Scientific and Practical Seminar dedicated to ninety years since the birthday of Doctor of Technical Sciences, Prof. M.I. Razikov (1922–1975), a known scientist in the field of welding and surfacing, who had been working for many years as a head of the welding chair at the Urals Polytechnic Institute, was held in Nizhny Tagil on the 3rd of February 2012. Prof. Razikov was also the organiser and first leader of the branch surface laboratory at the Urals Polytechnic Institute. The Seminar was attended by over 80 specialists and managers of 35 enterprises and organisations from 17 cities of Russia and Kazakhstan, including a number of leading mining and metallurgical enterprises of the Urals region — Nizhny Tagil and Chelyabinsk metallurgical works, Kamensk-Uralsky and Serovsky metallurgical factories, Uralvagonzavod, Kochkanarsky and Vysokogorsky ore-dressing and processing enterprises, Uralmashzavod, etc. The Seminar considered in detail the subject of upgrading of repair of mining and metallurgical equipment parts by using plasma hardening. Below we give the paper presented by Dr. V.A. Korotkov, covering the experience of application of plasma hardening unit UDGZ-200 at different companies.

Editorial Board

EXPERIENCE OF APPLICATION OF PLASMA HARDENING UNIT UDGZ-200 AT ENTERPRISES OF THE URALS REGION

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It is well known that the constricted arc (plasma) is widely applied for welding, surfacing, deposition of protective coatings, surface hardening, etc. Company «Composite Ltd.» (Nizhny Tagil) developed and certified mobile unit UDGZ-200, allowing plasma hardening to be performed with a hand tool. The unit has a double-case design, weight of 20 + 20 kg, and is powered from the 380 V mains, the power consumption being 10 kW. Argon is used as plasma and shielding gas, the consumption of which is 20 l/min. Productivity of the unit is 25–85 cm^2 of the surface treated per minute. Depending on the grade of the steel being processed, hardness of the treated layer is *HRC* 45–65, and its thickness is 0.5–1.5 mm. Carbon or tool steels are subjected to treatment. Therefore, no special cooling of a workpiece is required, this making the labour management much simpler. The required cooling rate is provided by removing heat into the bulk of a workpiece.

Figure 1. Die block for cutting of receiver bottoms after plasma hardening

Plasma hardening of different-purpose dies has received considerable acceptance. For instance, application of plasma hardening unit UDGZ-200 at Uralvagonzavod allowed hardness of the leading edges of cutting dies made from steel 5KhV2S to be increased to *HRC* 61, that from steels 5KhNM and 7Kh3 to *HRC* 64, and that of steel U8 — to *HRC* 58. Plasma treatment provided an approximately 2.7 times increase in resistance of the dies. The die block for cutting of receiver bottoms is shown in Figure 1. The discernible temper colours usually appearing in heating of metal do not lead to deterioration of parameters of surface roughness.

Plasma hardening of cast iron dies (inserts) for forming of large-diameter pipes is performed at the Chelyabinsk Pipe Rolling Mill (Figure 2). Earlier the Mill used gas flame hardening for such dies. Application of plasma hardening using a hand tool instead of gas flame hardening provided increase in hardness of

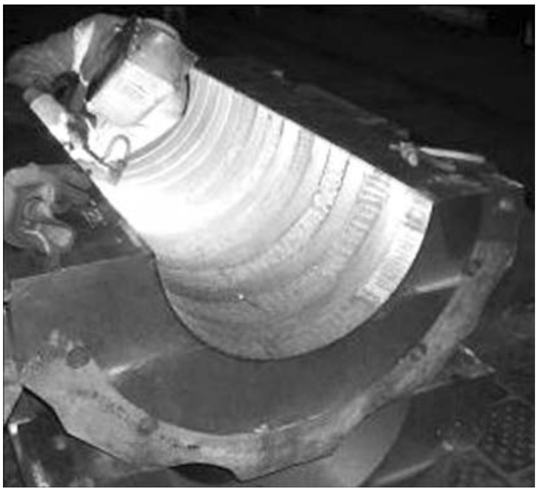

Figure 2. Plasma hardening of die performed at the Chelyabinsk Pipe Rolling Mill

the dies from *HRC* 50 to *HRC* 60. As a result, their resistance grew about 3 times.

Corporation VSMPO-AVISMA obtained positive results from application of plasma hardening for multi-ton dies of steel 5KhNM. For higher hardness and wear resistance, tempering of these dies after hardening from furnace heating was performed at a decreased temperature. But that affected strength of the dies — they began cracking. Surface plasma hardening allowed increasing the tempering temperature to prevent cracking without any decrease in hardness and wear resistance. As an experiment, this approach was applied at the Kamensk-Uralsky Metallurgical Factory (Figure 3).

Many large-size dies have a long-time manufacture cycle, involving cutting into relatively small parts for volume hardening in furnaces and subsequent labour-consuming fitting up of hardened fragments into a whole. The Volzhsky Motor Car Factory conducted an experiment by replacing volume hardening by surface plasma hardening (Figure 4), which allowed avoiding fitting up of the hardened parts (about 30 % of the total work content consumed for manufacture of a die), as they were manufactured as a whole following the drawing dimensions. A die used to make over 70,000 items (automobile cover tail beams) is still in a workable condition. The labour consumption for repair «conditionings» decreased approximately

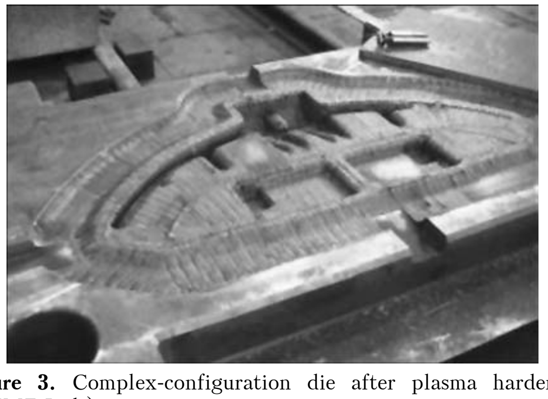

Figure 3. Complex-configuration die after plasma hardening (KUMZ Ltd.)

Figure 4. Fragment of split die after plasma hardening

10 times due to reduction of frequency and duration of these operations.

The similar result was obtained also by the Gorky Motor Car Factory with experimental hardening of

Figure 5. Die block of GAZ car after plasma hardening of pressure loop

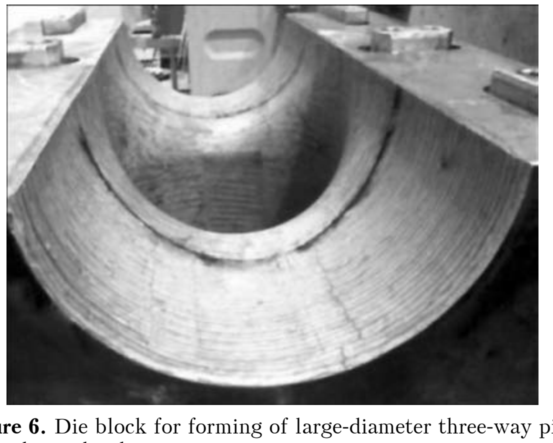

Figure 6. Die block for forming of large-diameter three-way pipes after plasma hardening

Figure 7. Plasma hardening of teeth of coarse-pitch gear

Figure 8. Plasma hardening of freight car centre plate collar and fragment of hardened surface

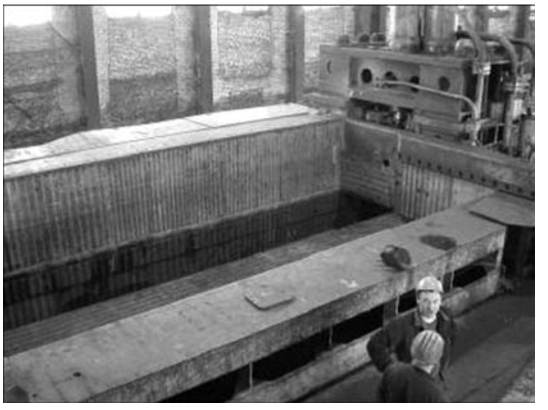

Figure 9. Shearing machine hopper lined with plates after plasma hardening

die blocks used for forming of right and left front car wings (Figure 5).

Three sets of die block for manufacture of formed-welded three-way pipes with a diameter of 530, 720 and 820 mm (steel 30GSL) fractured because of low hardness approximately after 50 forming operations at the Liskinsky Factory of Assembly Blanks. Plasma hardening with subsequent dressing of surfaces (Figure 6) allowed restoring performance of the die blocks. After the same quantity of formings they remained suitable for further operation.

Unit UDGZ-200 is successfully applied for hardening of gear and spline drives with modulus $m \geq 6$ (Figure 7). Plasma hardening is used to treat gear rings of mills, double-helical teeth and splines on gear shafts, transmission gears of railway locomotives, etc. As a result of plasma hardening the service life of gears is extended 2–3 times.

One of the most wearing locations on a freight car truck is a centre plate collar. Plasma hardening applied by Uralvagonzavod provided a two times increase in hardness of the collars (Figure 8), i.e. from *HB* 180 to *HB* 360, which resulted in a considerable reduction of their wear (from 1000 to 50 μm / 100,000 km).

This enterprise has experience in plasma hardening of transportation rails for wheelset axle production line. After manufacture of 200,000 axles the rails wore out by 3.2 mm in height. Similar rails after plasma hardening wore out only by 0.5 mm after manufacture of 320,000 axles. Therefore, wear resistance was increased more than 6 times as a result of plasma hardening. At present, Uralvagonzavod is arranging application of plasma hardening for mass production of railway cars.

The similar result was obtained with rail tracks for workshop transfer buggies at the Chelyabinsk Pipe Rolling Mill. Before utilisation of plasma hardening the rails were replaced at a frequency of one to two times, and in the most heavy-loaded sections — up to six times a quarter. That created much tension, as the rails were of a special gauge, and they were imported from Germany. After plasma hardening of rails and wheels in 2006–2007 their wear slowed down dozens of times, and the rails were replaced only in 2011.

The Mill performed plasma hardening of heavy crane rails KR-100. Wear of the hardened rails was about 0.2 mm, and that of the non-hardened rails was approximately 2 mm, the operation life being identical.

To provide protection from fast wear, the working surfaces of Pilger mill stands are covered with face plates, which are usually replaced three times a year because of wear. The stand itself under the face plates wears out by up to 10 mm, and it is necessary to clad it once a year and then mill the deposited layer. Plasma hardening of the face plates and working surfaces of the stands provided decrease in the rate of their wear, and consumption of the plates and quantity of the claddings on the stand were reduced by a factor of 3. The similar effect was obtained with plasma hardening of lining plates of the shearing machine hopper at Metallurgical Works «Kamastal» (Figure 9).

At present, Composite Ltd. performs plasma hardening of up to 1000 m^2 of working surfaces of various parts by using units UDGZ-200. Such a unit was purchased by Uralvagonzavod, VSMPO-AVISMA, ORMETO-YuUMZ, Orsk and Bakal mining equipment factories, as well as enterprises of Kazakhstan and Ukraine.