International Conference on Economic Engineering and Manufacturing Systems
Braşov, 25 – 26 October 2007

DEPENDENCE OF OVERLAY MATERIALS WEAR RESISTANCE ON THE LAYERS NUMBER

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Abstract. One of possibilities of parts functional surfaces betterment and in this way the service life prolongation is surfacing. Surfacing can be generally characterized as the formation of layers of special properties on metal surfaces. In this case it means the deposition of a filler material on the part surface using a suitable energy source (e.g. flame, electric arc) not only for renovation in order to reach the original dimensions, but for preventive overlays on new parts, too. In this case the reaching of suitable properties (e.g. hardness, stability to chemical attack, wear resistance) is the aim.

The best use of this method of production is the use of such a technology which is the best above all from the point of view of working requirements and service life.

Keywords: overlay materials, functional surfaces, abrasive cloth, abrasive wear, abrasive particles

1. Introduction

Development of fields of science and technics as metallurgy, mechanical engineering, civil engineering etc. conduces to changes in the sphere of production, where higher specific outputs are demanded, continual manufacturing techniques are supported, requirements on extraction, transport and treatment of various materials grow. New machines must secure a long-term trouble-free operation also with regard to production lines and plants.

Almost every set and mechanism includes a row of places of friction and excessive wear, which limit the machine capacity or the product quality. For these problems solution it is necessary to collect and to evaluate a great number of data and only afterwards to formulate laws of machine parts wear. But first it is necessary to reduce the number of empirical relations, which are now dominant in the field of friction and wear. Nevertheless it is necessary to solve the problems of friction in connection with its undesirable effect – wear [2, 5].

Owing to the technical development tendency in many cases the machine dimensions, revolutions, operating speeds, pressures and temperatures increase. With the increased operating parameters the undesirable effects often worsen in the machine surroundings. Especially they are vibrations, noise level, amount of exhalations and industrial waste. Mostly it is owing to the operating conditions deterioration with regard to the excessive wear of functional surfaces. Nor the miniaturization tendency decreases the pretensions to material properties. On the contrary owing to the joints of friction reduction and at the operating capacity conservation these pretensions increase. Problems of friction or wear resulting from operating parameters increase or from miniaturization can increase so much that with regard to the material properties we find ourselves up to the material suitability. One of this situation solution is the seeking of new first-rate materials [3, 4, 5].

2. Used materials

In the repair practice many overlay alloys of different properties are used. It is possible to classify them into these classes:

1) Martensitic overlays: this class includes all overlays which can acquire the martensitic structure by hardening. The maximum hardness of the heat treated martensitic overlay depends above all on the carbon content.

The hardening or the other heat treatment is exceptional, therefore for the classification the hardness reached by cooling by heat removal into the basic material, so called natural hardness, is decisive.

2) Austenitic overlays: they are very wear resistant after the strain hardening. These steels are very ductile, but they have relatively low hardness – about 200 HV. By hard strokes the surface

formation hardens and the hardness increases up to 500 HV and is more wear resistant.
3) Ledeburitic overlays: in contrast to martensitic and austenitic overlays the overlay from the alloyed cast iron has the characteristic ledeburitic structure of very high abrasive wear resistance. Above all the hypereutectic cast irons, containing the long needles of free carbides in the basic more ductile eutectic, are very suitable for hard wear conditions caused by mineral abrasive. Partly the cheaper white cast irons are used, which differ only by the higher chromium content (2 to 5 %), partly the high alloyed cast irons, which contain 20 to 30 % of chromium.
4) Nonferrous materials on the cobalt and nickel basis: nonferrous materials on the cobalt basis are used with regard to their excellent properties to special purposes. Their merits are:

- high hardness up to about 700 ºC,
- maximum hardness can be reached without the heat treatment,
- high stability to chemical attack,
- high wear resistance.

5) Carbides: the tungsten carbides have the high hardness and the abrasive wear resistance by minerals. The overlay demands the ductile basement of the basic material to acquire besides the abrasive wear resistance the impact resistance, too [1, 3, 4, 5].

2.2. Tested overlay materials

In the repair practice many overlay alloys of different properties are used.

Eight overlay materials were chosen. The wear resistance of one, two and three-layer overlays were compared.

Use field:

The overlay material **A** is the universal overlay material determined for the hardening of parts, which are exposed to the intense emery wear at low effort, e.g. conveyer screws, dipper teeth, sand pump mixers and for cover layers on the ductile weld metal or on the hard Mn steel.

The overlay material **B** is determined for the universal hardening of parts from steels, alloy steels and Mn hard steels which are exposed to abrasion, pressure and impact. Preferred use field is the surfacing of parts for soil working, e.g. elevation dredger teeth, and parts for working of rock, e.g. breaker jaw, breaker cone, impact strip and hammer of the grinding mill bruiser, cutting edge and working surface of the cool work tool. Machining of the weld metal is possible only by grinding.

The overlay material **C** is determined for the hardening of the parts which wear out at uniform impacts. The main use field is the surfacing of tools soil working machines and for rock breakers.

The overlay material **D** is the basic electrode for cladding on operating machine parts in agriculture and forestry subjected to abrasion and mild impact.

The overlay material **E** is the basic electrode for cladding on functional surfaces subjected to abrasion combined with impact (earth moving machines, spike-teeth, mill parts, sealing surfaces). Suitable properties of overlay are at elevated temperatures, too.

The overlay material **F** is the basic electrode for cladding on functional surfaces subjected above all to high abrasion by soil and other mineral materials combined with compression and impact. It is used for cladding on functional surfaces and edges of earth moving machines and tools, millwheels, hammers for cement mills, edges of screw conveyers etc.

The overlay material **G** is the basic electrode for cladding on functional surfaces subjected to abrasion combined with impact and compression, if need be in aggressive medium also at elevated temperatures.

The overlay material **H** is universally applicable for welding of high stressed parts of pipeline power systems, hauling units, pressure vessels, ship and engineering structures made from steel of strength about 480 MPa. It is suitable for all welding positions, except vertical from above downwards.

Table 1. Chemical composition of used electrodes (%)

Electrode	C	Si	Cr	Mn	Mo	Nb	W	V
A	3.2	1	29	x	x	x	x	x
B	0.5	2.3	9	0.4	x	x	x	x
C	0.5	0.8	7	1.3	1.3	0.5	x	x
D	0.5	0.3	6	0.7	0.6	x	x	x
E	3.4	0.8	29	0.5	x	x	x	x
F	3.5	2	24	0.9	x	x	x	x
G	3.6	2.8	13	1	1	x	7.5	1.5
H	0.05	0.4	x	0.8	x	x	x	x

3. For tests used materials and their evaluation

For cladding of 1 layer, 2 layers and 3 layers deposit the metal plates of dimensions 78×80 mm was used (figure 1).

Figure 1. One layer deposit using the overlay material **A**

The test specimens of 25×25×17.5 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 25×25 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 relative wear value ψ_h [%] is calculated as a ratio of the mass lost of the test specimen to the mass lost of the reference specimen (etalon). The test results are presented in figure 4. As we do not know the density [ρ], the relation presented in the standard ČSN015084 was adapted and the relative wear value is calculated using the relation (1).

$$\psi_h = \frac{W_{hPZ}}{W_{hZ}} \qquad (1)$$

where W_{hZ} – mean mass of lost of the tested specimen [g], W_{hPZ} – mean mass of lost of reference specimen (etalon) [g].

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 figure 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 25×25×17.5 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.

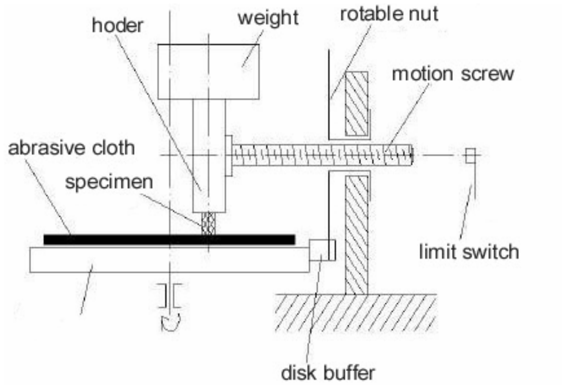

Figure 2. Operating principle of the pin-on-disk machine

4. Test results

Measured test results are represented in figures 3 and 4. Figure 3 shows the measured hardness of single layers. The highest hardness was determined at the material G. Compared with other overlays this material contains additional carbide generating elements W and V. It is evident that with the increasing layers number the hardness increases. The hardness of the constructional electrode was minimal.

Figure 4 shows the relative abrasive wear resistance. Compared with figure 3 it is evident that materials of high hardness need not have higher wear resistance. With increasing number of welded-on layers the relative wear resistance increases, too.

The increasing character of hardness and of relative wear resistance can be explained by different cooling rate in single overlay layers and by different chemical composition of tested overlays. At multilayer overlays the mixing with previous layer occurs. This tendency is the most expressive at the first layer when the overlay metal intermixes with the basic metal. Therefore the hardness and the wear resistance of one layer overlays are less than of two or three layers overlays.

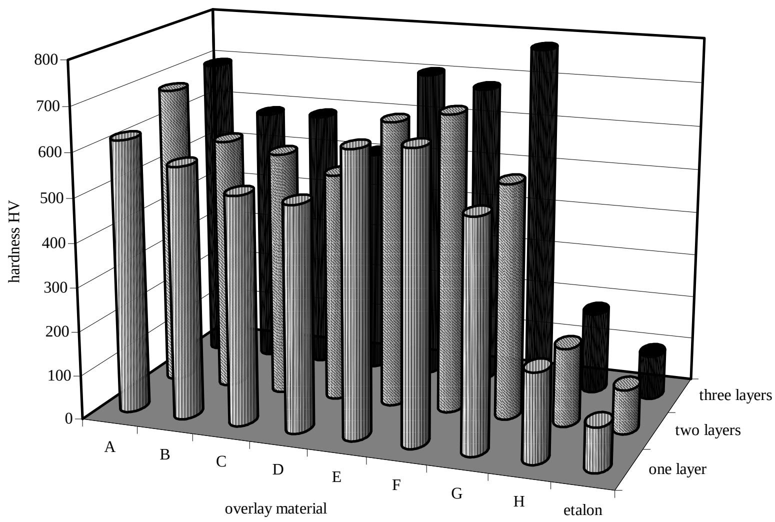

Figure 3. Measured hardness

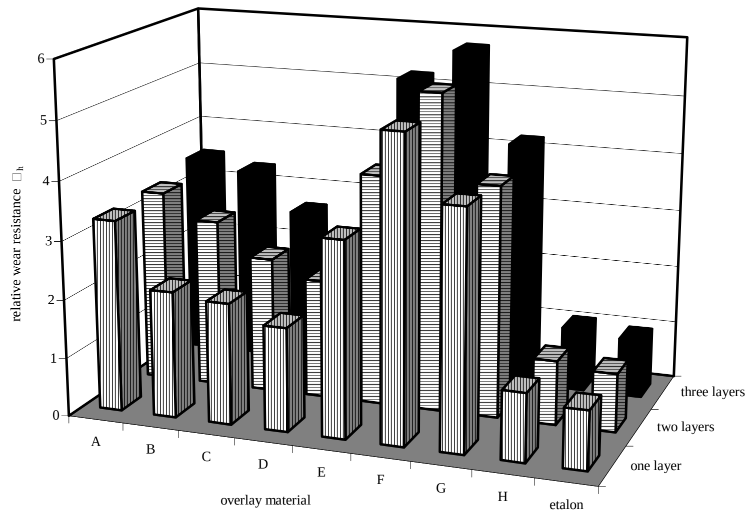

Figure 4. Measured relative abrasive wear resistance

For the complex and objective judgment whether the given overlay material is suitable for the concrete application it is necessary to verify the laboratory tests by a field test, when the test conditions should be the same or similar to the real conditions.

5. Acknowledgement

This paper has been done during the solution of the grant TF CZU 31140/1312/313105 of the title “Study of martensitic overlay layers and of the structural phases influence on their properties”.

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