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New Results in the Study of the Machine -Tools Vibrations Part 3. - Experimental Contributions at the Study of the Chatter Phenomenon

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SUMMARY

In the present paper is presented an experiment for the study of chatters. In order to interpret the results, Kochenburger's criterion is extended.
Keywords: *chatters, Kochenburger's criterion*

There has been lathed a series of steel flanges and at the moment when instability occurred, moment indicated by the noise produced by chatter, the knife has suddenly taken out from the piece (fig. 1). On the flange surface we can see the two waves, separated by the line marking the tool withdrawal (fig. 2).

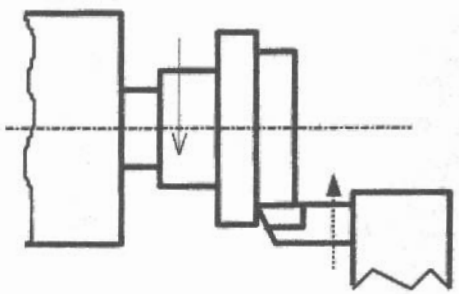

Fig. 1

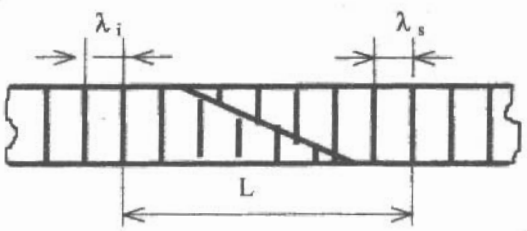

Fig. 2

There have been measured and calculated the following:

- λ_s = wave length of the vibration in the preceding cycle (as average of 3 measurements);
- λ_i = wave length in the current cycle (as average of 3 measurements);
- λ = wave length (averaged), supposed to be constant on the entire periphery of the piece:

$$\lambda = (\lambda_s + \lambda_i) / 2; \quad (1)$$

- v = cutting speed:

$$v = \pi.D.n / 1000 \text{ [m / min.]}; \quad (2)$$

- f = frequency of vibration:

$$f = v/\lambda \text{ [Hz]}. \quad (3)$$

In the course of measuring there have been kept constant cutting conditions: n = 100 rev / min; s = 0,083 mm / rev; b = 6 mm (the chip of the breadth).

After each measurement the piece was leveled, by removing the vibrating wave, so that the following vibration might not have been influenced.

There have been made about 600 measurements, in order to obtain the following dependence:

$$f = f(v); \quad (4)$$

speed variation was obtained by lathing pieces of various diameters .

The diagram corresponding to relation (4) is presented in fig. 3, the numbers near the points represent the number of determinations coinciding in that very point. Excepting a series of points which may be consider flagrant errors, it can be observed that frequency varies linear with speed, but for a certain speed it is possible to appear two frequencies, the inferior frequency being more likely to appear.

In order to explain the phenomenon presented in fig. 3 we use Kochenburger's stability criterion

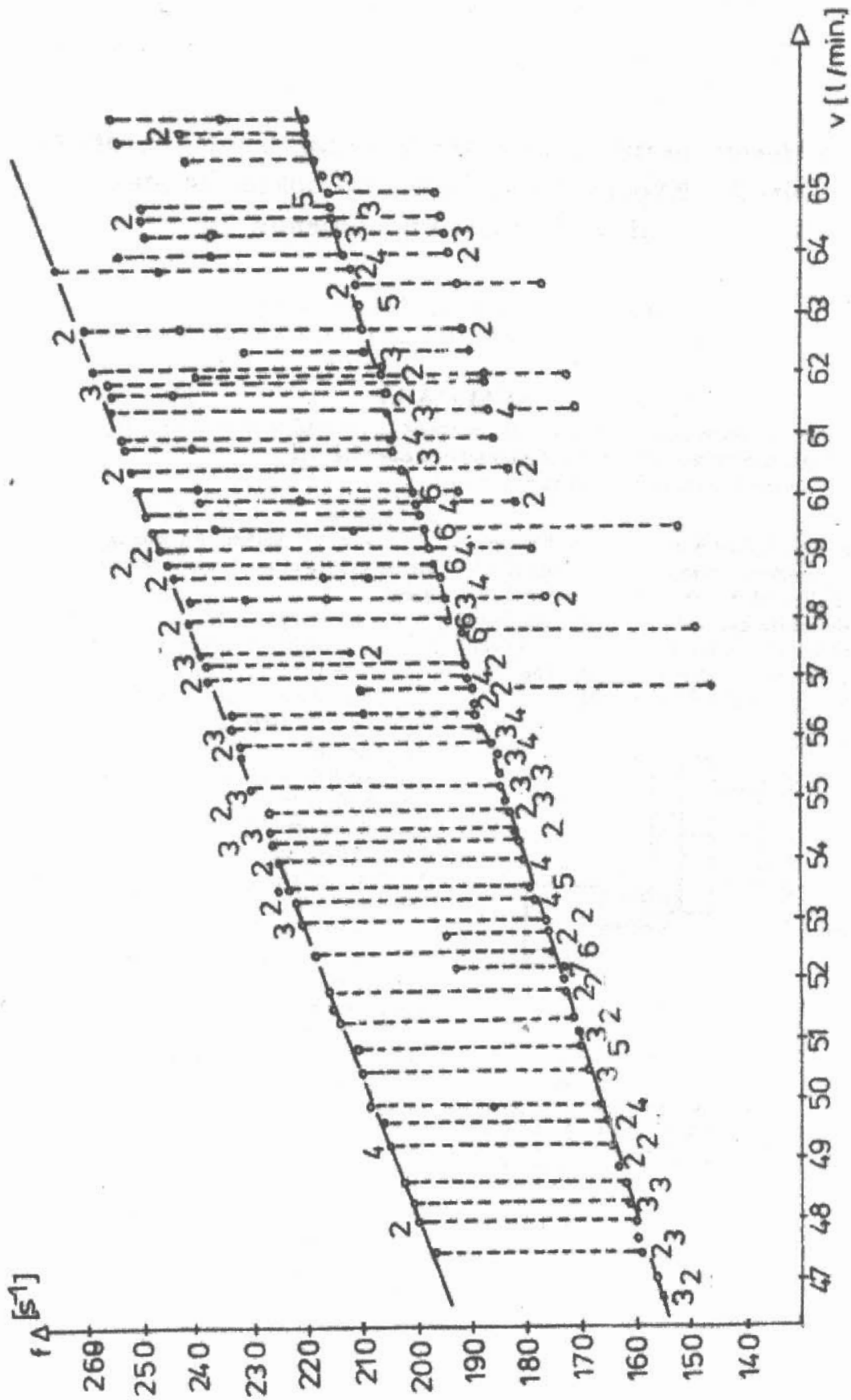
f [s⁻¹]
260
250
240
230
220
210
200
190
180
170
160
150
140
v [l/min.]
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Fig. 3

for non - linear systems (fig. 11 in [2]). As it is know [8], at an intersection of the gain - phase characteristic Y (j w) with the inverse negative gain -phase characteristic C (A) - under the form in fig. 4-P is unstable limit point, while Q is stable limit point. For any initial value of the amplitude A of the admittance size of the non - linear element, greater that the one corresponding to point P, it will occur a periodic transitory process in the system , and finally it will oscillate being kept by the amplitude and the pulsation corresponding to point Q. The transitory process will be periodically limitary amplified, if the initial amplitude is bigger that the one corresponding

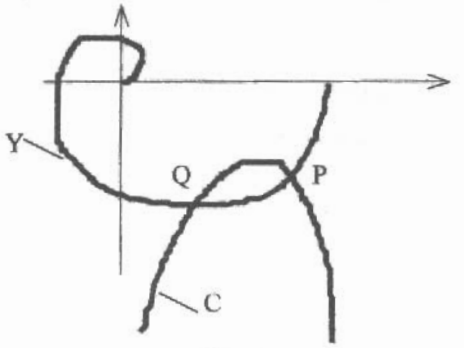

Fig . 4

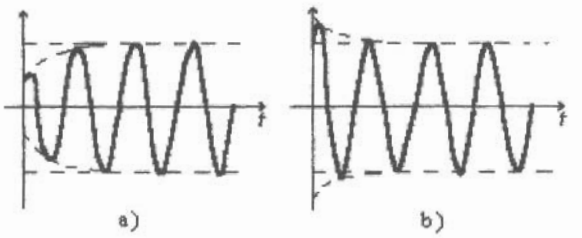

Fig. 5

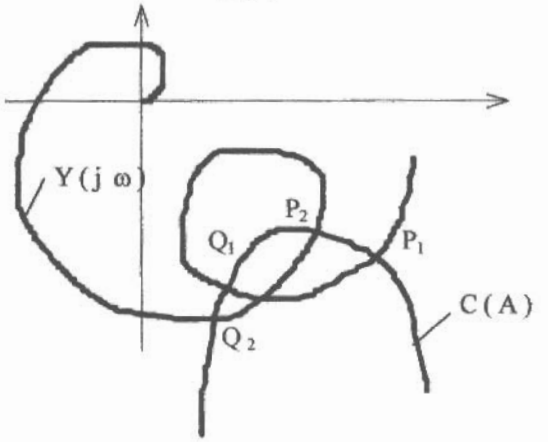

Fig. 6

to point P, but less that of point Q (fig. 5 a) and on the contrary, it will be periodically limitary damped down if the initial amplitude is bigger that one corresponding to point Q (fig. 5 b). In case of oscillations of amplitude inferior to that one corresponding to point P, the system will be similar to a stable system.

At systems having more freedom degrees the gain-phase characteristics made up of more loops, generally one for each form of oscillation [7].

The presence of sustained oscillations with two distinct frequencies can be explained by the presence of a loop in the gain - phase characteristic, in the area of intersection with the inverse negative gain – phase characteristic (fig. 6) , resulting the stable limit points Q_1 and Q_2 , of the pulsations ω^*_1 and ω^*_2 , with:

$$\omega^*_1 < \omega^*_2 .$$

When amplitude A of the admittance size (cutting force) in the non - linear element is increased, the first stable point to be found is Q, so that frequency (the probable one) of appearing pulsation ω^*_1 (to which frequency $f = \omega^*_1 / 2.\pi$ corresponds) is bigger than frequency of appearing the superior pulsation ω^*_2, phenomenon verified in fig, 3.

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Rezultate noi in studiul vibraţiilor maşinilor - unelte Partea a III – a. Contribuţii experimentale la studiul fenomenului de trepidaţie

- rezumat -

In prezenta lucrare se prezintă un experiment pentru studiul fenomenului de trepidaţie . S-au aşchiat un număr de flanşe si - in momentul producerii instabilităţii - cuţitul s-a retras brusc din piesa . S-au efectuat cca. 600 de măsurători in vederea obţinerii dependentei frecventei vibraţiei de viteza de aşchiere . Pentru a interpreta rezultatele , s-a realizat o extindere a criteriului lui Kochenburger.

Des résultats nouveaux dans l'etude des vibrations chez machines - outils 3-eme partie. Des contributions expérimentales dans l'étude de phénomène de trépidations

- résume -

Dans l'ouvrage on present un experiment pour l'etude de phenomene de trepidations. Pour interprete les resultats on extend le criterion de Kochenburger.