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Wettability of hardmetal surfaces prepared for brazing with various methods

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Hardmetals belong to the materials hardly wettable by liquid brazing alloys, so they should not be brazed without removing the surface layer after sintering. In the paper, mechanical and chemical methods of preparing a hardmetal surface for brazing are discussed. Special attention is paid to the electrolytic etching method that gives very good energetic properties to surfaces of hardly wettable materials. Electrolytic etching of hardmetals consists in anodic dissolution of tungsten carbide grains in water solution of alkaline metal hydroxides. The α phase (WC) is removed from surfaces of carbide preforms, leaving the much better wettable β phase (Co-W-C). Cobalt does not show amphoteric properties, so it does not dissolve in bases. With regard to brazing, besides significant development of the surface, an especially profitable feature of this method is isolating the metallic cobalt phase, which allows easier wetting by brazing alloys. On the grounds of surface roughness measurements, parameters of electrolytic etching were determined to remove WC grains from surfaces of carbide performs and to obtain much higher Co fraction on the brazed surface. The presented results are based on measurements of wetting angles on B40 hardmetal surfaces, isolated α and β phases and C45 steel, as well as on EDX cobalt analysis on hardmetal surfaces.

Keywords: *hardmetals, surface preparation, electrolytic etching, wetting measurements, EDX analysis*

1. Introduction

Hardmetals applied in tools manufacture are usually made in form of preforms joined with the body made of unalloyed or alloyed steels. Bonding hardmetals with steel is most often performed by hard and high-temperature soldering, or less frequently by brazing, resistance welding, fusion welding or gluing [3, 6, 8, 10–11, 15].

Hardmetals and steels used for tool bodies show diverse physicochemical and mechanical properties [3, 6, 8, 10–11, 15]. With respect to brazing, the most important are: two to three times smaller linear expansion coefficient, very low deformability and limited wettability of hardmetals, especially of carbide phases WC, TiC, TaC and NbC. In order to improve wettability of hardmetals by brazing alloys, it is necessary to choose their proper chemical composition and to prepare their surface properly for the bonding processes.

2. Methods of preparing hardmetal surface for brazing

Surface preparation of the materials to be joined has an essential effect on mechanical properties of brazed joints and thus their service reliability. Cleaning the hardmetal surface, performed irrespective of the bonding method, is aimed at removing the skin formed during sintering, as well as oxides and other impurities [11]. It should be done directly before brazing, because effectiveness of surface preparation declines with time and is mostly influenced by storage conditions of the parts to be brazed [8, 13]. Their surface preparation is often complemented by applying (in chemical, physical or plasma process) metallic layers like nickel, cobalt, copper or silver [3, 11].

Various methods of preparation are applied in order to develop the surface and to ensure its coherence and wettability, namely mechanical, chemical, thermal (or combined like thermochemical) and electrochemical [3, 5, 8, 10–11, 13]. Surface preparation of the components to be joined includes two main stages [3, 5, 6, 8–13, 15]:

- modification of surface layer by various methods: mechanical, thermal, chemical or electrochemical,
- cleaning and degreasing to remove impurities.

Mechanical methods remove most of organic and inorganic impurities, influencing surface topography and reactivity. In addition, rough surfaces change nature of the alloy flow in the gap to turbulent and are better wettable [13]. In the case of hardmetals, the most often used mechanical methods are: grinding, abrasive blasting and abrasive tumbling [3, 6, 8, 11]. They develop real surfaces of the parts to be joined, that results in stronger intermolecular interactions. From the viewpoint of brazing, it is profitable to maintain roughness heights within 10 to 25 μm [10, 12]. The condition of effective mechanical surface cleaning is maintaining the assumed brazing gap, with respect to both its width and surface parallelism [10, 13]. When a cooling agent is used in the mechanical cleaning process, all its residues should be completely removed (it often contains silicones) [12–13].

Mechanical methods permit creating a geometrical structure of the surface layer that ensures its maximum development but does not guarantee good surface activation, so they should be complemented by later chemical treatment [11]. Chemical treatment consists in degreasing or pickling the parts in baths with suitable composition and temperature [8, 10–13]. The most frequently used chemical methods are pickling in solutions of acids (hydrochloric, sulphuric and nitric) or bases [11–13]. Due to high physicochemical activity they can remove organic impurities, significantly reduce thickness of the oxide layers and change their morphology. Choice of a cleaning chemical depends mainly on kind of the impurities, but also on surface condition and the joint structure [13].

Electrochemical methods of surface preparation ensure very advantageous energetic surface properties and are applied in the case of very high strength requirements. Electrochemical treatment consists in anodic dissolution by electrolysis [2, 11]. The chemical reactions are opposite to those occurring in electroplating at coating the products with metallic layers. Dissolving is enabled by the electrolyte, an electrically conducting liquid. During the process, dissolved ions pass to the electrolyte where the reaction products precipitate [2, 11].