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DEVELOPMENT OF ELECTROMETALLIC EQUIPMENT AND NEWEST CONSUMABLES FOR APPLYING PROTECTIVE AND REDUCTIVE COATINGS TO PARTS OF MACHINERY USED IN MINING, TRANSPORT, AND FOOD PROCESSING INDUSTRIES

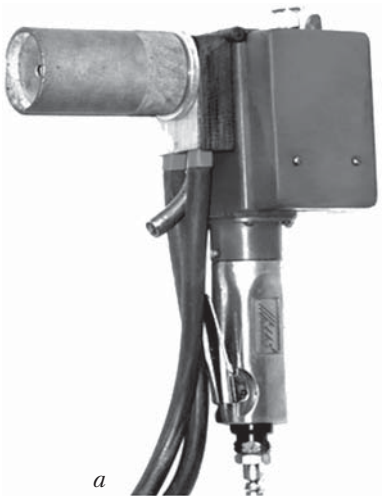
Design documentation has been developed and pilot industrial prototypes of stationary and manual arc spray gun have been manufactured. The manufactured equipment is intended for spraying protective and reductive coatings by the electric arc metallization method. The manufactured arc spray gun has been provided with power sources, commuting cables, and with control panels designed and manufactured by the author team. The arc spray gun enables to apply antifriction, friction, wear-resistant, corrosion-resistant and some other types of coatings from various electrode materials — solid and cored wires. Gazotermik small state-owned corporation as partner of R&D project has tested the manufactured arc spray gun equipment and determined the efficiency of developed and optimized cored wires.

Cylinder shafts for mining and food processing machinery have been coated using the developed equipment and new electrode materials.

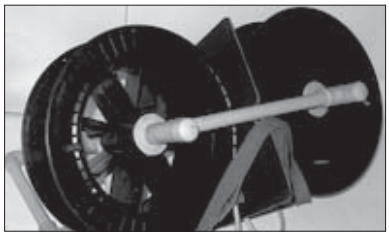
Keywords: stationary and manual arc spray guns, electric arc coatings, and electrode wires.

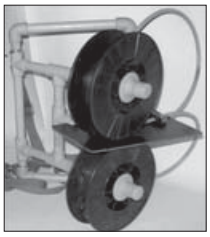
In recent years, application of coatings by gas-thermal methods has become widespread for restoring the geometrical dimensions of parts of machines and structures used for various purposes and enhancing resistance of their surfaces to wear and corrosion. Electric arc spraying is an economically advantageous and most effective method for applying protective and reductive coatings with given properties. It is in this way the surface of parts can be coated with films having a thickness from 0.1 to several ten millimeters. In this case, the parts do not undergo any thermal deformation, with physical and chemical properties of their material remaining unchanged.

Firstly, solid wires were used as electrode materials for electric arc spraying to restore the geometric dimensions of the parts and to ensure their anti-corrosion protection, which greatly narrowed the scope of method application. The use of powder wires as electrode materials has enabled to significantly widen the areas of application of electric arc spraying as it can be used, for example, to create wear-resistant dispersion-hardened coatings that can protect metal structures from abrasive and gas abrasive wear both at room temperature and while heating (for example, heating elements of TPP boilers) and operate under conditions of limited lubrica-



a





b

Fig. 1. Manual arc spray gun (*a*) and a spraying kit (*b*)

tion, lubricate starvation (hydraulic cylinders of mine equipment), and increased specific loads (engine parts). However, electric arc spray guns are not commercially manufactured in Ukraine, and the known range of powder wires for electric arc coating does not enable obtaining wear-resistant coatings for operation in corrosive environments.

The purpose of this research was to develop prototypes of manual and stationary arc spray guns and Fe-Cr-B-C based powder wires to protect the surfaces of parts from corrosive and abrasive wear.

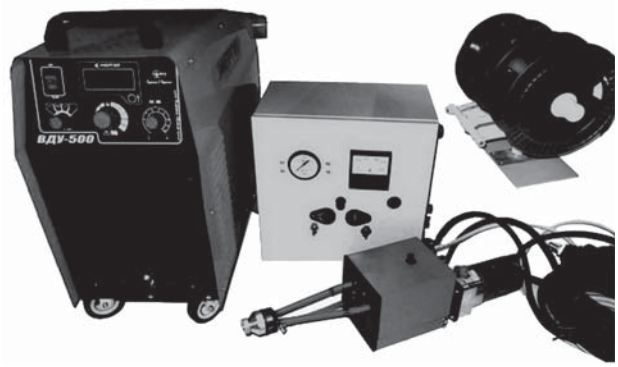


Fig. 2. Stationary arc spray gun kit for application of coatings

As part of the project, design documentation has been developed for the production of experimental and industrial samples of stationary and

Table 1

General Specifications of Manual Arc Spray Gun

Parameter	Value
Arc operating current (ПН = 100%), A	50—250
Arc operating voltage, V	17—35
Wire diameter, mm	1.6—2.0
Nominal capacity of material spraying (at operating current of 250 A), kg/hour:	
steel	6
aluminum SvA5 GOST 7871-75;	8
zinc TsI GOST 13073-77;	20.0
Material consumption rate for coating flat products whose dimensions exclude the material spraying outside the product, at least:	
steel (arc operating voltage 28 V);	0.65
aluminum (arc operating voltage 28 V);	0.7
zinc (arc operating voltage 18 V)	0.6
Gas (air) consumption, m^3/hour	60—90
Operating pressure of compressed air, MPa	0.5—0.6
Maximum power consumption, kW, at most	≤8
Dimensions, mm, at most	≤210 × 240 × 95
Device weight, kg, at most	≤2.5

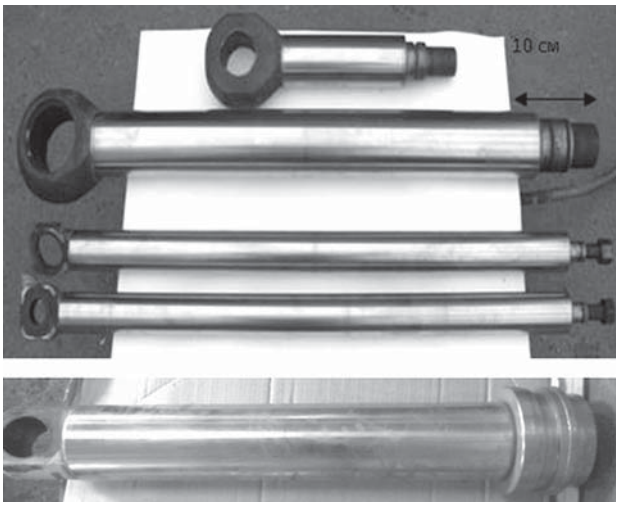
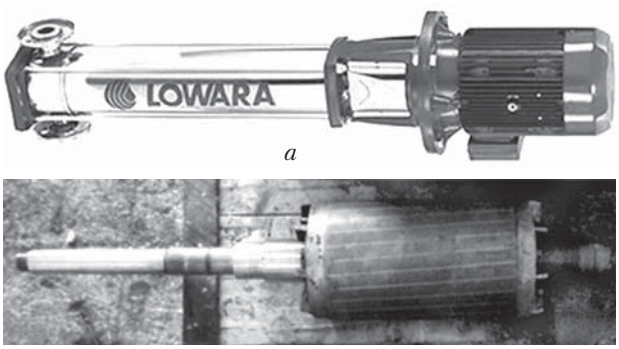


Fig. 3. Repaired surface of bricking cylinder shafts (mining equipment) using the electric arc spraying method for application of power wire coatings with further polishing: shaft length is 600–1000 mm, shaft diameter is 40–100 mm



а

б

Fig. 4. Stainless steel rotor shaft of *Lovara Shoe* pump repaired in the tightened places. The pump is used for sunflower oil production in aggressive corrosive environment. The coating is made of power wire ПД90Х17РГС; *a* — general view of *Lovara Shoe* pump, *b* — rotor shaft of *Lovara Shoe* pump

manual arc spray guns and their prototypes for the application of protective and reductive coatings by the electric arc spraying method have been manufactured.

The manual arc spray gun (Fig. 1) is designed for application of protective and reductive coatings in stationary (shop) and field conditions. It enables to restore worn surfaces and to apply anticorrosive, heat-, wear-resistant and other coatings. The specifications of designed model are given in Table 1. It is possible to use any metals in the form of wire with a melting temperature of up to 3000 °C. The device can be operated at a temperature from –5 to + 40 °C and a relative humidity of up to 80%.

The stationary arc spray gun (Fig. 2) is designed for applying protective and reductive coating in both shop and field conditions. The device enables application of antifriction, friction, wear-, corrosion-resistant and other coats. Its specifications are given in Table 2. Whole zinc, aluminum and power wires with a melting temperature of up to 3000 °C can be used as electrodes. The device can be operated at a

Table 2

General Specifications of Stationary Arc Spray Gun

Parameter	Value
Arc operating current (within the range of control over wire feed rate and voltage for given materials), A	50—300
Arc operating voltage, V	17—35
Wire diameter, mm	1.6—2.0
Nominal capacity of material spraying (at operating current of 300 A), kg/hour:	
steel Cv-08 02.0 mm GOST 2246-70 (arc operating voltage 28 V);	10
aluminum SvAMts 02–2.5 mm GOST 7871-75 (arc operating voltage 24 V);	8.0
zinc Ts1 02.5 mm GOST 13073-77 (arc operating voltage 18 V)	25
Material consumption rate for coating flat products whose dimensions exclude the material spraying outside the product, at least:	
steel (arc operating voltage 28 V);	0.65
aluminum (arc operating voltage 28 V);	0.7
zinc (arc operating voltage 18 V)	0.6
Gas (air) consumption, m3/hour	90—140
Operating pressure of compressed air, MPa	0.4—0.7
Arc maximum power consumption, kW, at most	≤15
Dimensions, mm, at most	≤620 × 120 × 190
Device weight, kg, at most	≤15

temperature from +5 to + 40 °C and a relative humidity of up to 80%.

Based on the research carried out, Fe-Cr-B-C powder wires were developed and their chemical composition was optimized (ПД90Х17РГС, ПД20Х16Р3Н2СЮ). The blend composition based on ferrochromber, ferrochromium, ferrosilicon, ferromanganese and self-fluxing alloy ПН-10Н-01 ensures a high hardness of electric arc coatings (700–800 HV), their low heterogeneity in terms of chromium content in the coating lamellas and, consequently, a high corrosion resistance (compared to stainless steel).

Pilot batches of optimized powder wires (ПД90Х17РГС and ПД20Х16Р3Н2СЮ) with a diameter of 1.8–2.0 mm have been manufactured and the modes for application of these electrode materials using the developed arc spray guns have been optimized.

The newly created stationary and mobile equipment, as well as the proposed consumables provide an opportunity to substantially extend the service life of parts of transport and armored machinery, equipment of thermal power stations, parts of aggregates used in mining and food processing equipment, gas pumping stations, components of printing machines, etc.

The specifications (instructions, manuals, process procedure for applying coatings) for applying the coatings with the use of manufactured equipment have been developed.

The partner of R&D project, *Gazotermik* state-owned company, has tested the prototypes and proved the effectiveness of the coatings obtained with the use of optimized powder wires on parts of mine and food industry equipment (Fig. 3).

CONCLUSIONS

The design documents and specifications have been developed and stationary and manual arc spray gun prototypes for applying protective and reductive coatings by the electric arc spraying method have been manufactured. The devices have been tested by *Gazotermik* state-owned company as partner of R&D project, while applying protective coatings on the parts of mine and food industry equipment.

The chemical composition and diameter of developed Fe–Cr–B–C based powder wires (ПД90Х17РГС and ПД20Х16Р3Н2СЮ) for obtaining coatings having corrosion resistance comparable to that of stainless steel in neutral environments and under conditions of intensive abrasive wear have been optimized.

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РОЗРОБЛЕННЯ УСТАТКУВАННЯ ДЛЯ ЕЛЕКТРОДУГОВОЇ МЕТАЛІЗАЦІЇ ТА НОВІТНІХ ВИТРАТНИХ МАТЕРІАЛІВ ДЛЯ НАНЕСЕННЯ ЗАХИСНИХ І ВІДНОВНИХ ПОКРИТТІВ НА ДЕТАЛІ ГІРНИЧОДОБУВНОЇ, ТРАНСПОРТНОЇ ТА ХАРЧОПЕРЕРОБНОЇ ПРОМИСЛОВОСТІ

Розроблено конструкторську документацію та виготовлено дослідно-промислові прототипи стаціонарного та ручного металізаторів. Пристрої призначено для нанесення захисних і відновних покриттів методом електродугової металізації. Проведено комплектацію виготовлених металізаторів джерелами живлення, комутуючими кабелями, пультами керування власної розробки. Металізатори дозволяють наносити антифрикційні, фрикційні, зносостійкі, корозійнотривкі та інші види покриттів з різних електродних матеріалів - суцільних та порошкових дротів.

Державним малим підприємством «Газотермік», як партнером науково-технічного проекту, проведено дослідно-промислову перевірку виготовленого устаткування для електродугової металізації та визначено ефективність розроблених та оптимізованих порошкових дротів. Розробленим обладнанням із використанням нових електродних матеріалів нанесено покриття на штоки циліндрів для обладнання гірничодобувної та харчової промисловості.

Ключові слова: стаціонарний та ручний металізатори, електродугові покриття, електродні дроти.

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РАЗРАБОТКА ОБОРУДОВАНИЯ ДЛЯ ЭЛЕКТРОДУГОВОЙ МЕТАЛЛИЗАЦИИ И НОВЕЙШИХ РАСХОДНЫХ МАТЕРИАЛОВ ДЛЯ НАНЕСЕНИЯ ЗАЩИТНЫХ И ВОССТАНОВИТЕЛЬНЫХ ПОКРЫТИЙ НА ДЕТАЛИ ОТВЕТСТВЕННОГО ОБОРУДОВАНИЯ

Разработано конструкторскую документацию и изготовлено опытно-промышленные прототипы стационарного и ручного металлизаторов. Устройства предназначено для нанесения защитных и восстановительных покрытий методом электродуговой металлизации. Проведено комплектацию изготовленных металлизаторов источниками питания, коммутирующими кабелями, пультами управления собственной разработки. Металлизаторы позволяют наносить антифрикционные, фрикционные, износостойкие, корозионностойкие и некоторые другие виды покрытий из различных электродных материалов — сплошных и порошковых проволок.

Государственным малым предприятием «Газотермик», как партнером научно-технического проекта, проведено опытно-промышленную проверку изготовленного металлизационного оборудования и определено эффективность разработанных и оптимизированных порошковых проволок. Разработанным оборудованием с использованием новых электродных материалов нанесено покрытие на детали горнодобывающей и пищевой промышленности.

Ключевые слова: стационарный и ручной металлизаторы, электродуговые покрытия, электродные провода.