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Modeling the Temperature Field in a Drill Under Influence of High-Frequency Current Hardening

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Annotation. The article presents an analysis of the main structural changes associated with temperature changes under the action of surface hardening by high-frequency currents on the drill surface

Keywords: hardening, heat treatment, model, temperature, drill, depth, heating, high frequency current.

Hardening of metals by high-frequency currents, abbreviated as HFC hardening, is one of the most common methods of surface heat treatment of parts [1]. This method is used for parts made of materials such as steel (carbon and structural), as well as for parts made of cast iron [2]. The main advantage of hardening with high frequency currents is its economy. In addition, when using this method of hardening, we can harden not only all surfaces of the part, but also any of its individual zones, through which the greatest (critical) load will be distributed.

The advantage of this method is that, despite the hardening of the upper layers of the part, the inner layers remain as viscous as before heat treatment. That is, the blank acquires an increased surface hardness, but at the same time does not become brittle, remaining stable and reliable. In addition, for heating not the entire part, but only its surface, the enterprise spends a significantly smaller amount of electrical energy; therefore, it saves variable costs for the production of a particular part.

Hardening by high-frequency currents occurs in three main stages:

1) Heating in an induction furnace to the hardening temperature;
2) Exposure of the part at such a temperature;
3) Fast cooling.

Heating during hardening by high-frequency currents takes place in an induction furnace. There is also a holding of the heated part. Cooling is carried out in a special bath filled with a coolant, which can be water, oil, emulsions [3]. In addition, for cooling, special installations are used that spray coolant onto the blank.

Let us list the main advantages of this heat treatment method. Advantages of high frequency hardening are:

1) Preservation of the blank after hardening by high-frequency currents of an unhardened core, which reduces the fragility of the part after such surface heat treatment.

2) Heating only surfaces that experience maximum or critical loads saves the variable costs of manufacturing the part by saving electrical energy.

3) If the production is not a single, then with the correct setting of process automation, it will automatically perform and maintain the required quality of hardening.

4) It is possible to adjust the depth of heating of the blank, which allows understanding the depth of the hardened layer.

5) The continuous-sequential hardening method allows using low power equipment.

6) A short time of heating and holding at such a high temperature eliminates the possibility of oxidation of the top and the formation of scale on the surface of the blank.

7) Rapid heating and cooling does not result in large warp and leash, which can reduce the allowance for finishing or semi-finishing.

<u>Workflow:</u>

The temperature of hardening by high-frequency currents is taken in the range of 700-950 °C.

We import the model geometry from the Compass program (Fig. 1). This geometry is almost the same as the drill from sections 4.2 and 4.3, but with a cut made to be able to track the depth of the blank heating.

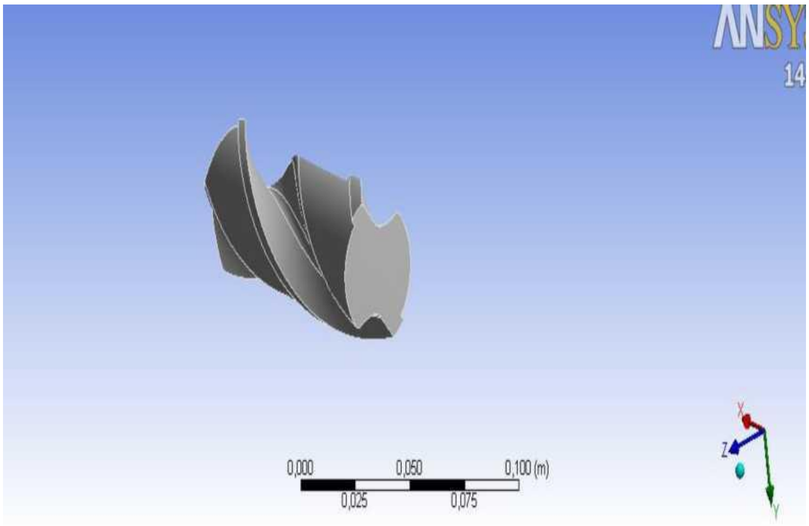

Fig.1 Importing model geometry.

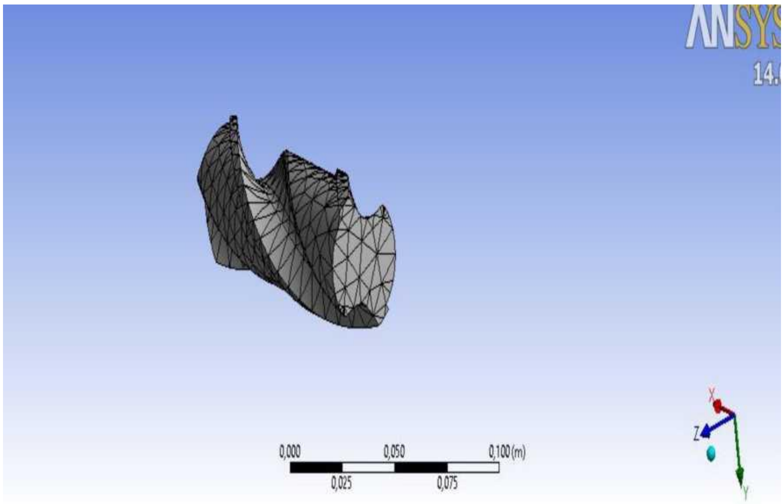

Fig. 2. Finite element mesh.

Let us apply the HFC hardening temperature T=900°C (Fig. 4):

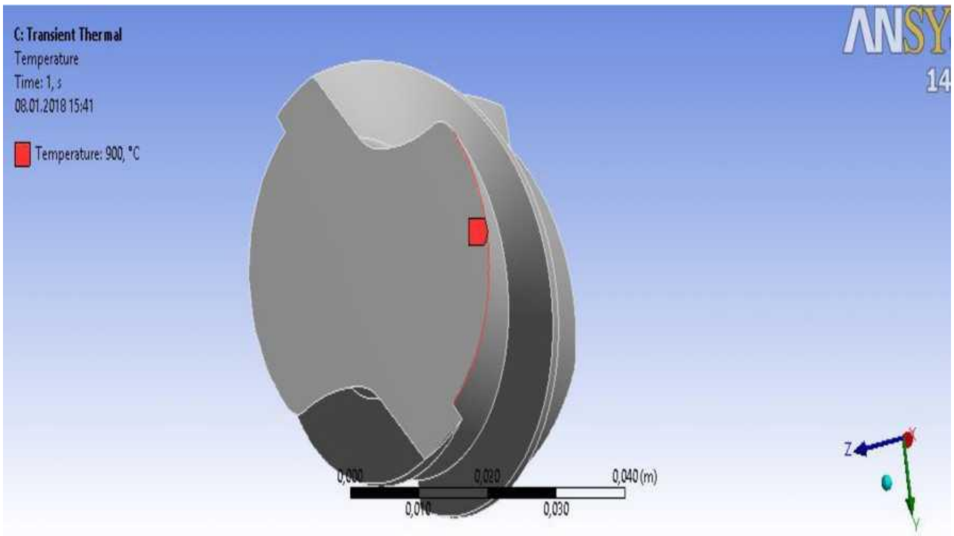

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Fig. 3. Temperature calculation.

Let us make a temperature calculation to determine the depth of heating of the drill during hardening of the high frequency current (Fig. 3):

Since it is impossible to measure the heating depth with a ruler in the results of temperature calculations due to the lack of functionality in ANSYS 14.0 [4], we use the ruler and the Paint program (Fig. 5):

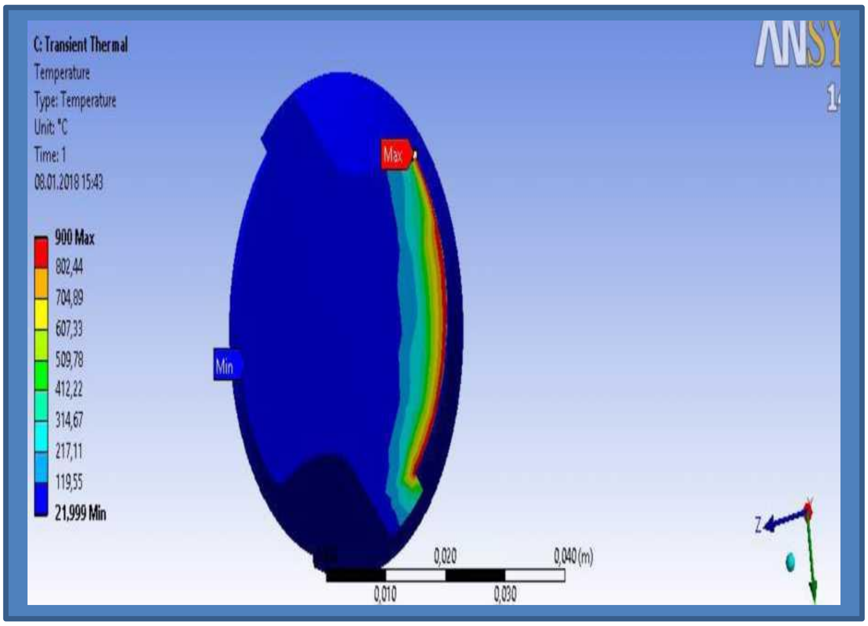

Fig. 4. Temperature application.

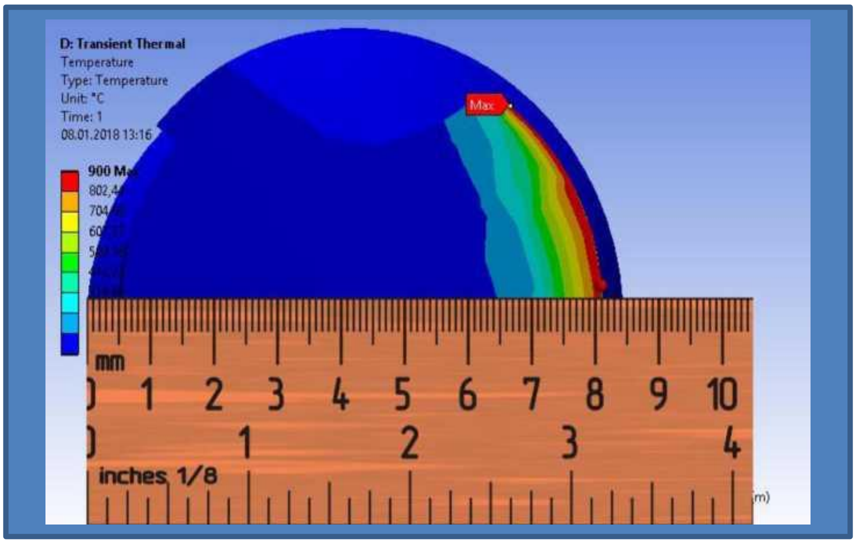

Fig. 5. Temperature calculation with the application of a ruler.

Using Fig. 37 (with a ruler) and knowing the diameter of the drill $D = 40mm$, we can find the heating depth by the ratio:

Heating depth (T>700 °C):

Heating depth (T>500 °C):

Conclusion.

The heating depth of the drill during HFC hardening was: *a=3.809 mm* (T> 700°C), and *b=3.809 mm* (T>500°C). This means that the main structural changes associated with temperature changes under the action of surface hardening with high frequency currents occur exclusively on the surface of the drill. Such a distribution of temperature fields allows, in turn, reducing plastic deformation (because only the surface is hardened) with an increase to the required values of the surface hardness of the cutting tool, in this case, the drill.

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