ANTIFRICTION PROPERTIES OF PLASMA-SPRAYED STEEL COATINGS

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In recent years, there has been a considerable increase in the use of the plasma-spraying deposition process. Up to now, however, the process has been used mainly in rocket engineering and power-generating plant construction, where good oxidation resistance and protection against the effects of heat are the principal requirements to be fulfilled by coatings, and for this reason spraying has been performed mainly with ceramic oxide composites and refractory oxygen-free compounds.

Other methods for the application of surface coatings (gas-flame and electric arc spraying) are used mainly in the construction of agricultural machinery and in repair work, where coatings are expected to improve the antifriction properties and wear resistance of parts. The excellent antifriction characteristics of gas-flame and electrometallized coatings are chiefly attributable to their appreciable porosity, which creates favorable conditions for the manifestation of the "self-lubrication" effect. However, there has been a tendency of late for the range of applications of these coatings to decrease, mainly because of their insufficient strength of adhesion to the substrate material.

The mode of deposit formation in plasma spraying is essentially the same as in all other spraying techniques, and consequently plasma-sprayed coatings are also porous, which makes them in principle suitable for use as antifriction, wear-resistant materials for friction units of machines. An important characteristic feature of the plasma-spraying process is the high temperature attained in the plasma jet (15,000-30,000°C compared with 3000°C in the gas-flame jet and 5000-6000°C in the arc jet). The plasma jet ensures extremely high (supersonic) particle flight velocities. Inert gases, mainly argon and nitrogen, are used for plasma generation. These characteristics of the plasma-spraying process enable the properties of the resultant coatings to be controlled within wide limits. It has been demonstrated [1] that the strength with which plasma-sprayed steel coatings adhere to their substrates is three times the strength of adhesion of gas-flame and electrometallized steel deposits. Antifriction plasma-sprayed coatings have so far received very little study and have found no practical application.

TABLE 1

Coating	Wear after $480 \cdot 10^3$ roller revolutions, μ			Relative wear resistance, %		
	roller	mating part	joint	roller	mating part	joint
Uncoated induction-hardened Type 45 steel	52,0	39,0	91,0	100	100	100
Electrometallized	85,5	54,5	140,0	61,0	72,5	65,0
Plasma-sprayed	55,5	30,0	85,5	94,0	129,0	106,0

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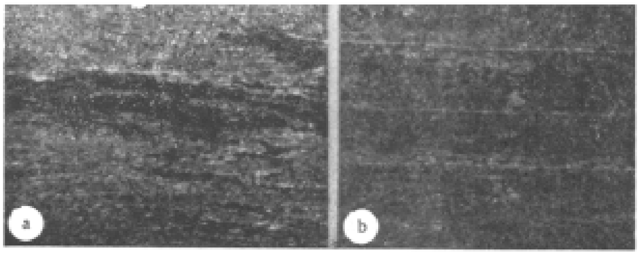

Fig. 1. Friction surfaces of mating parts after rubbing against: a) electrometallized coating; b) plasma-sprayed coating.

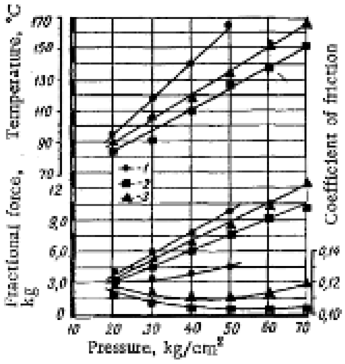

Fig. 2. Characteristics of friction process at variable loads: 1) induction-hardened Type 45 steel; 2) plasma-sprayed coating; 3) electric arc coating.

The object of the present work was to study the antifriction properties of plasma-sprayed coatings and to assess the possibility of utilizing this technique for increasing the wear resistance of automobile and tractor components and for the reclamation of worn parts. Determinations were made of the relative wear resistance of plasma-sprayed coatings, their sensitivity to load variations during the friction process, and their resistance to seizure under conditions of interrupted lubricant supply. In earlier investigations [2-4], automobile and tractor components were reclaimed by the arc spraying of high-carbon steels, particularly U8A steel. To obtain a basis for comparison, in our work, too, U8A steel was chosen as the coating material. The material of the substrate, rollers to be spray coated, was normalized Type 45 steel – the most widely used automobile steel.*

The antifriction properties of coatings were investigated in the friction machine described in [2], which is based on the principle of a shaft rubbing against a segment of an insert. The results of tests on plasma-sprayed coatings were compared with those obtained for Type 45 steel quenched to a hardness of 55 HRC (reference standard) and electrometallized coatings. The latter were spray-deposited by the process recommended in [3]. After spraying, the coatings were machined to the required depth, ground, and impregnated with oil at a temperature of 80-90°C for 20 h.

In [3-6], it is noted that electrometallized coatings exhibit high wear resistance in operation with copious lubrication, but are insufficiently wear-resistant under boundary friction conditions. As the latter type of friction predominates in the majority of real friction units and, in addition, is accompanied by substantial wear, test conditions close to boundary friction were chosen for our experiments. The lubricant selected, a transformer oil to GOST 982-56 standard, was a relatively poor lubricant and had low viscosity, which also helped to establish conditions approximating boundary friction and ensured high rates of wear.

In view of the need to attain an appreciable intensity of wear in a short time at relatively low friction surface temperatures and the desire to obtain experimental results comparable with those reported in [3], a constant sliding velocity of 2.3 m/sec was chosen for our tests and the load was varied in the range 20-70 kg/cm². In such tests, conditions approaching those of boundary friction are established, according to [3], when one drop of lubricant is supplied every 45 sec of testing.

Wear was measured with a UPOIV-2 instrument, measurements being repeated five times at intervals of 4 h. The wear of the mating parts, made of ASM antifriction alloy,† was determined by weighing (with an accuracy of 0.2 mg) and analytically converted to linear wear. In addition to the wear measurements, determinations were made also of the temperature in the contact zone of rubbing pairs and the frictional force. The running-in process of the rubbing parts was taken to have been completed when the

*U8A and Type 45 are carbon steels with 0.8 and 0.45% C, respectively – Publisher.

† Nominal composition: 3.5-5.5% Sb, 0.3-0.7% Mg, balance Al – Publisher.