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The Effect of the Cooling Rate in the Cooling Process of Steel Materials on Hardness

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Abstract: This article discusses the theory of cooling steel materials. The article examines the effect of the cooling rate on the hardness of steel materials.

Keywords: Cooling, cooling rate, metal, billet, structure, temperature, process speed.

Outdoor stacking or refrigerators are most often used to cool metal workpieces. To relieve residual stresses, prevent the formation of cracks inside and on the surface of steel, and obtain metal with the necessary structural and mechanical characteristics, controlled and, most often, delayed cooling is required for individual high- and medium-carbon, high- and low-alloy steel alloys.

The choice of the mode and method of this process is also influenced by the chemical composition, the tendency to form defects during cooling and the required properties of the finished product.

With conventional cooling of metal workpieces, the purpose of which is to cool the steel as quickly as possible, special racks or refrigerators are used.

To cool individual grades of steel alloys, for example, spring steel, which must have a certain hardness, the products are placed on an edge and pressed against each other. During the process, they are moved around the refrigerator, changing the height by one row. To achieve a given hardness, the rolled products are cooled by a single mass.

If such products are cooled individually stacked on a rack, their hardness will exceed the required values. High-grade steel is also cooled in the usual way using open air and refrigerators.

Refrigerators must have dimensions and designs that allow metal workpieces to be cooled to temperatures below +50 °C.

Alloyed steel alloys in blumes and blanks are stacked or collected in bags for air cooling. By reducing the speed of the process, it is possible to avoid the formation of internal stress zones, the formation of cracks and reduce the hardness of the material to the desired values, which will make it easier to get rid of surface defects during cutting. Also, slow cooling reduces the likelihood of defects during subsequent fire hardening of steel.

The rate of cooling of steel after quenching depends on the environment in which it is carried out. The highest speed is provided by cooling in water. This method is used for medium-carbon low-alloy steels and some grades of corrosion-resistant steels. With a carbon content of more than 0.5% C and high alloying, water is not used as a cooling medium, since such alloys are cracked or completely destroyed.

For cooling, water is used – pure or with salts dissolved in it, alkaline solutions. For alloy steels, blowing or cooling in mineral oils is used. In isothermal and stepwise processes, melts of salts, alkalis and metals are used for cooling. Such environments can alternate between each other.

Slow cooling is required by solid and alloyed flake-sensitive steels. For such a process, heated through furnaces or pits and boxes (heated or unheated) are used. With slow cooling, which starts in the range of +600 ...+750 ° C, the temperature equalizes along the cross section of the profile. This allows you to eliminate the internal stress of the material in the rental.

Accelerated modes are used when cooling rolled sheets and wire rods before it is wound into rolls or bunts. The fast process allows to reduce scale formation and obtain the required metal structure. Accelerated cooling in an aqueous environment with the use of tubes or roller shutters and air is also often resorted to.

Steel in sheets or tape is cooled at temperatures ranging from +700 to +500 ° C, which makes it possible to give the metal the most uniform structure. Such high-carbon and alloyed steel grades as UD, K12, Sh 15, etc. are cooled in an aqueous medium to prevent the formation of a grid of carbides.

When cooling metal workpieces after molding, the formation of external or internal cracks and flocculants is possible. Such flaws are most often easily detected upon examination and have different lengths. Hardening or cold external cracks can appear both directly during cooling and some time after it. In this case, we can talk about hours and even days.

As a rule, such defects have a shallow depth and are elongated in the form of discontinuous lines during rolling. In some cases, the depth of cold cracks can be significant and reach the central layers of the metal. Steel alloys with low ductility can crack through when cooling, especially at the ends of the workpieces.

The causes of cold cracking can be zones of residual stress formed during rolling, or areas of thermal and structural stresses that occur during cooling of workpieces. By reducing the cooling rate of rolled products, it is possible to significantly reduce internal stress and minimize the likelihood of quenching cracks.

This does not apply to all steel alloys. For example, when cooling blums, slabs and other low-carbon steel blanks, you can not be afraid of cracking and flocculation at any cooling rate. Carefully adjust the cooling mode of the metal is necessary mainly in the manufacture of parts made of steels with alloying additives. Different types of such alloy are prone to cold cracking to varying degrees.

In each specific case, the use of various techniques is necessary to prevent the formation of defects. The highest tendency to cold cracking is shown by high-speed, high-carbon or alloyed tool, high-chromium, chromium-nickel, chromium-nickel tungsten and some similar grades of steel alloys.

Flocks are internal cracks that form in steel forgings or rolled products and have a significant negative effect on the properties of the metal. Such defects can be observed when examining micro- and macro-glyphs or in steel fractures. A high tendency to flocculation is characteristic of chromium-nickel, chromium-nickel-molybdenum, chromium, manganese and other martensitic and pearlitic steel alloys.

The formation of flocks most often takes place in the manufacture of blumes, slabs and other blanks or finished large-sized rolled products using large- and medium-grade rolling mills.

Cold cracking and flocculation can be prevented or minimized by slow cooling and heat treatment of intermediates. Various methods are used to slow down the cooling of workpieces. The metal is stacked, immersed in special pits or boxes, lined with insulating materials, lowered into heated and unheated wells.

For thermal insulation during cooling of steel billets, blast furnace slag, slag, sand, diatomaceous earth and other similar materials are used.

Nowadays, metal cooling is widely used using heated furnaces, which allow the workpieces to be kept at the right temperature for the required time period, reducing the time spent on heat treatment. This method is especially relevant for steel alloys with a high tendency to flocculation.

Special water cooling systems with special adjustment are used for quenching and subsequent self-starting with a fast thermo-hardening cooling mode.

The described methods are not universal. In addition, heat treatment is not applicable to all materials. In order to achieve the highest quality in the heat treatment and cooling of products, you should carefully choose the technology for each individual metal.

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