CHAPTER VI

DISCUSSION AND CONCLUSIONS

Discussion of results

The calibration curve between load and strain gauge bridge reading (% of strain) for vertical and horizontal components as shown in Fig. 5.1 and Fig. 5.2 should be the same, because both vertical and horizontal component bridge circuits use the same size of strain gauges with the same gauge factor of 1.87 . The slight difference of the two curves may be caused by an error in the position of the strain gauges, or a difference in strain gauge lead resistance.

The cross-coupling of the dynamometer should theoretically be zero since the strain gauges have their centre lines on the neutral axis of bending of the measuring beam as mentioned in chapter 3. But in fact slight cross coupling did occur. The causes of this cross coupling may be error in strain gauge positions or the fact that the cutting edge of the tool tip was not placed exactly on the centre line of the measuring bar cross-section.

In the experiment series 3 and 4, the dynamometer was used to determine the relationship between cutting forces and several other cutting parameters. From Fig 5.4, for constant feed and depth of cut, it is shown that cutting force decreases with increasing cutting speed, and the rate of decrease of the cutting force at low speed is larger that at higher speed.

This is due to the higher friction present at lower cutting speeds, which results in a "built up edge", a series of intermittent welds between chip and tool-face.

But thrust force is increased with the cutting speed, since increase of speed means an increase in the velocity of feed. Figs. 5.5 and 5.6 show that for a constant cutting speed, both F_c and F_t increase with increasing feed. Since any increase of feed involves an increase in the removal of metal per revolution and hence an increase in shear area and shear force on the chip, this is to be expected. The results of the tests in series 4 show that the reduction of F_c and F_t due to the presence of a cutting fluid at low speed is larger than at high speed as shown in Figs. 5.4 and 5.5. This is because the friction force between tool and chip at low speed is a bigger factor than at low speed as mentioned above. But the purpose of using a cutting fluid is not only to reduce friction but also to remove heat generated at the tool-tip, and this becomes increasingly important at higher cutting speeds.

Any errors occuring in the values of cutting force as measured, other than those due to the dynamometer itself, may be due to:-

a) Errors in balancing and reading the bridge galvanometer.

b) Inconsistency in the cutting angles of the carbide tips used. Unfortunately these had to be ground before use in order to give a sufficient clearance value. Although this was done with great care using a grinding jig constructed specially for the purpose, some errors are inevitable.

In addition to the above, it was observed that the hardness of the specimens was not constant across the cross-section of the steel bars which were used as test-pieces. Fig. 5.7 a, shows the distribution of hardness across the 2 in. dia. steel specimen.

The degree of hardness is lowest at the centre and maximum at a radius of 0.875 in., but for specimen "B" in Fig. 5.6 b, the degree of hardness is maximum at a radius of 0.6 in. according to the manufacturing process of the steel bars.

The result of the series 5 test is shown in Fig. 5.8. These show that the cross-section area ratio of chip before cut and after cut increases with increasing speed, which means that the force at the chip due to friction between chip and tool decreases while cutting speed is increasing. For ideal friction-less cutting the cross section area ratio of the chip should be unity, which means that the length of the chip would be equal to the distance moved during cutting. Fig 5.8 also shows that the cross-section area ratio of chip is increased by the use of a cutting fluid, again indicating a reduction of friction. Thus the chip produced when cutting with a fluid will be larger than without.

The result of the series 6 a. tests show that the amplitude of vibration of the tool holder increases with cutting speed. The natural frequency of the tool holder as obtained in tests 6b is about 980 c/s, which is lower than the calculated result in Chapter III of 1,230 c/s. The discrepancy between these two values may be caused by lack of rigidity of the steel table which supports the dynamometer, and the mass of the connecting rod between the tool holder and the vibrator which will reduce the natural frequency of the system. and in the result of series 6 b. shown that after correct the mass of the system and recalculating then get the pure natural frequency of the measuring bar of 1,[illegible]0 c/s, which is in good agreement with the theoretical value of 1,230 c/s.

Conclusions

The conclusions from this study may be summarised as follows

1. The least reading of the dynamometer is 0.42 lb. in both vertical and horizontal bridge circuits

   $$\text{(least reading} = \frac{\text{cutting force in lbs.}}{\text{total number of divisions on measuring dial}}\text{)}$$

2. The cross coupling of the dynamometer is 1.26%
3. The natural frequency of the dynamometer tool holder is about 1,280 c/s
4. The maximum resultant force to be applied to the dynamometer tool should be about 150 lbs.
5. The friction force between tool and chip is reduced with increase of speed.
6. Both F_c and F_t increase with feed/rev.
7. Frition is reduced by the use of a cutting fluid, this reduction being more marked at low speeds than at high speeds.