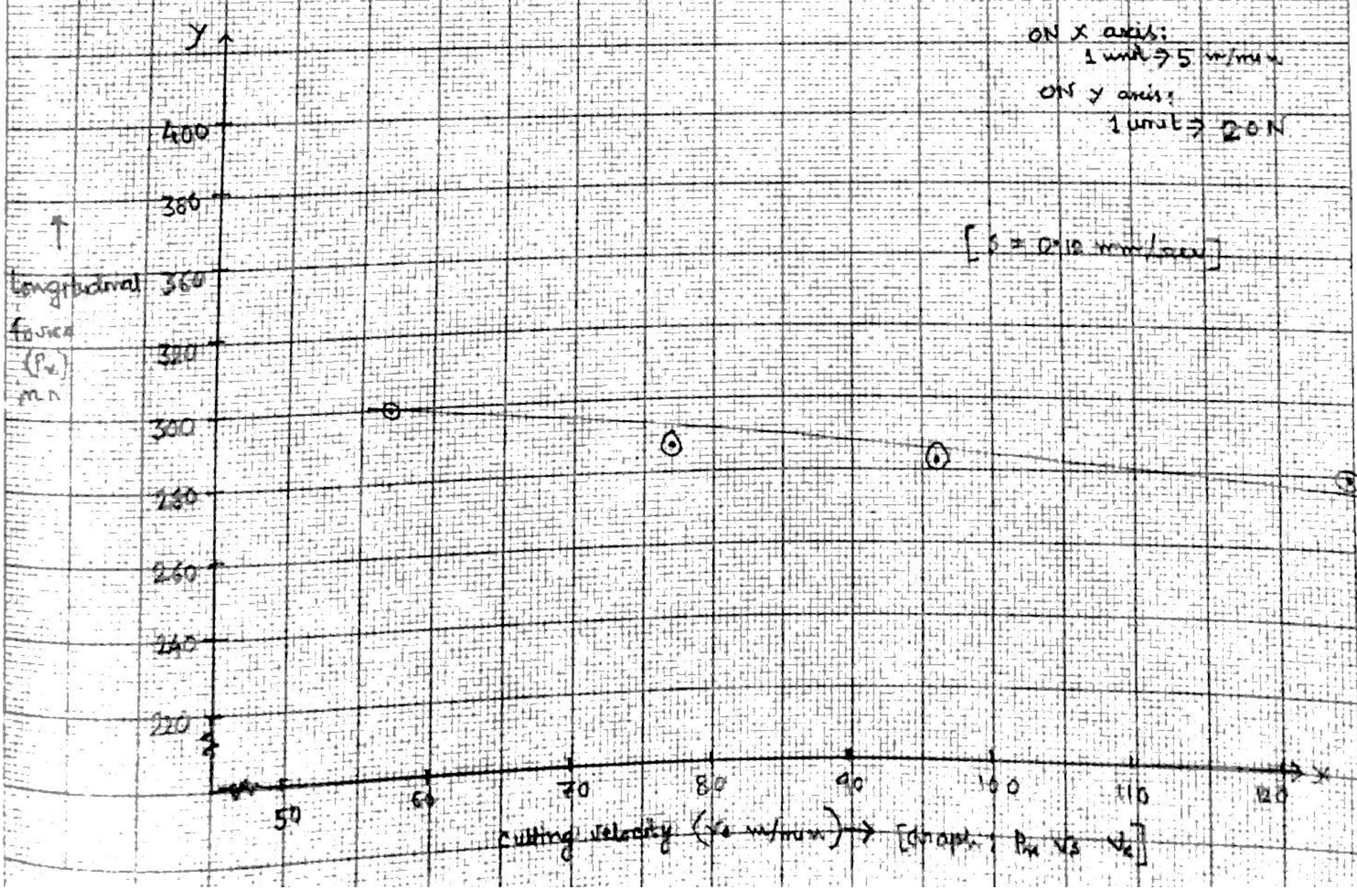
[Graph: Pz vs S]



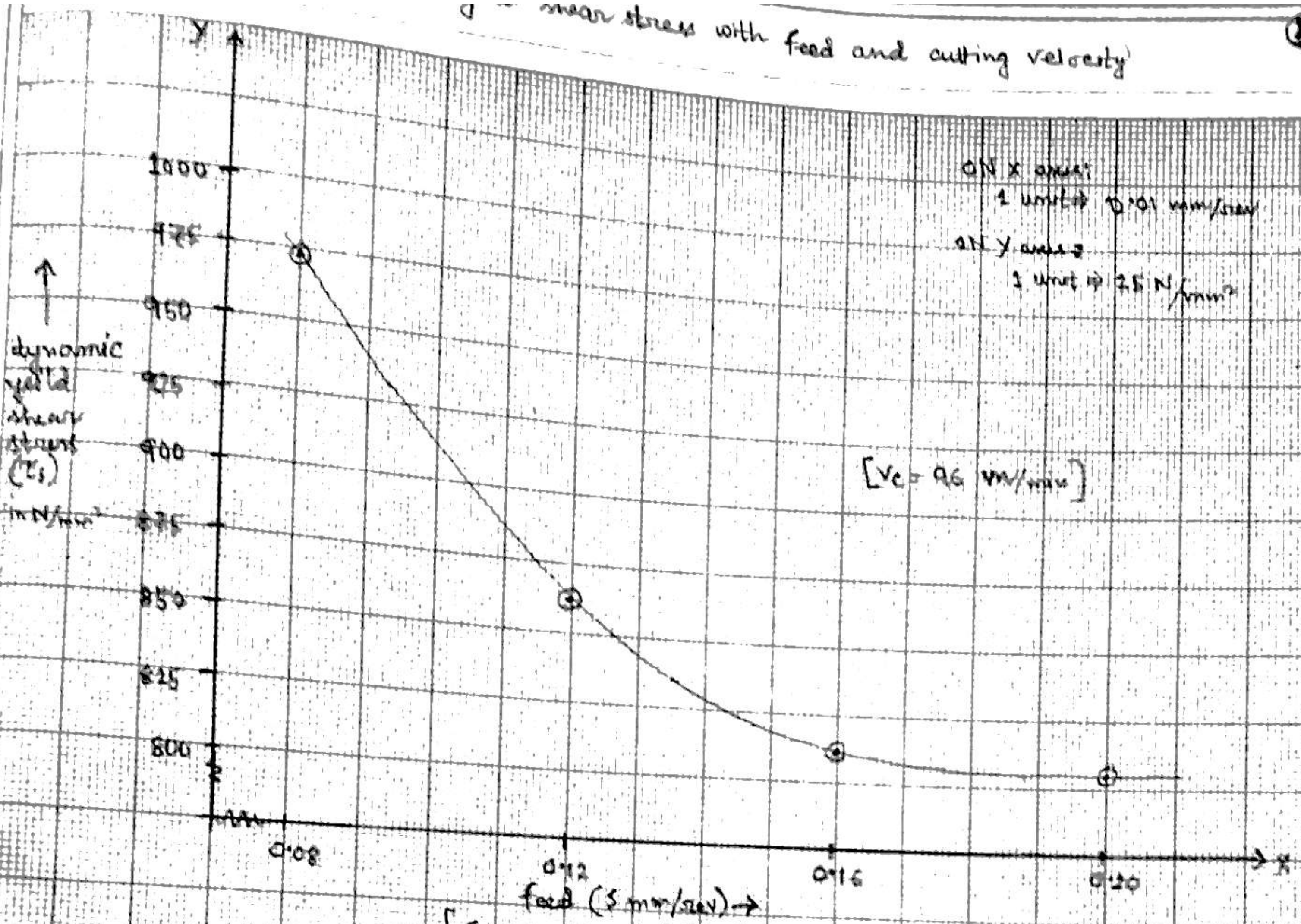
[Graph: Pz vs Vc]

Variation of Longitudinal force with feed and cutting velocity

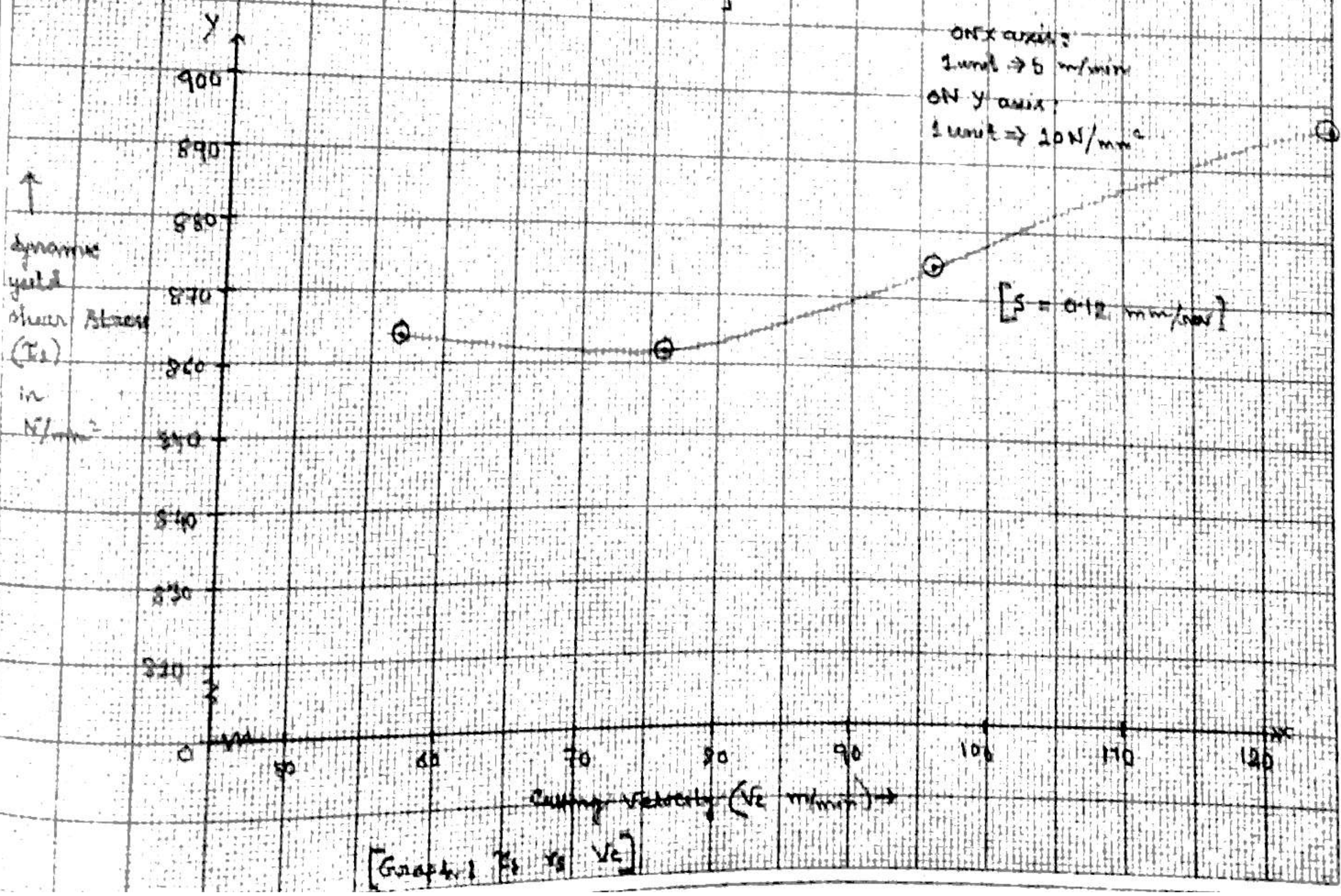




... shear stress with feed and cutting velocity

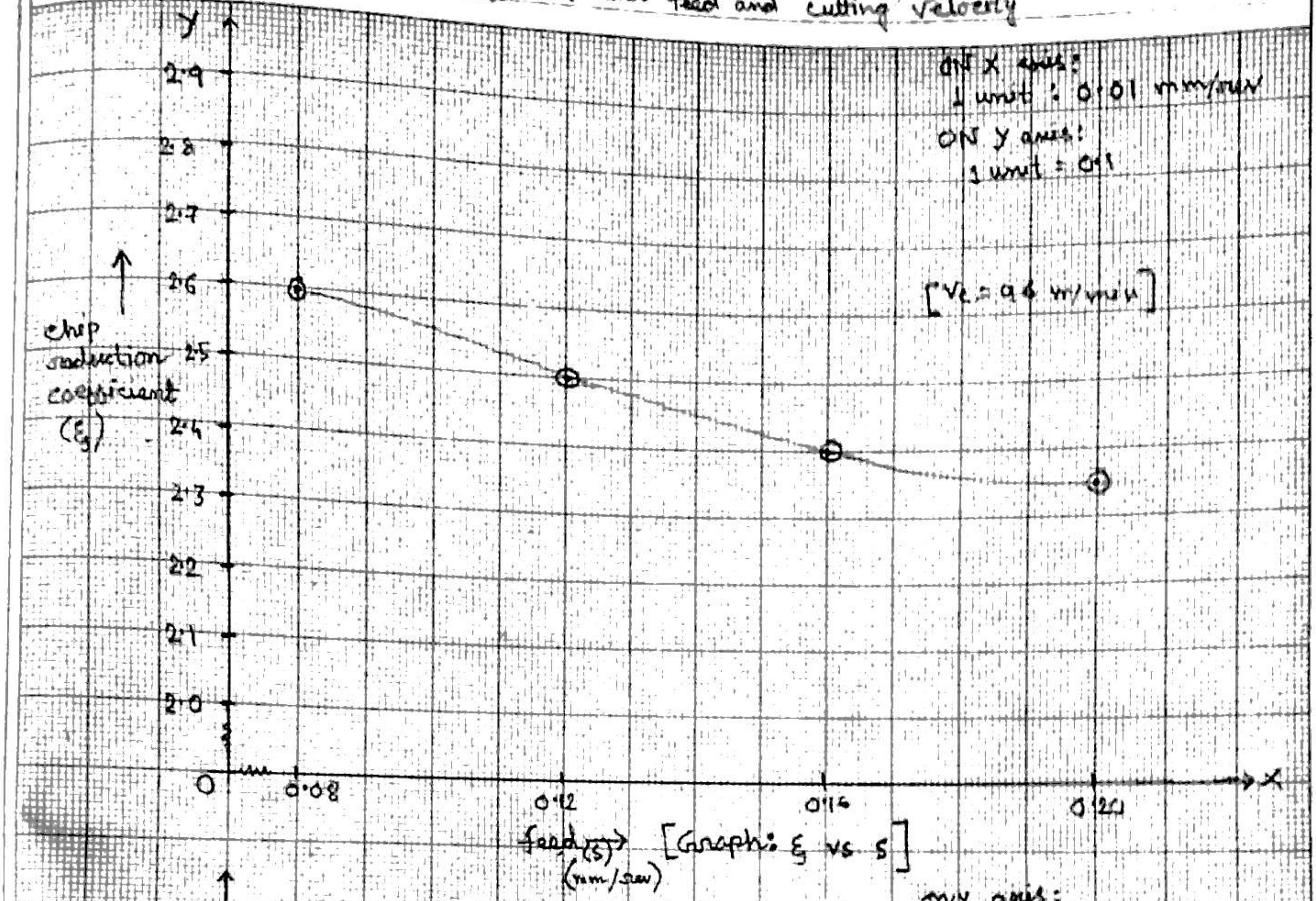


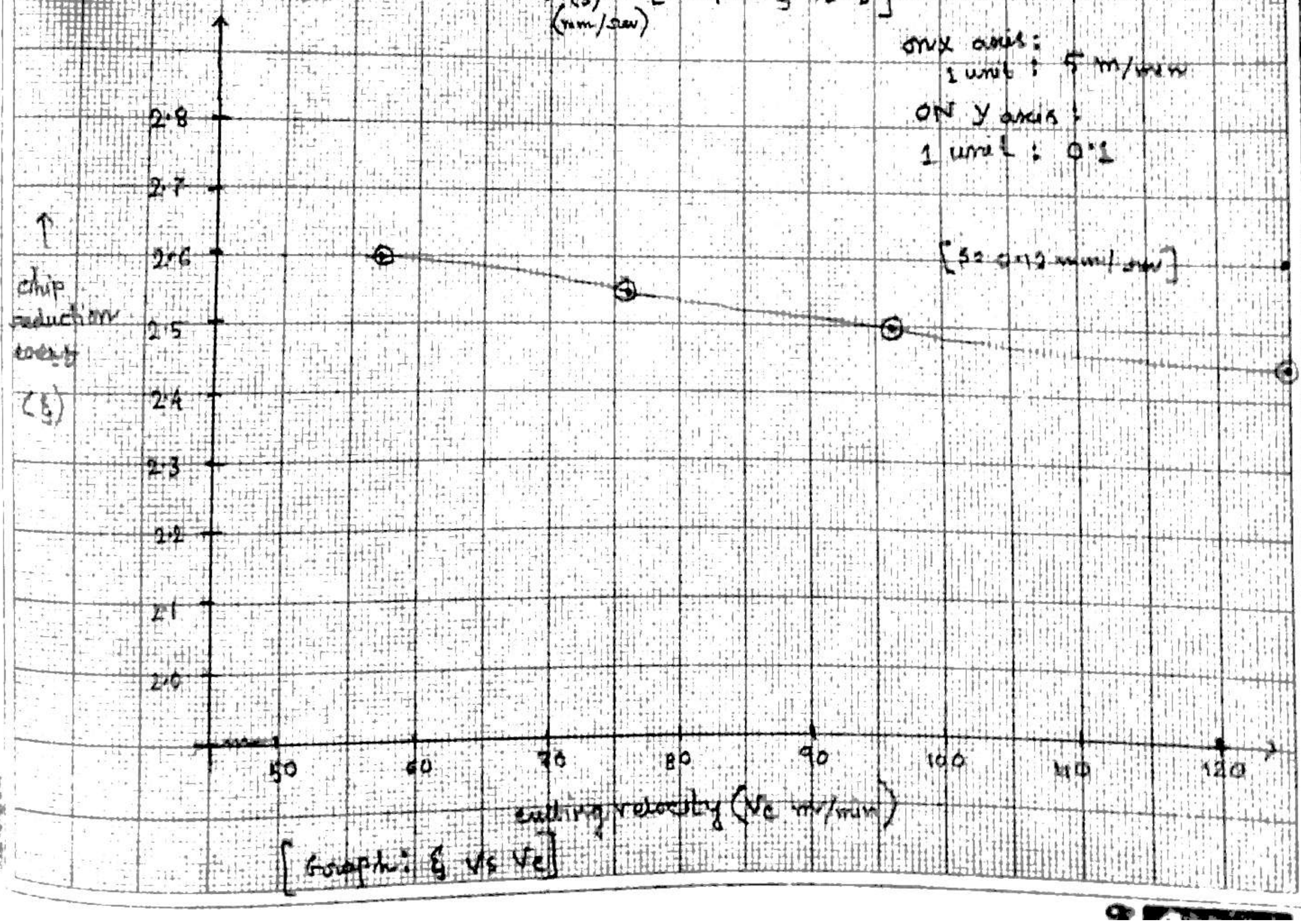
[Graph : τ_s vs S]



[Graph : τ_s vs V_c]

Variation of chip reduction coefficient with feed and cutting velocity





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DISCUSSION :⇒

(1) Explain the nature of variation in the graphs.

⇒ (i) main cutting force or tangential force (P_Z) increases with the increase in feed and decrease with the increase in cutting velocity. It happens because,

$$P_Z = t s \tau_s (\xi - \tan\gamma_0 + 1).$$

the other parameters including cutting velocity are constant and hence P_Z increases almost linearly with feed.

with increase in cutting velocity P_Z decreases slightly because ξ decreases with increase in V_C an τ_s decreases (very small) with increase in V_C.

(ii) $P_{x} = P_{xy} \sin\phi$

$$= \frac{P_Z(\xi - \tan\gamma_0 - 1)}{(\xi - \tan\gamma_0 + 1)} \sin\phi.$$

hence, P_X is a function of 3 parameters, i.e.; γ_0, P_Z & ξ. and P_X thus increases or decreases as the same reason as earlier one.

(iii) τ_s is a function of P_Z, s and ξ; $\tau_s = \frac{P_Z}{ts(\xi - \tan\gamma_0 + 1)}$

as, s increases, τ_s decreases,

as, V_C increases ξ decreases and P_Z almost remains constant

(iv) ξ first increases and then decreases with increase in s and V_C, because, $\xi = e^{\mu\left(\frac{\pi}{2} - \gamma_{dyn}\right)}$.

and, $\xi = \cos\gamma \cot\beta + \sin\gamma$

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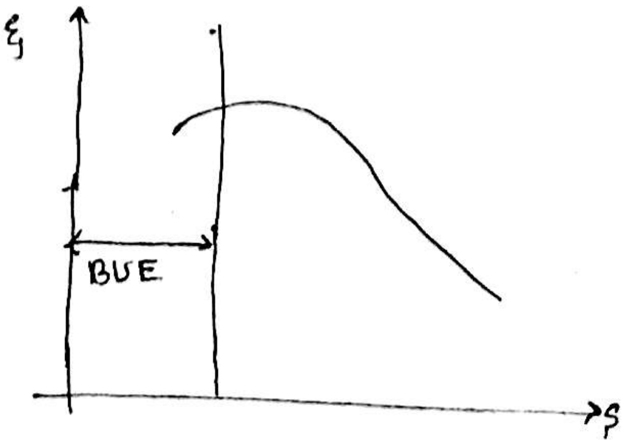

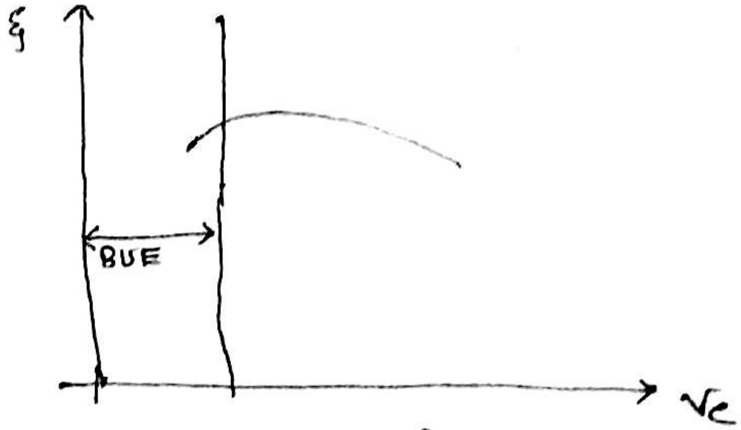

ξ is a function of β that means shear angle and γ_{dyn} and hence ξ is related to the formation of builtup edge. Beyond the builtup edge ξ decreases with the increase in ς and v_c. We operate in such feed and cutting velocity range.

(2) Determine the ratio of main cutting force to feed force. Why it is more than 1?

(i)

Observations:	1	2	3	4	5	6	7	8
main cutting (P_z) force:	543.8	706.2	856.2	1043.8	725	712.6	712.8	719
feed force (P_{xy}):	232.6	290.2	336.5	400.5	310.1	298.9	292.8	289.1
ratio ($\frac{P_z}{P_{xy}}$):	2.338	2.433	2.544	2.606	2.337	2.384	2.434	2.487
	ς increases → (v_c const)				v_c increases →		($ς$ constant)	

(ii) (a) P_z is the main cutting force because it is directly related to the power of the machining which is due to the turning of the work piece whereas, P_{xy} comes due to the feed given to the tool. Cutting velocity is higher than feed in turning and hence P_z is greater than P_{xy}.

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(b) For orthogonal cutting,

$$\frac{P_z}{P_{xy}} = \frac{\xi - \tan\gamma_0 + 1}{\xi - \tan\gamma_0 - 1}$$

from this expression also we can suggest that,

P_z must be greater than P_{xy} ; $P_z > P_{xy}$

and hence, $\frac{P_z}{P_{xy}} > 1$.