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PROPERTIES MULTILAYER OVERLAY MATERIALS

VLASTNOSTI VÍCEVRSTVÝCH NÁVAROVÝCH MATERIÁLŮ

Abstract

At present a great number of machines and mechanisms of various types are used in the industrial production. Often the whole operation depends on the trouble-free service of single parts and many times a minor defect may conduce to the shutdown of the whole production line or of the other operation. From this reason the uncaused losses of many thousands often occur. One of the very effective measures of the wear resistance increase is surfacing of functional surfaces using the suitable overlay material. Used overlay materials have various properties.

In the paper the chosen overlay materials are compared by means of the abrasive wear determination. The wear resistance was tested using the laboratory apparatus with bonded abrasive particles (according to CSN 01 5084).

Abstrakt

V průmyslové výrobě se v současné době vyskytuje obrovské množství strojů a zařízení různých typů. Často je celý provoz závislý na spolehlivém chodu těchto zařízení a mnohdy i drobná závada na jediné součásti může vést k odstavení celé výrobní linky nebo jiného provozu. Tím vznikají nezanedbatelné, často mnohatisícové škody. Jedním z velmi účinným opatřením, jimiž zvyšujeme odolnost proti opotřebení, je navařování funkčních povrchů vhodným návarovým materiálem. Návarové materiály, které pro tento účel používáme, mají různé vlastnosti.

V příspěvku jsou porovnány vybrané návarové materiály, u nichž byla stanovena odolnost proti abrazivnímu opotřebení. Odolnost byla zkoušena na laboratorním zařízení s vázanými abrazivními částicemi (dle ČSN 01 5084).

1 INTRODUCTION

The optimal user utility of various products, machines, machine parts, tools and instruments affects remarkably the economy in all fields of productive and nonproductive activity. Among others it is important from the point of view of most of the materials consumption, namely of metals and metal alloys.

Losses caused by wear are not only losses of material, but they are also significant in losses in production, namely in the case of important functional parts outage. Owing to wear of the important machine functional parts often a destruction of a greater complex occurs. Then the losses are very perceptible.

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In practice several ways are possible how this aim can be reached. One of them is the surfacing of functional surfaces by the use of overlay materials of special properties. Surfacing is used not only for renovation but for new machine parts production, too. Wear resistance is an important indicator, which characterizes the overlay material suitability for the given purpose. The knowledge of all factors is necessary for the design and for the process of manufacture and renovation.

Surfacing is used not only for renovation but for new machine parts production, too. It may bring a significant effect in saving of material, costs and time. The great advantage of surfacing is the relative rapid wear resistance increase.

The main saving is in the possibility to use the common carbon or low-alloy steel and the material of higher wear resistance is applied only on edges and surfaces which get worn.

2 EXPERIMENTAL DETERMINATION OF ABRASIVE WEAR RESISTANCE

Laboratory tests

According to the conditions in the contact area the laboratory tests are classified in:

- testing machines with bonded particles,
- testing machines with free particles,
- testing machines with a layer of free particles between two contact surfaces.

Bonded abrasive particles can be in form of an abrasive cloth or of an abrasive wheel. Machines with abrasive cloth are used for testing of metal materials most often. Simplicity and reliability are their advantage. The scattering of results is relatively small. The variable quality of used abrasive cloth is their disadvantage. It must be running compensated by the use of etalons.

Following machines pertain to this class:

- machines with rotary motion – CSN 01 5084 “Determination of metal material resistance against wear by abrasive cloth”,
- machines with linear reciprocating motion, eventually machines with abrasive belt.

The advantage of machines with rotating disk is the possibility of abrasive wear testing under high temperatures. The disadvantage of all machines with bonded particles is the decreasing abrasiveness of the abrasive wheel or of the abrasive cloth in the course of tests. The abrasive particles become blunt and they crumble out by the interaction with tested surfaces. More-over the surfaces are befouled by the worn out particles.

Testing machines with free particles is possible to classify in:

- machines with abrasive vessel,
- machines with elastic disk,
- machines with abrasive drums.

The principle of machines with abrasive vessel is the vessel containing abrasive particles, which the test specimens are dipped in. The interaction of specimens and abrasive particles motion causes that the specimen surfaces wear out.

The advantages of machines with abrasive vessel are the better approximation to service features, the possibility to use various abrasive particles and to test under high temperatures, too. The disadvantage is the decreasing abrasiveness owing to their interaction with tested specimen surfaces (crushing, blunting, contamination by worn out particles etc.). In practice it is solved by the periodical exchange of abrasive particles.

At machines with elastic disk the abrasive effect is provoked by particles showered between the specimen and the rotating disk. In this way the conditions near to the operation of parts working in soil are simulated. The reduced repeatability of test results at the use of nonstandard abrasive of various particles size is the disadvantage.

Machines with abrasive drum are very simple and reliable. They make possible measurement of several specimens in one stage. The possibility of various abrasive types use (e.g. soil, sand, scappling, grit) is the advantage.

Except the above mentioned machines a row of pilot character machines exists (laboratory jaw crushers, hammer mills etc.).

It is usually possible to simulate only some of basic parameters. Therefore the laboratory test results are applicable only after the total analysis of real service conditions. On the other hand in laboratory conditions we can study the single factors influence on the wear character and intensity.

Field tests

Field tests make possible to watch and evaluate the wear directly on the given machine part or assembly group. The test results are often influenced by a variability of operation factors. Therefore they are significant only for the concrete production equipment working in similar conditions.

3 TESTED MATERIALS AND TESTING METHOD

For determination of abrasive wear resistance three overlay materials. Overlays of seven layers were welded on. The nominal chemical composition of the overlay metal is presented in Tab. 1 (according to the catalogue of the manufacturer).

Tab. 1 Nominal chemical composition (%)

Overlay material	C	Si	Mn	Cr	Ti	V
A	0,25	0,5	0,3	13	-	-
B	4,5	0,8	1	33	-	-
C	3	2	0,3	6,3	4,8	5,7

The manufacturer characterizes the overlay materials as follows:

- A – electrode for the corrosionproof martensitic-ferritic deposit, suitable for cladding on shafts, table rollers, pinions, seatings etc.,
- B – high-productive electrode for cladding on parts of earth moving and stone treatment machines subjected to high abrasion by sand, gravel, ore, coal and other mineral matters; the overlay is corrosionproof at temperatures up to 1000 °C,
- C – basic electrode giving the deposit with high fraction of fine carbides in martensitic matrix; it is abrasive wear resistant, suitable for machines for rock drilling, hammers, scrapers, excavators etc.

For cladding layers deposit the metal plates of dimensions 80 x 80 mm was used (Fig. 1).

Fig. 1 Deposit using the overlay material **A**

The test specimens of 25 x 25 mm size were made using the grinding apparatus for the metallographic samples preparation. The supply of a great quantity of the cooling liquid is its advantage. Then during the grinding any excessive heating does not occur. Using the above mentioned process 3 specimens were cut from each plate.

The etalons were made from the bar steel 12 014 of the square section of 25 x 25 x 20 mm. The hardness HV 30 of all specimens was measured using the hardness tester HPO 250. The measured results are presented in Fig. 3.

The tests of the abrasive wear were carried out using the pin-on-disk machine with abrasive cloth according to ČSN 01 5084. The pin-on-disk machines with abrasive cloth are used most often. Their advantages are the simplicity and the reliability. The results variance is relative small. The disadvantage is the variable quality of the abrasive cloth, which must be continuous compensated by use of etalons. The schematic of the abrasion testing machine is presented in Fig. 2. The machine consists of the uniform rotating disk whereon the abrasive cloth is fixed. The test specimen is fixed in the holder and pressed against the abrasive cloth by the weight of 2.35 kg. The screw makes possible the radial feed of the specimen. The limit switch stops the test. During the test the specimen moves from the outer edge to the centre of the abrasive cloth and a part of the specimen surface comes in contact with the unused abrasive cloth.

The test machine according to the ČSN 01 5084 was accommodated. The holder is adapted for the specimens of 25 x 25 x 20 mm size.

The wear resistance tests were carried out as the comparison tests. The wear was determined by weighing. The test conditions, as load, speed, length of the path were equal. The specimens and etalons were tested alternately.

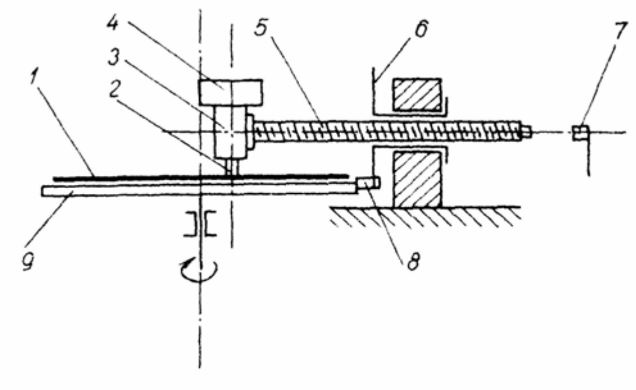

Fig. 2 Diagrammatic arrangement of the pin-on-disk machine for the abrasive wear resistance determination using the bonded particles (1 - abrasive cloth, 2 - specimen, 3 - holder, 4 - weight, 5 - screw, 6 - nut with cog, 7 - limit switch, 8 - pin, 9 - horizontal plate)

4 TEST RESULTS

The wear resistance of overlay materials was tested from the overlay surface to the basic material by steps of 1.5 mm. The hardness was measured on the front surface of dimensions 25 x 25 mm. The same surface was worn out. Afterwards the surface was grinded off to the depth of 1.5 mm and the whole process was repeated (hardness, wear resistance). The test results are presented in Figs. 3and 4. The wearing test was finished when the overlay thickness of about 2.5 mm was reached, because the specimen of smaller thickness could not be fixed in the holder. The microstructure of the overlay surfaces was evaluated, too (Figs. 5, 6 and 7).

The tests were finished when the distance from the overlay surface of 16.5 mm was reached, approximately in the boundary between the overlay and the basic material.

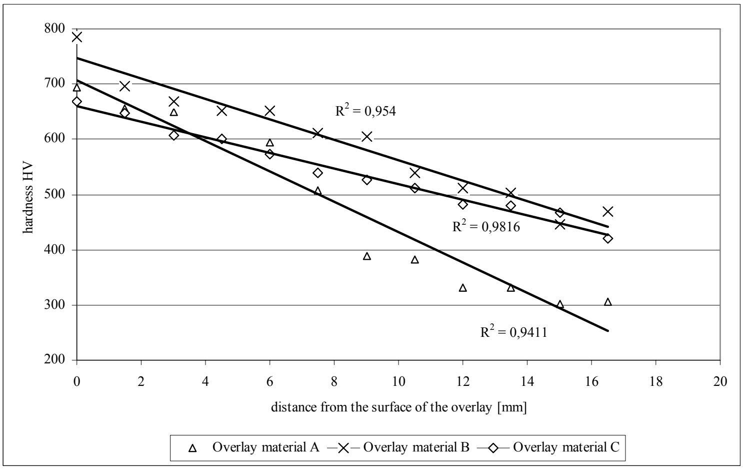

Fig. 3 Relation between hardness and distance from the surface

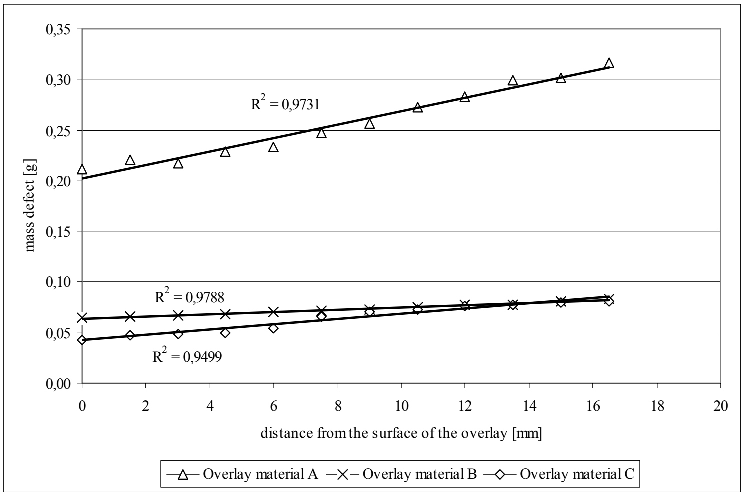

Fig. 4 Relation between mass defect and distance from the surface

Microstructures of overlay materials specimens are presented in Figs. 5, 6 and 7.

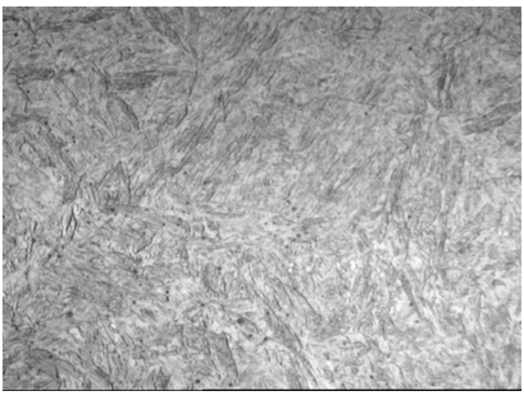

Fig. 5 Martensite with needlelike orientation - overlay A (Vilella Bain, 500 x magnified)

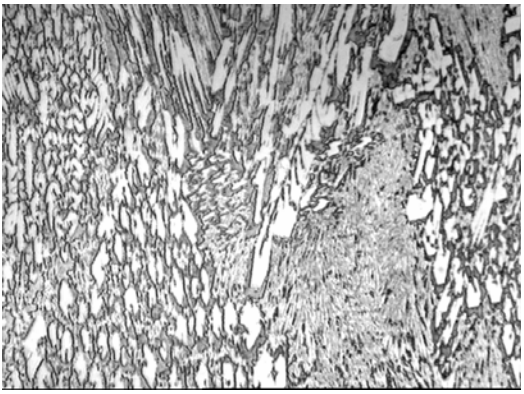

Fig. 6 Carbidic formations with fine martensite - overlay B (Kalling, 500 x magnified)

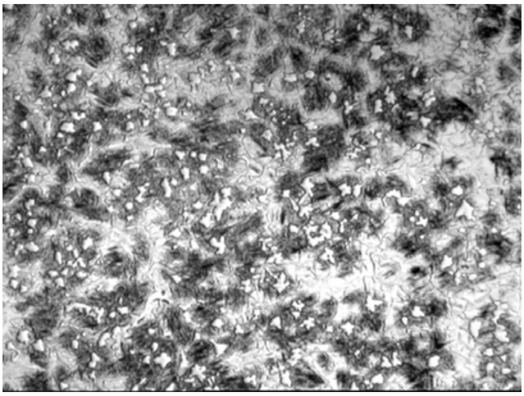

Fig. 7 Fine needlelike martensite with Cr, V and Ti carbides - overlay C
(Vilella Bain, 500 x magnified)

5 CONCLUSION

At renovation by surfacing or at preventive surfacing such processes are looked for in order to reach the best wear resistance. The wear resistance depends on the overlay hardness and on the microstructure.

According to the presumption the experiments confirmed that the hardness of all three tested overlays decreases in the direction to the basic material. The decreasing trend is possible to express by a linear equation (by a line) (see Fig. 3). At the wearing tests the mass defect of single layers was determined. The mass defect increased (again according to the presumption) in the direction to the basic material (see Figs. 4).

The decreasing character of the overlay hardness can be explained by the different cooling rate and by the different chemical composition of tested overlays. At all layers of multilayer overlays the mixing with previous layers occurs. This tendency is most expressive at the first layer when the overlay metal intermixes with the basic metal. In this way the “dilution” of the overlay metal by the previous layer metal occurs. In practice the alloying elements content of the previous layers is always smaller. Besides at cooling the reciprocal diffusion of elements in the liquid mass and in the solid solution occurs in the direction of the concentration gradient.

With regard to these presumptions it is possible to say that the course of the chemical composition will correlate with the resultant overlay hardness and the content of the most important elements of the overlay material will decrease in the direction to the basic material.

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