

Selection of Electrode Wires. Primary Features Affecting the Quality of Electrode Wires

Abstract: The article discusses factors affecting the technological and welding properties of electrode wires, indicates the difference in surface quality between a copper plated wire and a wire not subjected to copper plating as well as presents wire-related non-standardised quality criteria applied by wire manufacturers and packaging.

Keywords: reels, drums, mass packages

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Introduction

Makers of steel structures permanently seek to reduce operating expenses. In terms of Ukraine, an additional stimulus is the fact that costs of base materials and welding consumables on the Ukrainian market are coming up to the same price level as those of European manufacturers. As mechanised gas-shielded arc welding is the primary technological process used when making steel structures, in most cases the electrode wire is becoming the principal element of cost reduction policy.

Regrettably, many company owners and managers believe that they can achieve the greatest savings using cheaper electrode wires, not taking into account the fact that the cost component of the electrode wire is only restricted within the range of 4 % to 5% of the total cost of welded structure. As can be seen, the reduction of electrode wire purchase price does not significantly decrease the entire fabrication cost. In fact, inexpensive electrode wires may represent significantly lower quality, which, instead of reducing expenses may

decrease productivity, increase equipment operating costs and necessitate more frequent purchases of parts and consumables to maintain welding equipment in the proper technical condition. Additional costs are generated by the preparation of welded joints and their post-weld processing.

In turn, in spite of a higher price, a good-quality electrode wire can contribute to actual savings through the optimisation of the above-named costs and increased productivity. For this reason, companies dealing with steel structure fabrication should view the quality of welding wires through the prism of the total cost of welding works. When selecting a wire, it is necessary to take into consideration not only its price but also its technological and welding-related properties and other features affecting the productivity, reliability and service life of welding equipment as well as those minimising the costs of the additional processing of welds and the zone adjacent to the weld following the completion of the welding process.

Features affecting the quality of electrode wires

The primary technological and welding-related properties of the wire, including feeding stability, the amount of metal spatter and the stability of welding arc depend on the quality of the wire surface, geometrical dimensions of the wire, its mechanical properties and special features including the helical lift and unwinding. Unwinding is determined by measuring the diameter of a circle constituted by one coil of the wire freely lying on the flat surface (Fig. 1). The optimum unwinding of an alloyed electrode wire having a diameter of 1.2 mm is restricted within the range of 0.8 m to 1.0 m.

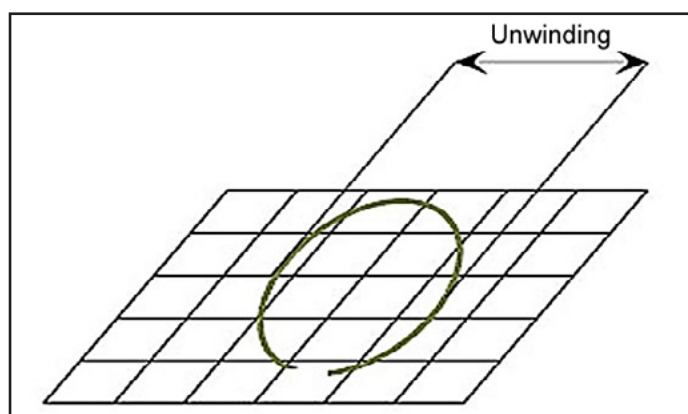


Fig. 1. Schematic measurement of the unwinding of the electrode wire coil

An unwound length shorter than 0.8 m increases the probability of the accelerated damage (beyond repair) of the duct inside the welding torch hose and the excessive wear of the contact tube.

The spiral shape of the helical lift is another important indicator of electrode wire feedability. The feedability of the wire is determined in two ways, i.e. by measuring the value of the vertical lift of a wire freely lying on the plane or by measuring the divergence of the ends of a hung wire (Fig. 2). The helical lift of one end of the wire coil lying on the flat surface as well as the divergence of the ends of the wire of a hung coil should be restricted within the range of 15 mm to 20 mm.

The crucial factor affecting technological and welding-properties of the electrode wire

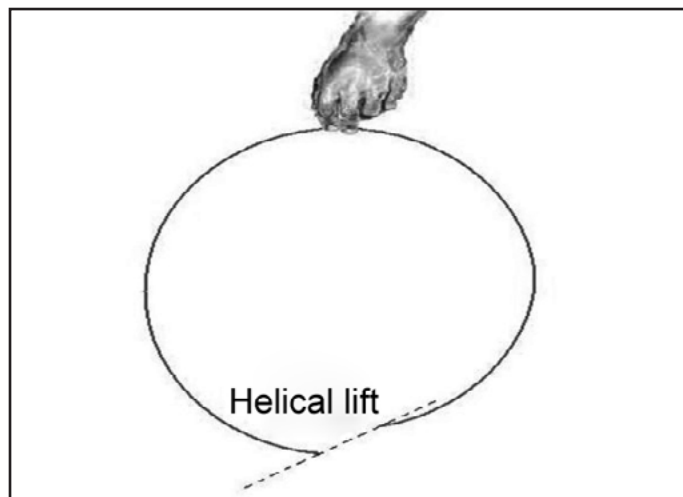


Fig. 2. Schematic measurement of the helical lift of the electrode wire

is its surface quality. The surface of the wire should be free from overlap, cracks, scratches, pits, scale residue as well as leftover ground coat and drawing lubricant. All this impedes the steady feeding of the wire at a constant rate by the feeding rollers, which significantly impairs the electric contact between the surface of the wire and the contact tube of the welding torch, which, in turn translates into the unstable burning of electric arc, the occasional jamming of the wire in the welding torch and, consequently, the formation of welding imperfections. The disturbed movement of the electrode wire (pushed or pulled) in conduits (passages) resulting from the low wire surface quality leads to a significant increase in the amount of spatter, contamination and the intense wear of the working elements of a semi-automatic welding machine, i.e. rollers and contact tubes. Non-metallic inclusions and drawing lubricant residue on the wire surface are responsible for the formation of gas pores, inclusions and cracks. In addition, the above-named leftovers significantly increase the emission of welding fumes, detrimentally affecting the welder's respiratory tract.

Relatively reliable methods improving the quality of the electrode wire include the application of a copper coating on the wire. The above-named coating helps improve the electric contact between the wire surface and the contact tube as well as eliminate the impact of

mechanical damage to the surface of the wire on its technological properties. However, the insufficient quality of the wire surface before copper plating and the quality of the copper coating itself may increase all of the above-named issues. The application of copper coating on the wire surface containing non-metalling inclusions scale residue (rolled-in) leads to the non-uniform contact between copper and the steel wire surface. During welding, in areas characterised by improper adhesion, the copper layer starts flaking and peeling, contaminating the entire wire feeding “path” to the welding arc burning zone, i.e. rollers, the spiral and the contact tube.

The same negative effect occurs in areas where drawing lubricant was removed improperly. The flaking and peeling during the storage of the wire significantly quickens its corrosion. The foregoing is related to the fact that where the adhesion to the steel wire surface is inadequate, the copper coating forms an electrochemical galvanic pair with the aforesaid surface. The difference of potentials and the poor flow of electric charges in such areas results in the significant acceleration of the corrosion process, where corrosion-affected areas are impossible to detect visually due to the fact that they are hidden under the copper coating.

Another important indicator in terms of wires coated with copper is the thickness of the copper coating. Standards provide for the restriction of the maximum copper coating thickness by specifying the maximum percentage of the coating weight in relation to the total weight of the wire. Multiannual experience related to copper wire production demonstrates that the total content of copper (wire + coating) should not exceed 0.3% of the total weight of the wire. However, currently valid standard GOST 2246 restricts the above-named content to 0.25% [1]. In fact, manufacturers of copper electrode wires try to reach a copper content on the surface restricted within the range of 0.10% to 0.15%, paying almost exclusive attention to the appearance of the wire surface and the uniformity of the copper coating.

For instance, in relation to a wire having a diameter of 1.2 mm, the thickness of the copper coating amounts to approximately 0.16 micron.

In cases of doubts concerning the conformity of the copper coating thickness with the requirements specified in related standards, the thickness is verified by weighing and copper is removed from the electrode wire surface by means of chemical or electrochemical etching.

The most effective treatment of the electrode wire surface, providing the latter with the maximum purity and uniformity, involves polishing followed by the application of the microscopic or even nanoscopic layer of current-conductive anti-friction lubricant. The polishing process is accompanied by the additional calibration of the wire diameter. The current-conductive anti-friction coating is a layer of microscopic thickness, entirely eliminating the possibility of exfoliation or cracking and, consequently, eliminating problems related to the contamination of the electrode wire with copper particles. Another advantage involves significantly improved the electric contact between the polished surface of the wire and the contact tube of the welding torch. The use of such a wire is safer in terms of welding process “hygiene” as the welding “spray” does not contain copper vapours and other toxic components usually contained in the surface coating.

Electrode wires with the polished surface are manufactured by all major producers of welding consumables. In Ukraine, the first wire having the polished surface is produced by the Vitapolis company under the trademark of HORDA.

In addition to the quality of the wire surface, all major producers (Esab, Thyssen, Böhler, Lincoln Electric etc.) apply additional (non-standard) wire quality criteria, affecting technological welding properties:

- deviation of the wire diameter from the nominal value (regardless of requirements specified in related standards, producers maintain the above-named deviation not to exceed -0.02 mm, where wire ovality should not exceed

- 0.003 mm in relation to a wire having a diameter of 0.8 mm; 0.005 mm in relation to a wire having a diameter of 1.0 mm and 0.007 mm in relation to a wire having a diameter of 1.2 mm);
- tensile strength ($1300 \div 1500 \text{ N/mm}^2$ in relation to a low-alloy wire and $1600 \div 1800 \text{ N/mm}^2$ in relation to a wire made of stainless steel and high-alloy steel);
- straightening (unwinding of coils and the helical lift);
- appearance of packaging and its quality.

Paying stricter attention to the wire diameter is directly related to internal standards applied by producers of contact tubes. Because of the fact that contact tubes are made of copper alloys (with an addition of chromium, zirconium, tungsten etc.), the internal diameter of the passage, through which the wire is moved during welding, should allow for the thermal expansion of the material of the tube and a slight decrease in the diameter of the above-named passage as well as an increase in the wire diameter resulting from thermal expansion. For instance, in relation to an electrode wire having a diameter of 1.2 mm (actually, the wire diameter is usually restricted within the range of 1.18 mm to 1.19 mm), the internal diameter of the tube is usually restricted within the range of 1.35 mm to 1.38 mm.

Tensile strength does not significantly affect the wire feeding characteristics during welding. It is important that the wire should not be soft or brittle. However, far more important is the manner in which the wire is straightened. Straightening through contraflexure involves the multiple contraflexure of a wire in two perpendicular planes, aimed to compensate the mechanical properties of the wire in cross-section and along its length. The behaviour of a properly straightened wire, which, after passing through the sheathed flexible hose (spiral) of the welding torch, leaves the contact tube, is assessed on the basis of the measurement of the diameter of one coil lying on the flat surface. Most leading producers state that a wire having a diameter of

1.2 mm wound on a standard reel having a diameter of 300 mm, should straighten up to a diameter of at least 800 mm. Ends of one coil of wire lying on the flat surface should not rise (Fig. 3) or deflect from the coil plane (Fig. 4) by more than 15 mm to 20 mm. The same wire leaving the large-sized pack, i.e. Marathon Pack, "DizkaPack" etc. should straighten nearly to the straight line, which could ensure even a more stable welding process.

Wire packaging is also an important factor affecting the stability and effectiveness of the

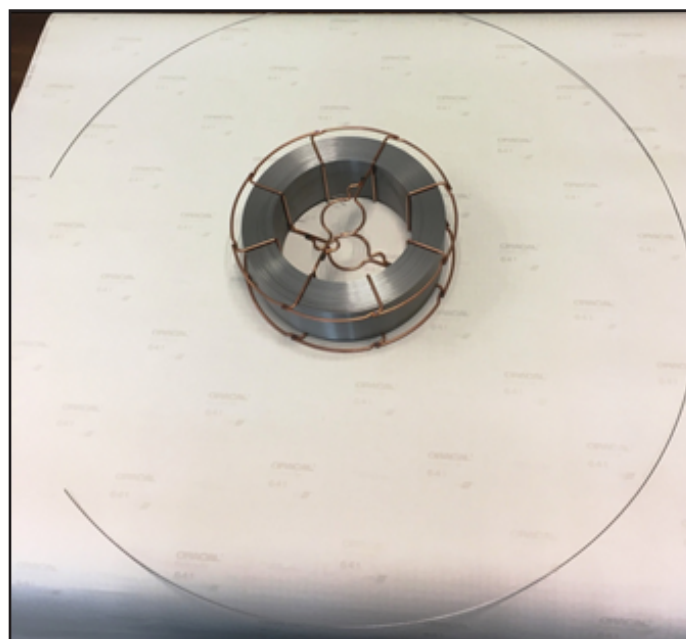


Fig. 3. Unwound coil of the electrode wire



Fig. 4. Suspended coil of the electrode wire when measuring the helical lift

welding process. Presently, most producers provide electrode wire precisely wound (in layers) on reels. However, also in the latter case some slight differences in the winding manner (detectable only during the welding process) may occur. For instance, sometimes, in spite of the precise winding of the wire on the reel, the wire sticking out of (leaving) the contact tube may tend to change its direction, forcing the welder to “catch” the weld axis. In terms of robotic or automated welding, the aforesaid situation is entirely unacceptable, making the process impossible. The above-presented phenomenon takes place if the winding of the wire on the reel was preceded by improper initial straightening, where individual coils were placed next to each other forcefully and manually, not using an automated winding machine. The wire properly prepared for precise winding “lies down spontaneously” in a uniform manner, one coil next to another. During welding, the wire leaves the contact tube without changing its own direction or vibration, ensuring the proper formation of the weld.

In Ukraine, producers of electrode wires use the following types of winding and packaging:

- D200 – reel made of impact-resistant polystyrene, having an external diameter of 200 mm and an opening having a diameter of 52 mm, to be placed on the wire feeder pin; the weight of the steel wire on the reel amounts 5 kg.
- D300 – reel made of impact-resistant polystyrene, having an external diameter of 300 mm and an opening having a diameter of 52 mm, to be placed on the wire feeder pin; the weight of the steel wire on the reel is restricted within the range of 15 kg to 18 kg.
- BS200 – twisted reel made of high strength wire, having an external diameter of 200 mm and an opening having a diameter of 52 mm, to be placed on the wire feeder pin; the weight of the steel wire on the reel amounts 5 kg.
- BS300 – twisted reel made of high strength wire, having an external diameter of 300 mm and an opening having a diameter of 52 mm,

to be placed on the wire feeder pin; the weight of the steel wire is restricted within the range of 15 kg to 18 kg.

- K300 – twisted ring made of high strength wire, having an external diameter of 300 mm and an internal diameter of 180 mm; to be placed on a special adapter to the standard wire feeder pin; the weight of the steel wire on the ring is restricted within the range of 15 kg to 18 kg,
- K415 – twisted ring made of high strength wire, having an external diameter of 415 mm and an internal diameter of 300 mm. to be placed on a special adapter to the standard wire feeder pin; the weight of the steel wire on the ring is restricted within the range of 25 kg to 30 kg.

As a rule, reels are packed in a cardboard box, inside which the wire must be wrapped in humidity resistant plastic foil. Humidity resistant packaging can be hermetic or conditionally hermetic. If air/water etc. tightness cannot be guaranteed, inside the packaging there should be a material absorbing humidity. Humidity can form as a result of temperature changes during the storage and transport of the wire. The most reliable type of packaging involves closing the reel with wire in a vacuum bag, which in turn is placed in a box made of corrugated board.

Recently, packing wires in large-sized containers, e.g. drums made of corrugated board or hard paperboard, intended for applications on robotic or automated welding stations, is enjoying increasing popularity. During packing in a drum, the wire is straightened through contraflexure and arranged in such a manner so that its single coils leave the drum straightened and do not twist around the wire axis. Vitapolis LLC produces such wires in the above-named packaging referred to as “DizkaPack”. In the aforesaid case it is necessary to use special substances in a drum. In a closed drum, such substances create an atmosphere with a corrosion inhibitor, preventing the corrosion of the wire surface during storage and transport.

Concluding remarks

Paying attention to the above-presented criteria concerning the quality of electrode wires and the careful selection of suppliers, responsibly treating functional properties of wires, ensure the obtainment of the proper quality of welding

works and high productivity, leading to the optimisation of total production costs.

References

- [1] ГОСТ 2246-70 «Проволока стальная сварочная. Технические условия»