Research regarding the improving of the machining parameters in the field of grinding process

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Abstract: Grinding is one of the most important machining processes that confer the final size and surface finish for the workpiece. The paper presents a theoretical study regarding the manner in which the quantity of heat that results during grinding process is transmitted to the technological elements. The study reveals as well the influence of thermal deformations on the dimensional accuracy of the workpiece. Experimental data regarding the influence of cutting speed on the temperature in the machining zone for different cutting processes are distinguished.

Key-Words: grinding, balance, accuracy, machining zone, temperature

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1. Introduction

During the grinding process high temperatures are generated in the machining zone at the contact between the tool and the workpiece. This fact has consequences on the accuracy of the obtained piece. In order to maintain a high surface finish and the dimensional deviations within the tolerances it is necessary to keep the temperature in the contact area at a certain level. That is why we have to find the source of the high temperature and to achieve a thermal balance for the grinding operation.

2. Heat sources at grinding

Grinding is a manufacturing process that uses tools with undefined geometry. A number of authors consider that grinding can be compared with milling that uses a disc milling cutter where the abrasive grain can be a tooth of milling cutter.

But this model has drawbacks in that the abrasive grains have different sizes, clearance and rake angles and are situated at different distances each others. As well, grinding wheel has the characteristics of cutting edges of abrasive grains changing continuously and as a consequence the temperature which is raised in the contact tool workpiece has a variable range. Now we will consider a simplified case when an abrasive grain comes into contact to the part surface. If the abrasive grain is located at a distance that doesn't allow to cut it only rubbing the part surface without removing chips. This represents a first heat source Q_1. The force on abrasive grain increases and it can be fractured and this is other heat source Q_2.

If the abrasive grain removes chips at the tool part contact are three zones as a heating zone (Fig.1). Zone I is of elastic deformation, zone II is of elastic and plastic deformation and zone III is zone where are removing chips [1].

The heat in the contact zone is generated by the transformation of mechanical energy required for chip formation, and against friction caused by rubbing of the grain along the part surface.

As is it shown in Fig.2 the heat in the zone of tool-part contact zone is: Q_{ff} - heat at friction, Q_γ - heat between rake face and chip, Q_α - heat between rake face and part, Q_{det} - heat to remove the chip, Q_{intas} - heat caused by friction forces inside the chips.

The total heat (Q_c) will be [2]:

$$Q_c = \sum Q_{g1} + \sum Q_{g2} \qquad (1)$$

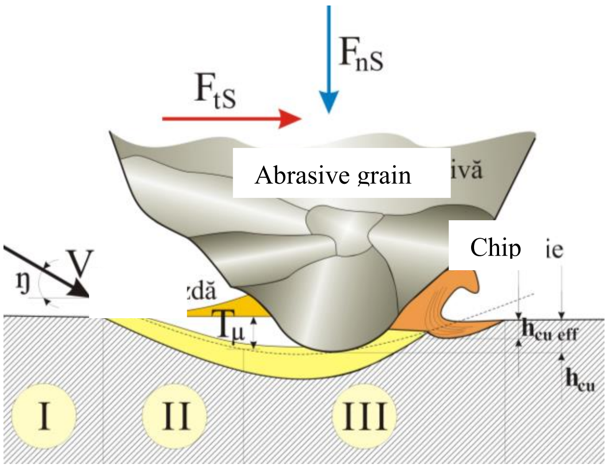

Fig.1 Chips removal in grinding operation.

where: Q_{g1} is the heat produced by an abrasive grain in contact with part surface and Q_{g2} is the heat produced by the abrasive grain which doesn't cut.

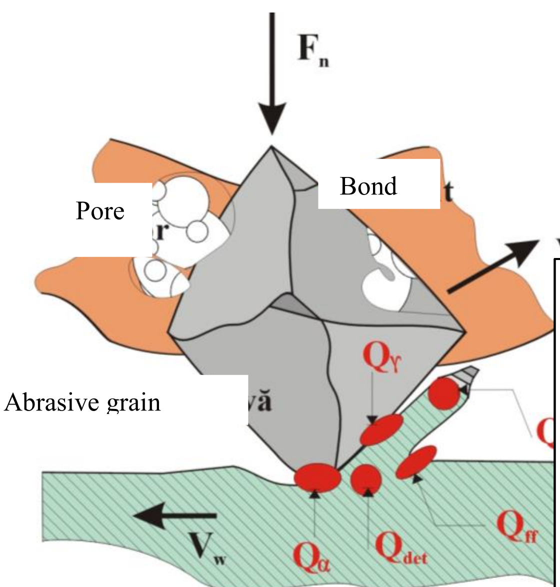

Fig.2. Heat sources at chips removing.

$$\sum Q_{g1} = \sum Q_{ep} + \sum Q_{fg} \qquad (2)$$

where: Q_{ep} is the heat generated during the elasti[...] deformation of part material by the abrasive gra[...] the heat produced by the fracture of abrasive grain.

$$\sum Q_{g2} = \sum Q_{I} + \sum Q_{II} + \sum Q_{III} \qquad (3)$$

where, Q_I, Q_{II}, and Q_{III} represents the heat from the zone I, II, and III.

3. Heat dissipating process in grinding

The model of orthogonal cutting heat dissipating can be used for grinding process: the heat generated from cutting is distributed to the chips, tool, workpiece and cutting fluid.

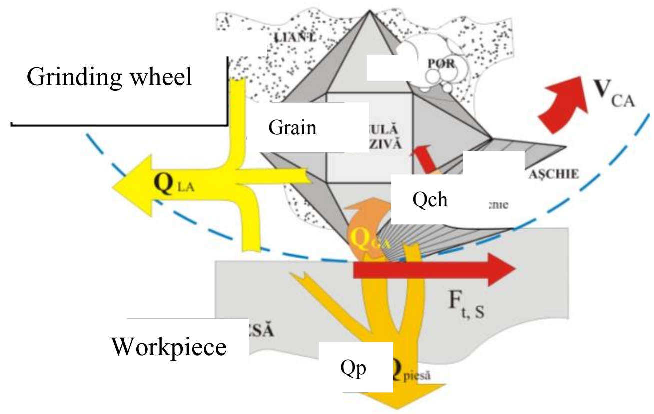

Fig.3 Directions of distributing the thermal flows in zone III.

Fig.3 shows that Q_{LA} is the heat taken by the cutting

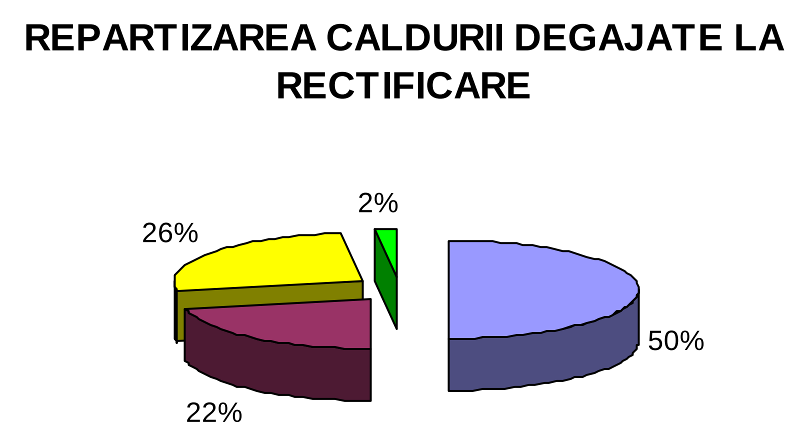

Fig.4 Distribution of heat at grinding process.

The heat taken by the environment is approximately equal to the heat distributed in the cutting fluid.

4. Thermal balance in grinding operation

The general equation of thermal balance at grinding is:

$$Q_c = Q_p + Q_{CA} + Q_{LA} + Q_{ch} \quad (4)$$

where, Q_c is the heat quantity produced by cutting.

From the equation (4) results that the main ways of action to reduce the heat taken by the part and abrasive wheel are: reducing the total quantity caused by cutting and increasing the heat taken by the chips and cutting fluid. Distribution of heat produced to workpiece causes distortions by differential thermal expansion and contraction. When a part of the generated heat is conducted into the workpiece, it expands the part being ground, thus making it difficult to control dimensional accuracy.

Distribution to the environment of heat generated in grinding operation, by cutting fluid is shown in Fig.5.

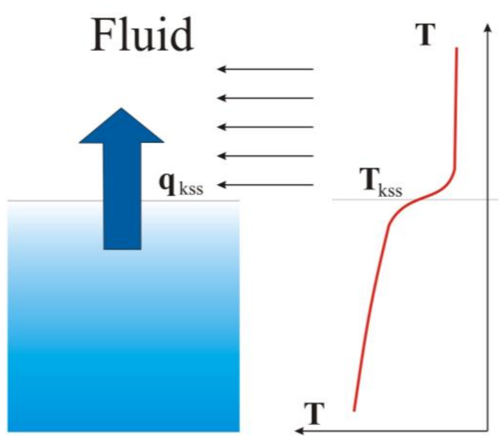

Fig.5 Distribution to the environment of the heat generated in cutting action.

According to [3] the heat generated in grinding can produce change in dimensional accuracy. For instance, the height B of a part which is ground will be modified by the value ΔB as in the following equation:

$$\Delta B = \alpha \cdot B \cdot \Delta\theta \quad (5)$$

where, α is the coefficient of linear dilatation [$1/^0C$], Δθ is the variation of part temperature [^0C] given by the formula [5]:

$$\Delta\theta = \frac{Q_p}{m \cdot c} \quad (6)$$

where, Q_p is the heat taken by the part, m is the mass of the part [kg], c is the thermal capacity of the part [J/kg^0C].

Resulting from the equations (5) and (6):

$$\Delta B = \alpha \cdot B \cdot \frac{Q}{m \cdot c} \quad (7)$$

It is noted that the changes of the part dimensions caused by the cutting generated heat is directly proportional with the heat generated in cutting, and the coefficient of linear dilatation and reverse proportional with the part mass and thermal capacity.

An example of the influence of different gradients of temperature on the accuracy of a part at grinding operation is presented in Fig.6.

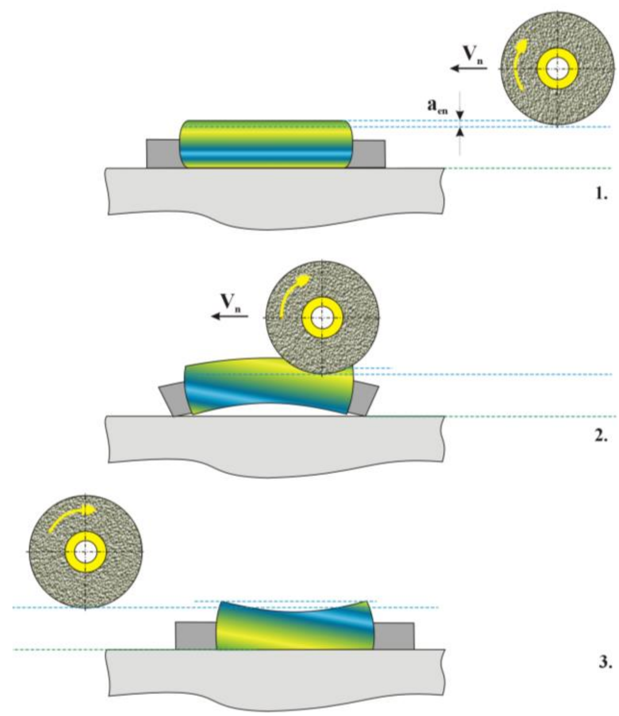

Fig.6 Part deformation during grinding process.

Before machining, the part has parallel sides and the grinding allowance is a_m. During grinding process the part takes over a quantity of generated heat and after that dissipates it to the outside. But, as in the core of the part a quantity of heat

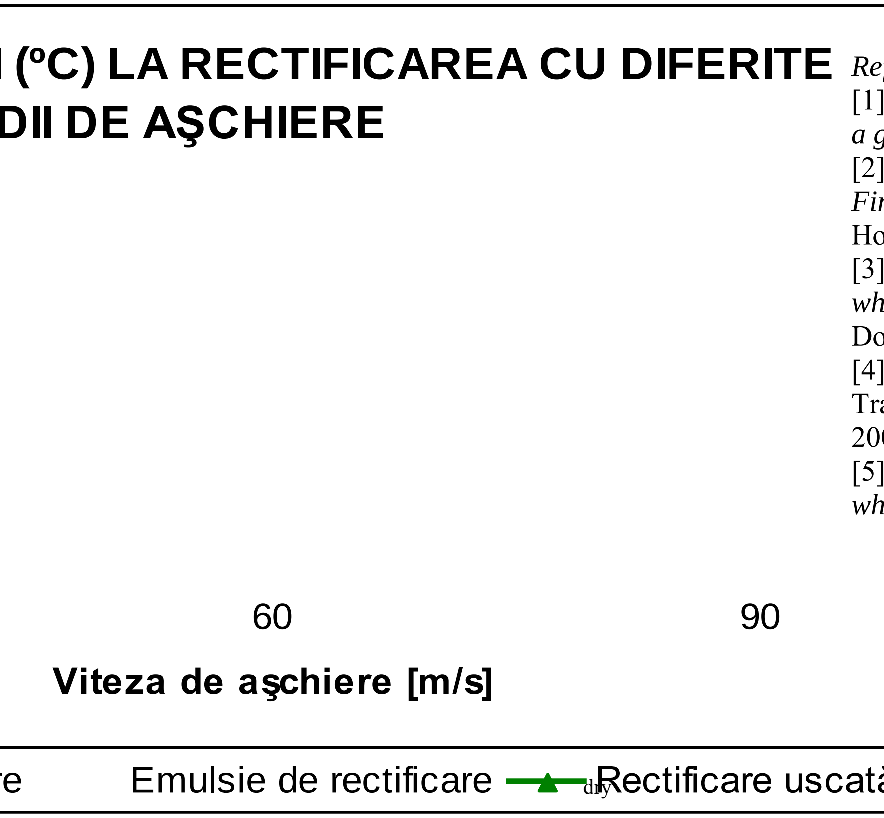

Fig.7 Part temperature at grinding by using different cutting fluids.

The values in Fig.7 were obtained for grinding a wheel made of low carbon steel with aluminum oxide, with a grinding allowance of 0,1 mm. One can note that the best cutting fluid in this case is water-base emulsion that faster dissipates the heat to the environment.

5. Conclusion

During the grinding process a great percentage of energy used to remove material from the part surface is transformed into heat, taken over by the chips. But because part being ground takes a range of temperature which affects the surface finish and dimensional accuracy is important to use a suitable cutting fluid which maintains removal of material in equal percentage from the entire part surface. In this way a good thermal balance is obtained thus creating conditions for reducing the magnitude and changing the type of residual developed stresses. The cutting fluid may be applied on the part surface as a stream or as a mist around the wheel periphery and in some cases from the inside of the wheel thus ensuring a better cooling at tool part surface.

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