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Effect of grinding wheel loading on force and vibration

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ABSTRACT

Grinding wheels are applied in industry in a large variety of ways such as centre less, cylindrical, external and internal, surface and double disc etc. under a variety of cutting conditions. The abrasive grinding wheels has two major roles. The first role is inherent in which the wheel rotates to its function with regard to the production of good surface finish and the ease of material removal in grinding. The second role refers to the apparent behavior of the grinding wheel and depends upon the interaction of the wheel with the characteristics of the grinding machine and other application conditions. A grinding wheel is a very forgiving tool and its grinding action is somewhat dynamic in that it can be altered significantly by changing the grinding conditions.

KEY WORDS: Grinding wheels, Double Discs, Force.

1. INTRODUCTION

Force: In grinding forces are generated by two mechanisms, chip formation and friction. Forces are generated by structural elements of the grinding wheel which are in physical contact with the work piece. Actually the friction related part of the total grinding force can be greater than the part related to the chip formation under certain conditions. These two types of grinding forces cannot be clearly distinguished because they always come together in the chip formation process. Smaller frictional forces will provide favorably free cutting forces with reduced effect of heat on the work surface and reduced loading of the wheel surface by sticking work material. The cutting force determines the wheel life and wear, the accuracy and finish of the machine surface, energy consumption and other criteria of grinding process. In order to study the effect of wheel loading on various materials, some experiments were conducted. A standard sequence of operation with a single point diamond tool was followed for truing and dressing of the grinding wheel before the start of each experiment. With the work piece mounted on a dynamometer, the radial force and tangential force measurement was achieved. Loading curves was obtained in each experiment along with corresponding variation of radial force and tangential force. For mild steel and brass basic nature of the loading curves was found to be similar, (i.e.,) newly dressed wheel loaded rapidly in the initial stage and this was followed by a steady increases in the loading at a slower rate. The initial rapid loading is due to the contact between the virgin cutting surface and work piece causing free pores on the wheel to get filled up rapidly by the chips. The loading rates decrease because of continuous falling off of loaded particles due to wheel wear etc. However in this latter stage, a steady net increase in the loaded volume was observed throughout indicating a near constant positive difference between the rate at which fresh material was being loaded and that at which loaded particles were being removed from the wheel surface. In the case of aluminum it is seen that the loaded volume increases rapidly to values very much higher than observed with mild steel and brass. This may be due to material property on reduced wheel wear. The approach of saturation loading in the case of aluminum was accompanied by a marked reduction in volume removal rate. Force increased reduction in loaded volume due to rubbing between wheel and work. The nature of such curves for mild steel specimen with aluminum oxide wheel is shown in figure1 &2 for brass with aluminum oxide wheels.

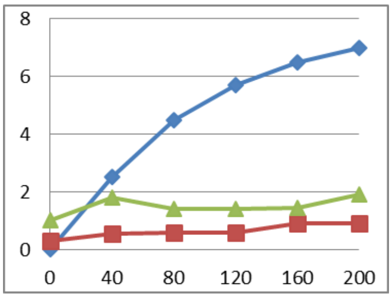

Figure.1. Loading curve for mild steel with Al_2O_3 wheel (x-axis $V_{R(}mm^2)$,Y-axis $V_{L(}mm^3)$)

The factors which increased grinding force also induce higher wheel loading. The total value of the cutting force largely determines the wear of the grinding wheel, while the relationship between the tangential and normal force gives a measure of the cutting capacity of the wheel. The dynamometer method is used to measure the force.

Method of measuring the force: In order to put the analysis of the metal cutting operation on a qualitative basis, certain observations must be made before, during and after a cut. One of the most important measurements of this type is being the determination of cutting force components. A dynamometer is used for this purpose. Normally, the dynamometer employs a plastic member which deflects under the action of cutting forces. The strain undergone at the different sections of the dynamometer can be measured by mounting strain gauges at the suitable points of the dynamometer.

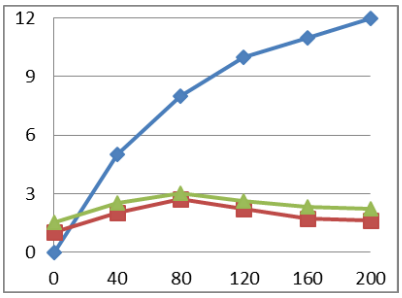

Figure.2. Loading curve for brass with Al_2O_3 wheel (x-axis $V_{R(}mm^2)$,Y-axis $V_{L(}mm^3)$

Construction

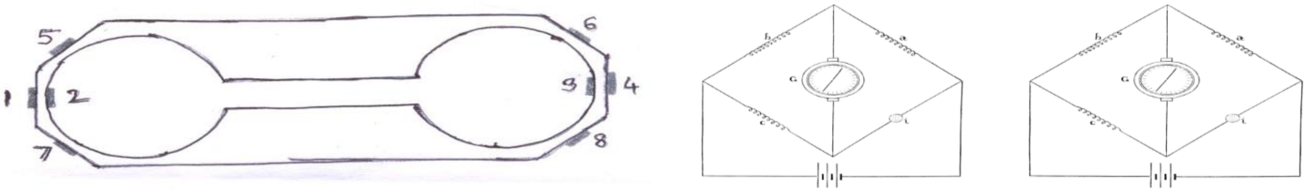

Figure.3. Arrangement of Strain Gauges in Wheatstone bridge in dynamometer.

Figure 3: Arrangement of Strain Gauges in Wheatstone bridge the figure 3 shows the dynamometer for use in measuring the radial and tangential force between a grinding wheel and work pieces in the surface grinding operation. Here we have in effect two octagonal half rings which are machined from a single piece of aluminum to provide a sensitive element of low mass and high natural frequency. Four strain gauges are mounted on each half ring and connected to form two complete wheat stone bridge circuits, one for measuring the vertical component of force and other for measuring the horizontal component. By using two gauges from each ring in each of the bridge circuits, the instrument becomes independent of the point of application of the load between the rings.

Calibration of the dynamometer: The dynamometer was calibrated for forces in two co-ordinate directions (radial and tangential). The calibration was done on a vertical milling machine table in the present investigation.

Radial force: The bottom plate was clamped in a small vice mounted on the machine table. The proving ring was placed centrally over the box type fixture. The vertical head was gradually lowered to load the dynamometer. The strain for different proving ring readings was noted. From this observation a calibration curve between strain and radial force is constructed. The relationship is linear.

Tangential force: The proving ring was kept in horizontal plane gripping between the fastening bolt of the box type fixture and vertical surface of the milling machine. While finding the strain for low magnitude forces, the grip may not be sufficient to hold the ring in between. Therefore, steel section was kept underneath the ring to support it. Then the table was moved in horizontal direction loading the ring in horizontal direction. The strain for different proving ring readings was noted. A calibration curve is drawn as shown I n figure 4 and 5 for radial and tangential force respectively with the noted readings as shown in table given below.

Table.1. Calibration of Dynamometer.

S. No	Proving ring (div)	Load (Kg)	Radial force	Tangential force
1	0	0	0	0
2	10	0.87	5	15
3	20	2.0	8	20
4	30	3.25	10	35
5	40	4.0	15	40
6	50	5.25	20	55
7	60	6.25	25	65
8	70	7.5	30	75
9	80	8.75	31	80
10	90	10.0	40	---
11	100	10.75	55	---

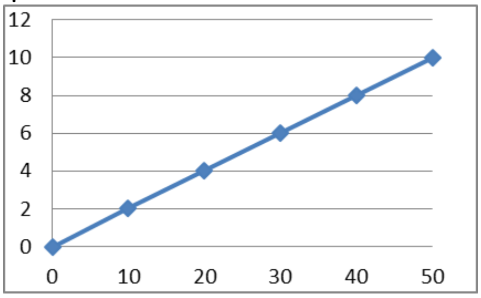

Figure.4. Radial Force (X-axis Strain in μ, Y-axis radial force).

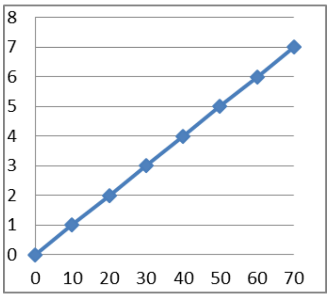

Figure.5. Tangential force (X-axis Strain in μ, Y-axis Tangential force)

The dynamic calibration to determine the natural frequency of the dynamometer may be done using a vibration generator. The dynamometer was tested for consistency. It was loaded with certain load and the strain was noted. The same load was kept constantly for several minutes. Strain was noted at some intervals. There was no change in the strain value.

Vibration: The formation of waviness on the grinding wheel and work piece circumferences is usually associated with a relative motion due to the presence of vibration which appears during grinding. The main factors which cause the vibration during grinding are the grinding time, wheel diameter, hardness and accumulation of the grinding wheel .The vibration in grinding can be divided into three groups as

- Forced vibration of the machine tool structure caused by the action of known excitation forces. The source of forced vibration is usually connected with the grinding wheel unbalance.
- Passive vibration transmitted through foundation from other machines.
- Self-exited vibration generated by the internal forces formed by the cutting action itself, without the presence of any external periodic forces.

The chatter vibration is having some influences on the grinding process. Some of them are grinding wheel and work piece start vibration radically in a systematic way. The amplitude of the distance between them will increase with grinding time. After sometimes when the amplitude has grown sufficiently, the chatter marks will appear on the work piece. Smaller grinding wheels cause higher chatter frequency than the large diameter grinding wheels.

Effect of loading chatter vibration: When a freshly dressed and balance wheel is used for grinding, on visible vibration occurs. Only after a certain machining time when no dressing operation has been applied, self-exited vibration appears and its amplitude starts to increase, gradually reading a level when the grinding process must be interrupted. Such a dynamic instability may be largely explained by the process of wheel loading and wear of the pores which takes place during the cutting action. The conventional grinding the effect of wheel loading is greater for the harder wheels. The experiments recorded shows that grinding with O and Q wheels were terminated after some time due to the wheel loading produced unduly violent vibration. The permeability is also lower. When the grinding wheel become loaded the friction force increases considerably. To analyze chatter the vibration results are continuously recorded and subsequently analyzed for wheels of three different hardness grades. Each wheel is tested under normal conditions and also with identical grinding conditions. To analyze the behavior ultrasonic technique has been adopted. The results can be interpreted as follows. The increased frictional force in the more porous softer wheels are mainly due to the accumulation of debris, which is readily removed by ultrasonic cleaning process where in high velocity movement of the fluid is produced in a small gap between the wheel and the work piece, so that the chip adhering to the grits are subjected to high energy impact by the fluid. The cleaning produced can be assessed by measuring the permeability of the wheel. The harder wheels produce a relatively greater area of worn flats on the more closely packed grits, so the removal of metal debris has a smaller effect. It will be seen from that at 105 and 120 minute immediately after the cleaning at 15 minutes interval the chatter is relatively but rapidly builds up again after 10 minutes because the smaller pores fill quickly.

2. CONCLUSION

In this it is found that as the wheel gets loaded there is an increase in magnitude of force and vibration up to a certain number of passes and then it start decreasing depending upon the wheel wear and loading. The measured force component of radial force is having more influence upon the tangential force. The radial force increases rapidly in the initial stage and then the rate is reduced until it reaches its maximum value. After that there is fluctuation in force depending upon the accumulation.

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