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COLD METAL OXIDATION

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The methods and results of studies of cold metal oxidation are presented

In mechanical engineering oxidation or burnishing - the formation of oxide films on the metal surface [1] are widely used to protect products against corrosion and to give them more attractive appearance. Metal Oxidation is carried out in several ways: chemically, thermally, electrochemically, by flame or arc [2]. Each of these methods has advantages and disadvantages concerning oxidation process technology, used equipment and accessories. This paper discusses the possibility of using a single and small-scale production of parts by two oxidation methods: chemical oxidation, cold blackening, and thermal or "hot" oxidation.

Comparison of cold blackening and hot oxidation shows that the first method has a number of advantages (Table 1):

Table 1. – Comparison of cold and hot oxidation

COLD blackening (chemically pure) – "INSTA-333 BLACK"	HOT OXIDATION
guild temperature	The bath temperature> 140 ° C
Low cost and ease of bath use	The high cost and complexity of the bath operation
Bath KhCh is always ready to use	It takes a lot of time to warm up
No warping	Perhaps buckling of parts
You can blacken iron	Problems with cast iron
Low equipment cost, easy to manufacture, self-sustaining	The high cost of sophisticated equipment
KhCh line can be installed almost everywhere, in any shop	Installation is allowed only in special rooms
simple ventilation	Need a powerful extractor
Security of service	Increased OSH requirements

– The process is applicable to the oxidation of various steels: carbon and alloy, structural and tool, cold-hot rolled, after forging or stamping, as well as cast iron and powder metals.

– Cold blackening solution is universal and parts from steels and cast irons of different brands and types can be subjected to blackening in the same tub.

– High decorative properties of the coating – the item acquires a deep rich black color, which improves its appearance and presentation.

– High efficiency of the process is characterized by the absence of costs for heating and maintaining the bath at a given temperature. The process is carried out at the shop floor temperature.

– Coating is recommended for mating parts. In the case of mating parts coating is not painted, does not crack, does not peel off. At the initial contact and during the subsequent lapping, the black oxide layer friction surfaces are produced, with simultaneous formation of the scuffed surfaces.

– The properties of the cutting tool are improved; its service life is increased.

– Landing size and hardness retained.

– There is no easily removable dark smearing plaque inherent to other blackening processes at room temperature.

– High corrosion protection. Cold oxidation technology provides excellent corrosion resistance of parts, up to 150 hours in the salt spray chamber.

– Dimensional stability-dimensions increase by 0.12-0.25 μm. This means that the surface properties of the oxidized part are maintained: the polished surfaces remain shiny, and the hardness of the heat-treated parts does not change. Dimensions of precision parts-stored "deformation, which may occur during hot oxidation – no".

– High performance - the duration of the cold oxidation process is 50-55 seconds, as opposed to 25-30 minutes with hot oxidation.
– Processability-the process is insensitive to variations in the concentration of the main drug.
– Blackening can be made on pendants, in bulk baskets or buckets, drums.
– The process is easily controlled due to the ease of control and adjustment of the working solution.
– Low capital costs-no expensive equipment, heating devices, instrumentation, powerful supply and exhaust ventilation is required.
– Safety of the solution – for the preparation of cold blackening non-aggressive, water soluble concentrate "Insta-black 333" is used; it is odorless, in contrast to the hot oxidation solution, where caustic substances are used with the presence of odors and harmful fumes with a high probability of emission and spraying of a hot caustic solution.
– Long service life of the bath-the solution can be replenished by adding a fresh drug.

Depending on the grade of steel, surface condition and whether the surface is jet-abrasive or not, the number of operations in cold blackening and, accordingly, the number of baths in the line can vary from 5 to 9

The maximum number of operations is nine.

1. Chemical degreasing-contaminants such as cutting fluids, emulsions, lubricants and corrosion inhibitors must be removed. Contamination can slow down or inhibit subsequent processes, negatively affecting the adhesion and appearance of the black film. For effective (guaranteed) degreasing it is recommended to use branded alkaline preparations "E-Wedge 148 E" or " E-Wedge 196»

2. Washing in the bath with bottom feed, top drain. Poorly washed alkaline degreasing film will quickly contaminate the bath in the next activation or blackening operation, which will lead to deterioration of adhesion of the black film and the appearance of spots on the surface

3. Etching in HCl solution (200-300 g/l) for the purpose of oxide film removal.

4. Washing in the bath with bottom feed, top drain

5. Activation by immersion for 0,5-3 min in 20 % aqueous solution of the drug "E-Prep 258" at 18-30° C

6. Washing in the bath with bottom feed, top drain.

7. Blacking – dip for 3-4 min at room temperature in acidic solution (pH of 1.8), containing ~ 20 ml/l of the drug "Instable 333 5X".

8. Washing in the bath with bottom feed, top drain.

9. Compaction by immersion of parts for 2 minutes in one of the film-forming inhibited hydrophobizing compounds called anticorrosive "E-Tech". Anti-corrosion quickly displaces moisture from the surface of the part and absorbed by the pores of the coating, providing long-term protection against corrosion. In cases where there is no need for pickling, stages 3 and 4 are excluded, and the treatment is carried out in seven stages: 1-2-5-6-7-8-9. A line of 7 baths of 75 liters is shown in the photo on the next page.

Black simple mild steel often requires even less operations – five: 1-2-7-8-9.

And in the case of applying jet-abrasive cleaning (CAO), provided that measures have been taken to prevent contamination of the surface of the products with oil, also requires five operations. Immediately after CAO the part should be cold flushed, and then immediately immersed in a blackening bath. The stage of degreasing and activation is passed (after CAO, the metal surface does not need additional activation). The sequence of operations in this case will be as following: CAO-6-7-8-9.

The black coating formed on the surface treated with jet-abrasive method will be matte.

When the processed products are immersed in a blackening solution the ions of the black compound are deposited on their surface instead of part of the iron ions passing into the solution. There is an autocatalytic reaction. The consequence of the accumulation of iron ions in the solution is the appearance of white flake particles, a mixture of amorphous iron oxide with other reaction products. This colloidal phase should be removed by continuous cyclic pumping of the solution through a filter with a retention pore diameter of 5 to 50 microns, at a rate of 2-3 bath volume per hour. The speed can be less-it is only important to ensure that the solution is constantly transparent (the bottom of the bath should be examined). Cleaning the solution from loose sludge will increase the service life of the solution to 10 years or more, improve the quality of treatment and reduce its cost.

Flushing – the most important operation of the process, which directly affects the quality of the coating. It is recommended to thoroughly rinse product in cold running water in the bath with a drain pocket, the water supply is provided from the bottom; water consumption: ~ 4 l/min flushing Time 1-2 min.

Taking into account the previously considered recommendations cold blackening of samples of different steels was carried out: 40X, R6M5, 45 steel in the research laboratory of the Department "technology and

equipment of machine-building production" of Polotsk state University. The appearance of the samples before and after blackening is shown in figure 1.

1

2

3

1 – appearance of the steel R6M5 sample before and after oxidation;
2 – appearance of the steel 45specimen before and after oxidation;
3 – appearance of the 40x steel specimen before and after oxidation.
Figure 1. – The appearance of the samples before and after blackening

As the results show, the samples after oxidation have a more attractive appearance; samples do not corrode long time and in humid atmosphere; the oxide film has sufficient adhesion to the metal. Taking into account the achieved technological effectiveness, this method of cold oxidation is recommended for the processing of parts made of carbon, alloy and high-speed steels in small-scale production.

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