

A METHOD TO DETERMINE THE DISTRIBUTION OF TEMPERATURE IN CUTTING TOOLS OF GIVEN CONFIGURATION

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Abstract: In order to predict the behavior of tools is is very important to determine the distribution of temperature during cutting. The difficulty of this problem is the impossibility to lay out the thermocouples at the surfaces placed between the cutting tool and the part to be cut. It is known that the rising of the tempering temperature leads to a gradual decrease of the fineness of the phase mixture and consequently to a decrease in hardness. In this paper is presented a method to determine distribution of temperature during cutting based on the hardness obtained after tempering.

Key words: quenching, tempering, hardness, temperature, cutting tools.

1. INTRODUCTION

The behavior of tools during running is influenced by the temperature obtained due to the friction with the part to be cut. In order to predict the behavior of tools during running is very important to know the distribution of temperature in the volume during cutting. The main problem in determining the distribution of temperature during cutting is the impossibility to lay out the thermocouples at the surfaces placed between the cutting tool and the part to be cut.

In the same time it is known that the rising of the tempering temperature leads to a gradual decrease of the fineness of the phase mixture and consequently to a decrease in hardness.

Also, there are many references concerning mathematical models from which some are developed in the form of soft sold in the markets.

In this paper is presented is presented a method to determine distribution of temperature in the volume during cutting based on a new approach of this problem, which is the hardness obtained after tempering.

2. SOME ASPECTS OF TEMPERING THE STEELS

As it is known, the quenched steel is hard and brittle due to the martensitic transformation witch is made by rising of the volume. The tempering is a subsequent heat treatment made in the attempt to realize a convenient combination of strength and toughness. This goal is realized by a heating to a temperature less than A_{c1} and a slow cooling.

During tempering, the two solutions –martensite and retained austenite- are suffering a gradual decomposition by diffusion, which arrive in a mixture of ferritic matrix with finely disseminated carbides particles. When the tempering temperature is raised, the fineness of the phase mixture is decreased and, consequently, the hardness is also decreased.

In the case of a plain carbon hypoeutectoid steel with 0,45 %C, the micro constituents obtained during tempering are in the following order: temper martensite, temper toostite, temper sorbite and globular pearlite in which the carbides particles are more and more globular. The tempering of this steel proceeds in several stages (Fig.1): I. heating up to 200 °C, when the excess carbon is eliminated as submicroscopic carbides; II. heating from 200 °C up to 300 °C, when the retained austenite is decomposed; III. heating from 300 °C to 400 °C, when are eliminated the internal stresses by recovery and recrystallization of ferrite; IV. heating from 400 °C to 700 °C, when is occurring the coalescence and spheroidizing of cementite.

Consequently, the hardness is decreasing gradually (Fig.1).

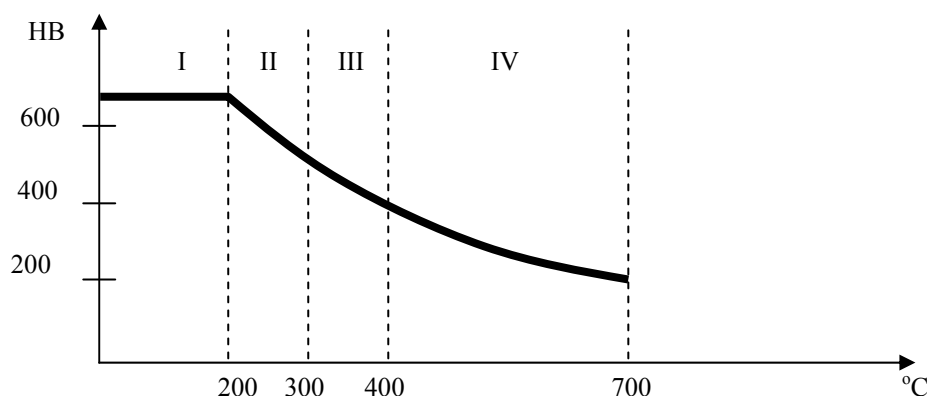


Fig.1. The evolution of hardness during tempering of the steel OLC45.

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3. ALGEBRIC SURFACES OF FIRST AND SECOND ORDER

The general form of an equation of a surface of the first order is put down as:

$$Ax + By + Cz + D = 0 \quad (1)$$

If D from the general form of an equation of a surface of the first order is put on the right side of the equation and, therefore, it is dividing by $-D$, it is obtaining the equation of a surface of the first order (Fig.2) by cuts:

$$a x + b y + c z = 1 \quad (2)$$

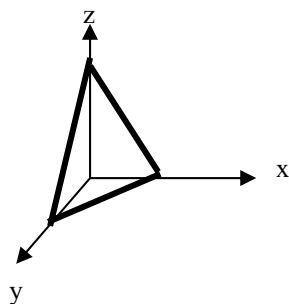


Fig.2. A plane given by the equation by cuts.

4. DESCRIPTION OF THE METHOD

Firstly, are prepared a number as great as necessary of OLC 45 steel specimens (at least 30 specimens) which have the configuration of the cutting tool to be studied. Also, the part to be cut is soft steel, as OLC 15.

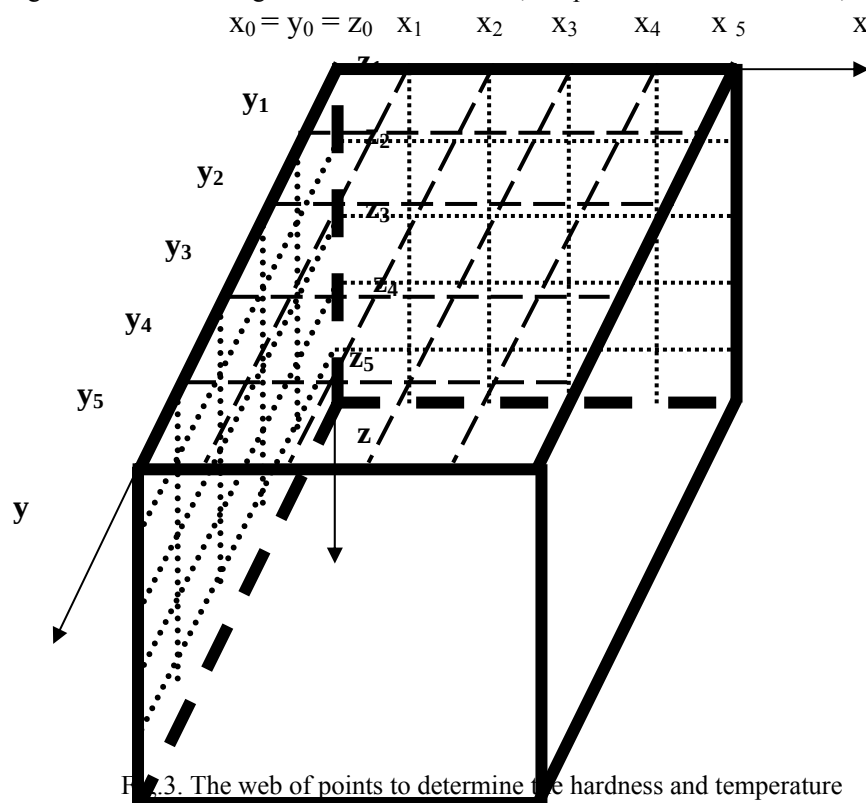


Fig.2.3. The web of points to determine the hardness and temperature

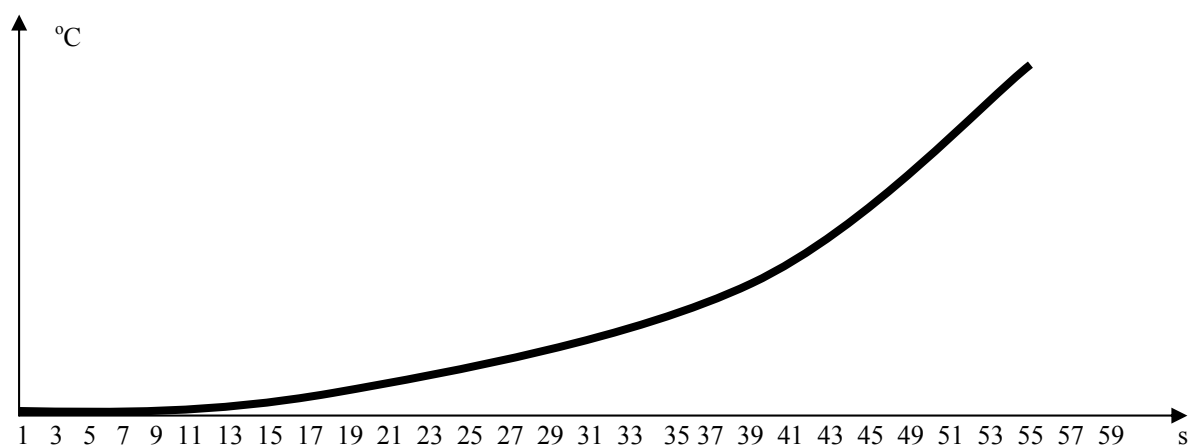


Fig.4.The evolution of temperature in time.

Table 1. The values of hardness and temperature obtained at $t = 1$ s.

x_1y_1		x_1y_2		x_1y_3		x_1y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_2y_1		x_2y_2		x_2y_3		x_2y_4	

HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_3y_1		x_3y_2		x_3y_3		x_3y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_4y_1		x_4y_2		x_4y_3		x_4y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_1z_1		x_1z_2		x_1z_3		x_1z_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_2z_1		x_2z_2		x_2z_3		x_2z_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_3z_1		x_3z_2		x_3z_3		x_3z_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
x_4z_1		x_4z_2		x_4z_3		x_4z_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
z_1y_1		z_1y_2		z_1y_3		z_1y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
z_2y_1		z_2y_2		z_2y_3		z_2y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
z_3y_1		z_3y_2		z_3y_3		z_3y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =
z_4y_1		z_4y_2		z_4y_3		z_4y_4	
HRC=	t =	HRC=	t =	HRC=	t =	HRC=	t =

The method proceeds in several stages:

- 1) The hardening by bulk quenching of all 30 specimens in the same conditions: heating temperature: 850 °C; maintaining time: at least 30 minutes; water bath;
- 2) The determining the distribution of hardness at a single specimen at the cross points of the web made from lines placed at 3 mm distance for 3 faces, as a verifying of the uniformity of bulk quenching;
- 3) The use, for the same type of cutting, of each specimen, taken separately for different times, for example: 1 s, 3 s, 5 s, 7 s, 9 s, 11 s, 13 s, 15 s, 17 s, 19 s, 21 s, 23 s, 25 s, 27 s, 29 s, 31 s, 33 s, 35 s, 37 s, 39 s, 41 s, 43 s, 45 s, 47 s, 49 s, 51 s, 53s, 55 s, 57 s, 59 s, after which proceeds to a cooling in water to reduce the self-tempering;
- 4) At the last specimen is determined the evolution of the temperature in time in an accessible point, for example, x_2y_2 with a thermocouple (Fig.2);
- 5) The determination of the hardness for all specimens at points x_1y_1 ; x_1y_2 ; x_1y_3 ..., which are mentioned in corresponding tables, for example: table 1; table 2...;
- 6) on the bases of stages 4) and 5) are converted the values of hardness in values of temperature.

5. CONCLUSIONS

The advantages of this method are the following: Permits to determine the temperature in the points of the surface where can not be placed thermocouples; May be used for all kinds of cutting tools; Permits the determination of a „cloud” of values of temperature, which is in 3D and variable in time;The „cloud” may be used as a verification of an elaborated mathematical model or as data for a new one using at least the equation of a plane by cuts.

REFERENCES

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