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Characteristics of Cemented Carbide Particles/Structural Steel Vacuum Brazing Joint

Značilnosti vakuumskega spoja zrn karbidne trdine s konstrukcijskim jeklom

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The strength of the vacuum brazing joint between cemented carbide particles and the structural steel base depends on microstructural characteristics of the hard metal/braze interface formed during vacuum brazing. These are determined by the selected brazing agent, the structural steel base, as well as the vacuum brazing procedure. The R&D work concerning the procedure of manufacturing these types of grinding tools is introduced, with a strong emphasis on the characteristics of the brazing agent used, the vacuum brazing procedure, as well as the resulting microstructural characteristics of the brazing joint between the hard metal particles and the structural steel base.

Key words: vacuum brazing, cemented carbide particles, structural steels, Cu-based brazing alloy-powders, microstructural features

Trdnost vakuumskega spoja zrn karbidne trdine s konstrukcijskim jeklom je odvisna predvsem od mikrostrukture mejne plasti kovinska osnova/karbidna trdina, nastale med vakuumskim trdim spajkanjem. Le-ta pa je odvisna od izbrane kovinske osnove (konstrukcijskega jekla), vrste karbidne trdine in tehnoloških parametrov spajkanja. V pričujočem prispevku je predstavljeno razvojno raziskovalno delo vezano na postopek izdelave brusnih plošč, ki so sestavljene iz jeklenih plošč na katere so nanešena groba zrna karbidne trdine. Poudarek je na opisu mikrostrukturnih značilnostih nastalega spoja v odvisnosti od uporabljene spajke, karbidne trdine in jekla, kakor tudi pogojev vakuumskega spajkanja.

Ključne besede: vakuumsko trdo spajkanje, zrna karbidne trdine, konstrukcijska jekla, spajke na osnovi Cu, mikrostrukturne značilnosti

1. Introduction

Tungsten carbides with Co matrix (WC-Co) are old and well-known composites, referred to as cemented carbides or hard metals. They are also well-known under the trade mark name WIDIA. The most important application of cemented carbides is in the production of machining tools, as well as in the production of wear resistant parts or layers in many fields of application. Waste cemented carbide parts of worn tools (inserts, knives, drills, cutters, saws, punches, etc.) can be ground and the resulting relatively rough and sharp edged particles of the WC-Co composite can be used for the manufacturing of grinding wheels which are fast and simply mounted on the electric drill. The cemented carbide particles are uniformly deposited on a clean surface of a steel base (grinding wheel) and the diffusion bonding of particles with the steel base can be obtained by different methods of brazing. The most convenient brazing method is vacuum brazing.

In wood, stone-cutting and leather industry, as well as in rubber industry, it is often necessary (by a fast and simple procedure) either to clean or to rub off the surface of the semi-finished products during individual steps of the manufacturing procedure. Stock-farming is gradually substituting for the hard and time-consuming trimming of hoofs by manual grinding. These kinds of grinding wheels are also appropriate tools for housework applications. Currently, this type of grinding tools is also increasingly in demand on the Slovenian market. The researchers of the Institute of Metals and Technologies in Ljubljana, Slovenia, have many years of experience in different R&D fields concerning wear resistant materials (metal powder manufacturing, heat treatment, vacuum brazing, material development, investigations and testing, etc.). Therefore, a decision was made at the IMT Ljubljana to develop a procedure of manufacturing these types of grinding tools.

For the brazing of sintered cemented carbides (WC-Co composites), either with tool or structural steel base as a brazing agent, technically pure copper (usually OFHC Cu 99.9 mass %) powder is commonly used[1,2,3]. The joining of WC-Co composites and steel base with pure Cu and the diffusion processes occurring in this connection, as well as the formation of different phases at the interface hard

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metal/braze and braze/steel base was the subject of several previous investigations[1-4]. The common statement of these is that, during brazing at the hard metal/braze interface, thin Co and Fe rich layer of an intermetallic compound is formed. Voids are also generated in the border zone of the hard metal which greatly reduce the strength of the joint.

Commercial producers[5,6] of Cu based brazing agents often recommend Cu-Ni based powders as a proper material for the brazing of cemented carbides/steels couples. Simultaneously, our own powder preparation experiments[7] show that by the water atomization of Cu-2%Ni alloy, a nearly spherical powder with relatively high apparent density and flowability, as well as a proper particle size distribution with the mean particle size between 40 in 70 μm can be obtained. Thus by the optimization of process parameters of water atomization[7,8,9] (especially of water pressure, tundish nozzle diameter and superheat) it can be concluded that the manufacturing of brazing powder with required morphological properties is possible.

Water atomization experiments show[7] that Cu-2%Ni alloy powder has even slightly better morphological properties in comparison to pure Cu based water atomized powder. In spite of the fact that water atomized powders have a relatively high oxygen content in prepared Cu-2%Ni alloy powder, good-quality joint between hard metal and steel is expected, if deoxidising atmosphere (vacuum) and good morphological properties of the powder are taken into consideration.

In the present article, the research work concerning the procedure of manufacturing these types of grinding tools is introduced, with a strong emphasis on the characteristics of the brazing agent used, the vacuum brazing procedure, as well as the resulting microstructural characteristics of the brazing joint between the cemented carbide particles and the structural steel base. Considering the relatively well investigated process of multiphase diffusion[4] during brazing with pure Cu, the aim of our work was also to find out if a similar phenomenon occurs in brazing with Cu-Ni alloy powder. The influence of a steel base chemical composition is also considered.

2. Experimental work

As a metal base for rough and sharp edged particles of the WC-Co composite, two different steels (soft low-carbon structural steel Č.0561 or DIN W.No.: 1.0570 with 0.2 mass % C and low-alloy hardening steel Č.4733, Ravne Steel Plant VCMo150 or DIN W.No.: 1.7228 with 0.5 % C, 1 % Cr and 0.2 % Mo) were selected. From the selected steels, round plates of standard grinding wheels dimensions (diameter approximately 115 mm and thickness 2 ÷ 6 mm) were made. For deposition, a mixture of metal powder (fraction 45 ÷ 75 μm of Cu-2 % Ni), binder and cemented carbide (ISO G10/G20 with 6 ÷ 10 % Co and nominal Vickers hardness 1500 HV) particles in size 1 ÷ 3 mm was prepared. After the deposition of the mixture on the steel base, the samples were vacuum brazed in IPSEN vacuum heat treatment furnace (type VTTC-324R).

Optimal brazing conditions were achieved in vacuum 10^{-3} mbars, in temperature range between 1100 and 1200°C, at heating rate ≈ 20°C/min. and at cooling rate ≈ 3°C/min. These brazing conditions ensure that the cemented carbide particles and the steel base remain in solid state during brazing, while the braze is melted. This ensures good wetting of cemented carbide particles and steel surface with the brazing agent.

The applied metal powder and the cemented carbide particles were examined by optical and scanning electron microscope. The apparent density and flowability of the prepared powders was determined by Hall's apparatus in accordance with MPIF standards[10] (Metal Powder Industries Federation Standards No.: 03 and 04). The oxygen content in metal powder was also determined. The chemical composition of selected steels was checked by X-ray fluorescence (ARL 3460 Metal Analyser). The hardness of individual components of grinding wheels was determined before and after brazing. Samples from manufactured grinding wheels (see **Fig. 1**) were then cut out for metalographic investigations and analysis with electron micro-probe analyzer (EPMA).

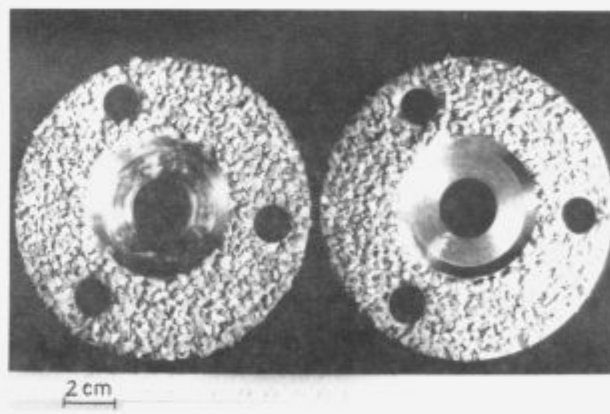

Figure 1: Macroscopic photo of grinding wheels manufactured at IMT Ljubljana
Slika 1: Makroskopski posnetek na IMT Ljubljana izdelanih brusnih plošč

3. Results and discussion

The water atomized Cu-2 % Ni powder prepared at IMT Ljubljana, which was used as the brazing agent in our experiments has mainly almost spherical particles (see **Fig. 2**). The powder particles are coated with a thin oxide film. Metalographic examinations also show internal porosity of some particles. The cellular solidification structure of powder particles (see **Fig. 3**) results from the high cooling rate (≈ 10^5 ÷ 10^7 K/s) obtained during water atomization. The size of cells strongly depends on powder particle size because the cooling rate primarily depends on the particle size formed during atomization.

High apparent density and good flowability are the basic features of a high-quality brazing agents.

Because of regular powder particle shape, the prepared powder has a relatively high apparent density (≈4,4 g/cm^3) and good flowability (≈18 sec./50 g).

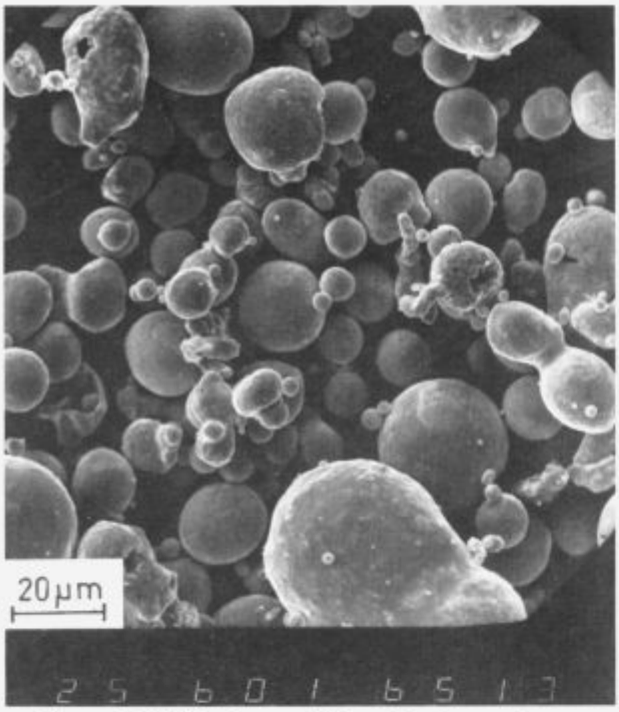

Figure 2: SEM micrograph of particle shape of water atomized Cu-2%Ni powder used as vacuum brazing agent
Slika 2: SEM posnetek delcev vodno atomiziranega prahu (spajke Cu-2%Ni) uporabljenega za vakuumsko trdo spajkanje karbidnih zrn z jekleno osnovo

As it has already been mentioned, the water atomized powders have a relatively high oxygen content (0.25 mass % of O_2 in prepared Cu-2%Ni alloy powder). This could be primarily attributed to particle surface oxidation during water atomization and surface adsorption of oxygen molecules during the handling with powder. In Cu based alloy-powders, oxygen solubility and oxides from slag[11] should also be taken into consideration. Individual contributions to the overall oxygen content of powder still have to be established in our future investigations. The brazing procedure is carried out in relatively high vacuum and therefore the high oxygen content of powder has little influence on the brazing quality. Because of the carbon content in the steel and in the cemented carbide, the reduction of oxygen with carbon is also possible. The Cu-Ni alloying system is one of complete solid solubility and therefore it can be concluded that the used braze is a substitutional solid solution.

Besides the braze, which is liquid at the brazing temperature, the diffusion processes (solid → liquid → solid) are influenced by the selected metal base (steel). Namely, because of the concentration gradients (and the driving force for diffusion is the gradient of the chemical potential), Fe and other alloying elements presented in the metal base diffuse across the braze at the interface braze/cemented carbide.

The diffusion of Fe is primarily influenced (suppressed) by the carbon content in steel[4], whereas the influence of other alloying elements (Cr, Mn, etc.) has not yet been analysed in detail.

In studying diffusion processes it has to be considered that mutual solubility of presented components is very small or practically equal to zero (solubility of braze in cemented carbide). Namely, the solubility of the main individual elements presented in the brazed components (Fe, Cr, Co, W) in braze (Cu) is relatively small. For example, Co solubility in Cu at brazing temperatures is ≈ 8 %, solubility of Cr is ≈ 0.65 % and Fe solubility is ≈ 5 %. But, W and C are practically insoluble in liquid Cu.

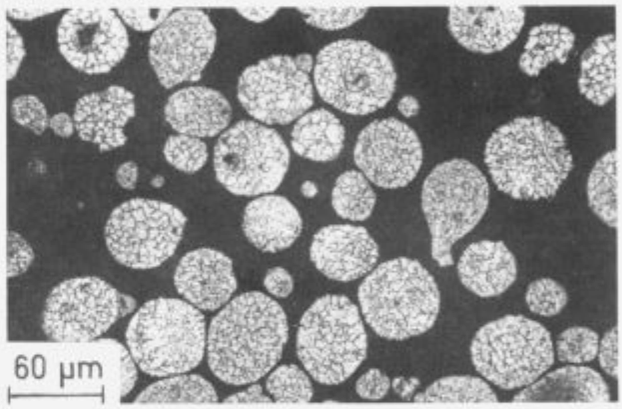

Figure 3: Optical micrograph of rapid solidified cellular microstructure of water atomized Cu-2%Ni powder particles with noticed internal porosity
Slika 3: Posnetek hitro strjene celične mikrostrukture delcev vodno atomiziranega prahu Cu-2%Ni z opazno notranjo poroznostjo

Cemented carbide particles were analysed with EPMA. Electron images show the expected sharp edged particles and the expected distribution of W and Co contents. In trace, Fe, Ni, Mn, Si and Cr are also present. The determination of qualitative and quantitative distribution of C is not possible with our EPMA.

3.1 Characteristics of cemented carbide particles/structural steel brazing joint

First, the brazing results analysis and a discussion of the brazing non-alloyed soft structural steel/cemented carbide with Cu-Ni braze will be presented. The selected steel has a fine grained ferrite-pearlite microstructure with approximately 15% of pearlite (see **Fig. 4**), low carbon content and Brinell hardness 205-215 HB. **Fig. 5** shows the cross section steel/braze/cemented carbide particle with elements distribution obtained with EPMA. It can clearly be seen that Fe diffused to the interfaces braze/cemented carbide particles, while W mostly remains in cemented carbide particles. Therefore, one can conclude that the diffusion of W is negligible, or rather, that it is limited to the diffusion to the interface cemented carbide/braze. Ni is found in braze. With Ni enriched regions are also interfaces steel/braze and braze/cemented carbide.

An increased amount of Co is noticed at the interface cemented carbide/braze and partially at the interface braze/steel. From this point of view it can be concluded that Co diffuses from the matrix of the cemented carbide particles to the interface cemented carbide/braze and across the braze to the interface braze/steel. The diffusion of Mn and Si is insignificant. On the basis of previous investigations[1,2,4], element

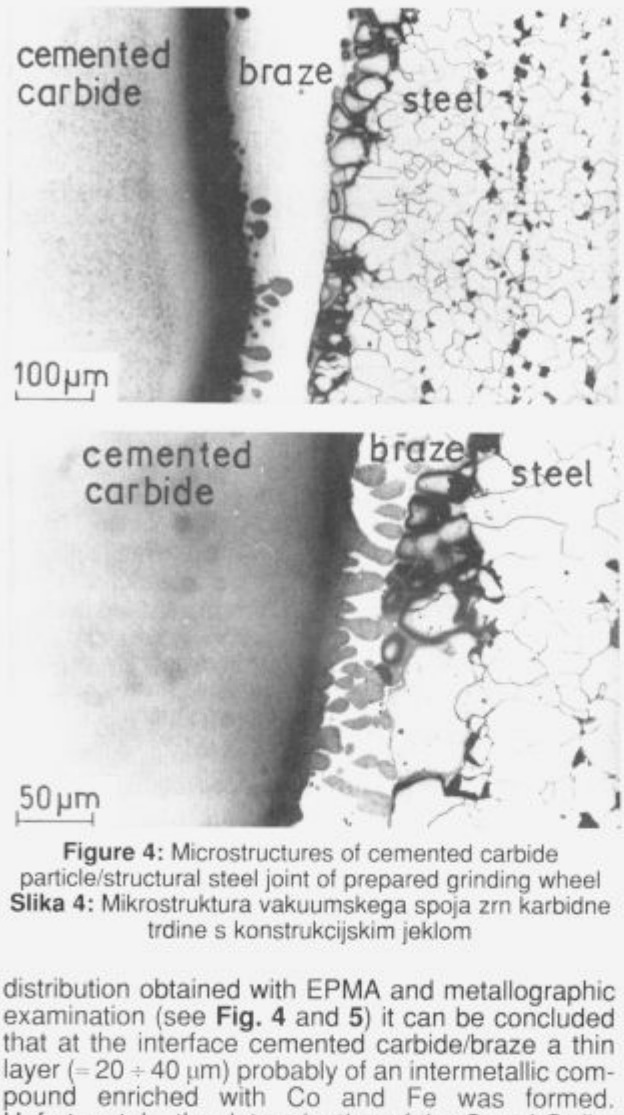

Figure 4: Microstructures of cemented carbide particle/structural steel joint of prepared grinding wheel
Slika 4: Mikrostruktura vakuumskega spoja zrn karbidne trdine s konstrukcijskim jeklom

distribution obtained with EPMA and metallographic examination (see **Fig. 4** and **5**) it can be concluded that at the interface cemented carbide/braze a thin layer ($\approx 20 \div 40\ \mu m$) probably of an intermetallic compound enriched with Co and Fe was formed. Unfortunately, the determination of the C and O distribution is not possible by our EPMA. Therefore, data of other investigators have to be considered[4]. The diffusion of C from steel across the braze as well as by the decomposition of cemented carbide particles and then the diffusion of W and C to the interface cemented carbide/braze is possible.

Studies of the Co-Cu-Fe-W quaternary system at the brazing temperatures and their subsystems with C have shown that the formation of a number of very stable compounds is possible. In addition to μ phase $(Co,Fe)_7W_2(Co,Fe,W)_4$, the formation of cementite phases M_3 ($[Co,Fe,W]_3C$), M_6C and $M_{12}C$ that have large negative Gibbs' energies is also possible. Energetically the most stable phase is $M_{12}C$, but a spot analysis (WDX) of the Fe/Co-containing compound phase at the interface cemented carbide/-braze showed[4] that at shorter brazing times especially phase M_3C is formed. The Gibbs' energy of this cementite phase is more than twice smaller than Gibbs' energy required for the formation of WC. Therefore it can be concluded that WC from cemented carbide particles during brazing is decomposed and released atoms of C and W diffuse across the Co matrix to the interface cemented carbide/braze.

C and Co reach Fe, which is present at interface, faster than W. Namely, the diffusion coefficient of C in Fe is very large because of its interstitial solubility and Co is the base of the solid solution of cemented carbide matrix. The diffusion of W is the slowest process, therefore it can be concluded that this process controls the formation of a compound layer and for very short brazing times energetically the most favourable process is the formation of a stable W-poor cementite phase.

Therefore in the first stage of brazing, C and Fe can diffuse from the steel across the braze to the interface braze/cemented carbide, because of their large concentration gradients. By the formation of cementite phase, the chemical potential of C is decreased and the conditions for WC decomposition, the diffusion of C and W to the interface cemented carbide/braze, as well as for the continuing growth and development of the compound layer are fulfilled. Some authors[4] explained the inferior strength of the vacuum brazed joint by the formation of a thin compound layer during brazing and appearance of microporosity behind this layer. The void formation during brazing with pure Cu, could be explained by the faster diffusion of Co from the cemented carbide matrix in comparison with the diffusion of other possible elements in the cemented

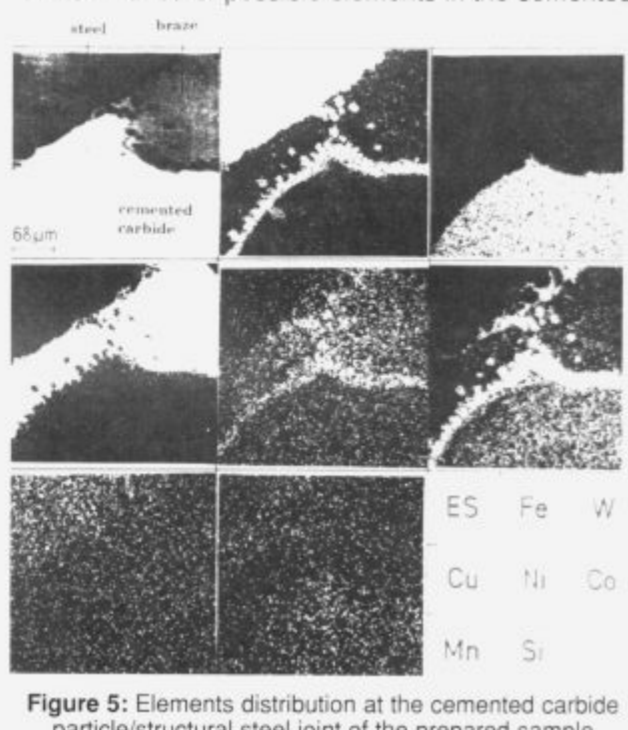

Figure 5: Elements distribution at the cemented carbide particle/structural steel joint of the prepared sample
Slika 5: Porazdelitev elementov v vzorcu izdelane brusne plošče na spoju zrno karbidne trdine/konstrukcijsko jeklo

carbide matrix (Kirkendall's effect). The metallographic examination of our samples (brazing joints) shows that microporosity is not present. On the basis of this, it can be concluded that the diffusion of Co is suppressed or, which is more probable, that Fe and especially Cu and Ni occupy the Co emptied sites. Namely, Ni, Fe and Co can form the system of a completely solid solution and therefore these elements can substitute for the Co in cemented carbide matrix and, as it was mentioned before, the micro-probe analysis of brazed samples really showed a region enriched by the Fe, Cu and Ni behind the formed compound layer.

At the interface steel/braze, the formation of a similar compound zone as observed at the interface braze/cemented carbide is not evident. The border zone steel/braze is enriched by Cu, Ni and Co (see **Fig. 5**). Co and Ni form a system of completely solid solubility with Fe, and solubility of Cu in γ Fe at brazing temperatures is $\approx$ 7.5%. Therefore, from this point of view and from the morphology of the border zone (see **Fig. 4**) it can be concluded that an intercrystalline diffusion of Cu is occurred, the solution of the mentioned elements in Fe is carried out and a homogeneous solid solution in the system Fe-Co-Ni-Cu at the interface steel/braze is therefore formed. **Fig. 6** presents schematically a brazing joint with established diffusion directions of individual elements and formed border zones at the interface steel/braze and braze cemented carbide particles.

The grinding experiments with prepared grinding wheels from the soft low-carbon structural steel and

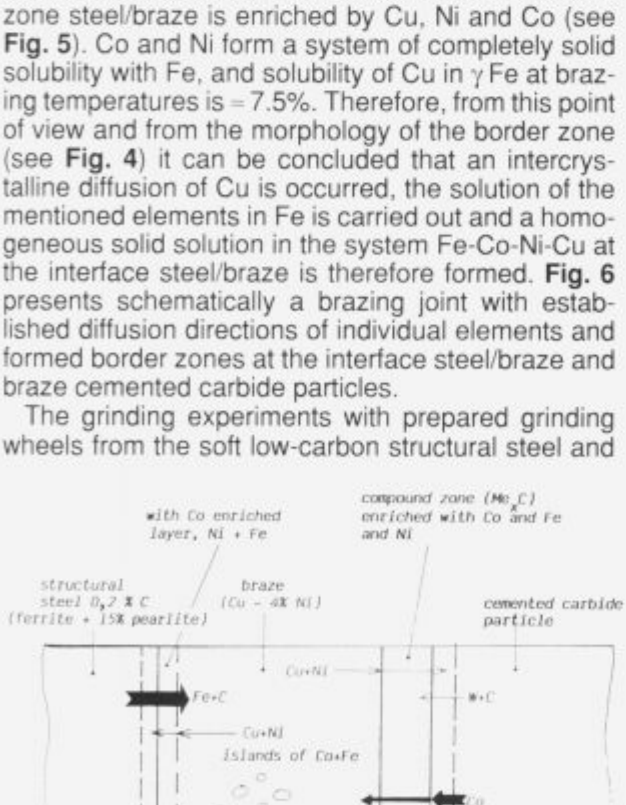

Figure 6: Schematic presentation of the brazing joint and the diffusion flows of the individual elements with generated border zones (sample of grinding wheel prepared by brazing of structural steel and cemented carbide particles)

Slika 6: Shematični prikaz vakuumskega spoja zrno karbidne trdine/konstrukcijsko jeklo z difuzijo posameznih elementov in nastalima mejnima conama

cemented carbide particles with Cu-Ni brazing agent showed that during the brazing a sufficiently strong diffusion bonded joint is formed. The average hardness of the steel base after brazing is 140 HV_1, of cemented carbide particles 1475 HV_1 and of the braze 100 $HV_{0.1}$.

3.2 Characteristics of cemented carbide particles/low-alloy hardening steel brazing joint

Now, the analysis of brazing experiments with the second selected steel will be presented. Here, in comparison with the first steel, a higher carbon content and a higher content of alloying elements (Cr, Mn, etc.) has to be considered. **Fig. 7** shows the cross section steel/braze/cemented carbide particle with element distribution obtained with EPMA. It can be clearly seen, that Fe diffuses to the interfaces braze/cemented carbide particles. W remains in cemented carbide particles. Therefore it can be concluded that the diffusion of W is negligible or more precisely that it is limited by the diffusion to the interface cemented carbide/braze.

Ni is mostly in the braze. With Ni enriched regions are also interfaces steel/braze and braze/cemented carbide. An increased amount of Co at the interface cemented carbide/braze as well as at the interface braze/steel is noticed. On the basis of that it can be concluded that Co diffuses from the matrix of cemented carbide particles to the interface cemented carbide/braze and across the braze to the interface braze/steel. The presence of Mn at the interface braze/cemented carbide is evident. Because of the presence of Cr in steel, the diffusion of Cr also occurs. The diffusion of Si is insignificant.

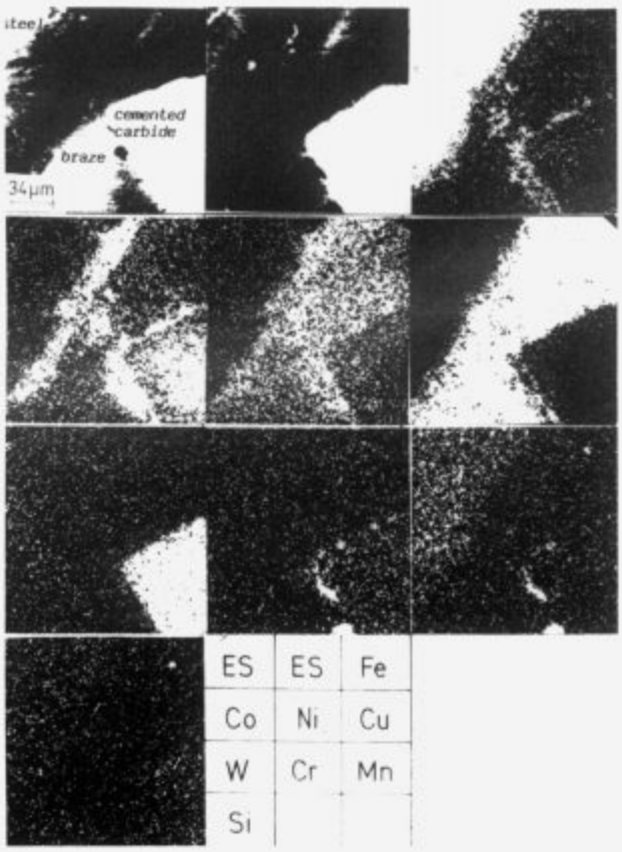

Figure 7: Elements distribution at the cemented carbide particle/low-alloy hardening steel joint of the produced grinding wheel sample

Slika 7: Porazdelitev elementov na spoju zrno karbidne trdine/jeklo za poboljšanje izdelanih brusnih plošč

On the basis of previous statements, element distribution obtained by EPMA and metallographic examination (see **Fig. 7** and **8**) it can be concluded that at the interface cemented carbide/braze, a thin layer ($\approx 20 \div 30$ µm), probably of an intermetallic compound enriched with Co and Fe, or what is more probable, concerning the diffusion of C, of the cementite phase Me_xC was formed. The thickness of the formed layer depends on the thickness of the braze and cemented carbide particles distance from the steel base, respectively, as well as on the brazing temperature and the soaking time at the brazing temperature.

In the layer of the braze, at certain places (islands), an increased content of Co and Fe can also be noticed. Because of intensive diffusion of Co out of cemented carbide particles, a diminished Co content behind the formed compound layer is observed. But at the same places, an increased content of Cu, Fe and Ni is noticed. Therefore it can be concluded that the diffusion of Ni, Fe and Cu proceeded in opposite direction. Besides Fe, Co, Ni and W (probably also C), Cr and Mn, were also found at the interface braze/cemented carbide. Therefore it can be stated that during the brazing of steel base and cemented carbide particles with Cu-Ni brazing agent (alloy-powder), a really very complex compound was formed. As it was mentioned above, some authors[4] have established that brazing joint between the steel plate and cemented carbide in this region is the weakest, because of the brittle nature of the compound layer formed during the brazing.

At the interface steel/braze seems to form no similar compound layer (as it was observed at the interface braze/cemented carbide). However, the noticeable increase of Co content is also observed, as well as the absence of W and the diminishment of Fe content because of its diffusion towards the cemented carbide. The border zone steel/braze is also enriched with Cu and Ni (see **Fig. 7**). Therefore, from that and from the morphology of the border zone (see **Fig. 8 a**) it can be concluded that as the intercrystalline diffusion of Cu proceeds, the solution of the mentioned elements in steel (Fe) is carried out and a homogeneous solid solution forms in the system Fe-Co-Ni-Cu at the interface steel/braze.

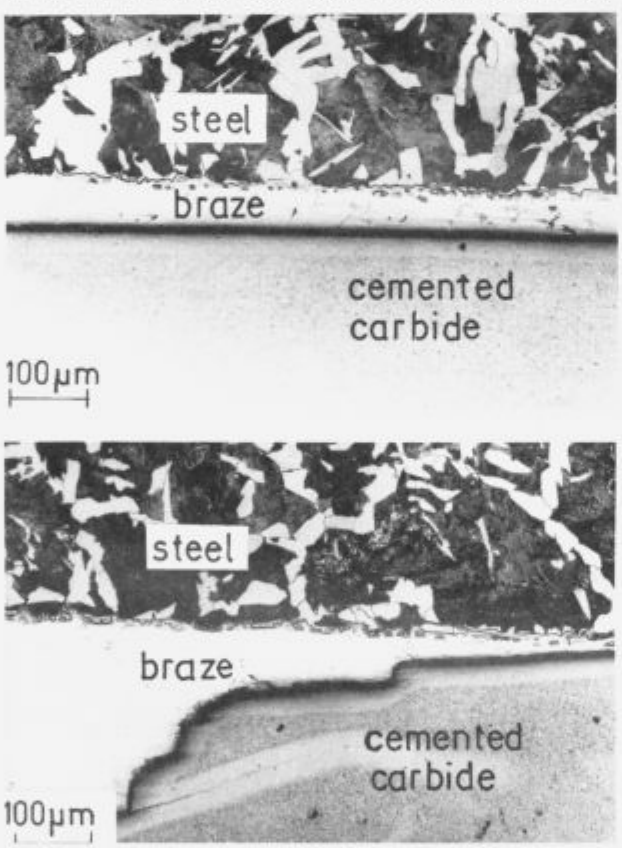

Figure 8: a) Microstructure of cemented carbide particle/low-alloy hardening steel joint of the grinding wheels produced at IMT Ljubljana and **b)** noticed damage (hair-shaped crack) of the cemented carbide particle

Slika 8: a) Mikrostruktura vakuumskega spoja zrno karbidne trdine/jeklo za poboljšanje vzorca brusne plošče izdelane na IMT Ljubljana in **b)** opazne poškodbe (lasne razpoke) karbidnih zrn

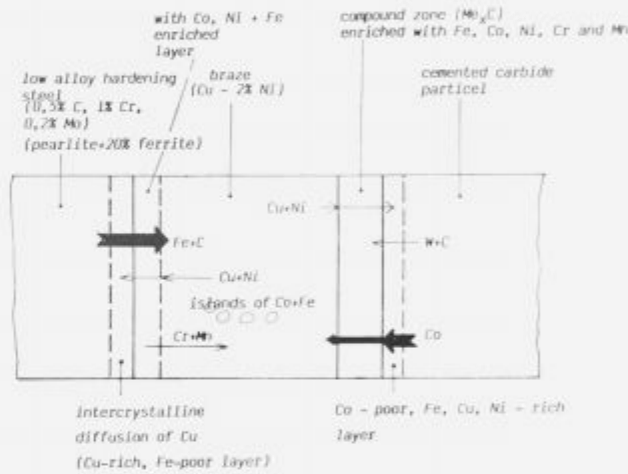

Figure 9: Schematic presentation of brazing joint and the diffusion flows of the individual elements with generated border zones (sample of grinding wheel prepared by brazing of low-alloy hardening steel and cemented carbide particles)

Slika 9: Shematični prikaz vakuumskega spoja karbidna trdina/jeklo za poboljšanje vzorca na IMT izdelane brusne plošče z difuzijo posameznih elementov in nastalima mejnima conama

Islands enriched with Fe and Co in the braze layer are observed, especially at some places, where the cemented carbide particles are very closely located to the steel base. Therefore it can be concluded that the most intensive diffusion of these two elements during brazing (in comparison with other active elements) occurs if the diffusion of interstitial C, which could not be analysed by our EPMA, is neglected.

Metallographic examinations also showed that some of the cemented carbide particles used were damaged (hair-shaped cracks). After brazing, around these cracks, a thin layer of cemented carbide with diminished Co content is observed. It can be concluded that during the brazing these damaged regions represent an active part for the diffusion of Co from cemented carbide to the interface cemented carbide/braze and across the braze to the interface braze/steel (see **Fig. 8 b**). **Fig. 9** presents schematically the brazing joint with established diffusion directions of individual elements and the formed border zones at the interface steel/braze and braze/cemented carbide particles.

The grinding experiments with prepared grinding wheels of low-alloy hardening steel and cemented carbide particles with Cu-2%Ni brazing agent showed that during the brazing a strong enough diffusion bonded joint is formed. The microstructure is ferritic-pearlitic with the prevailing content of pearlite and rare ferrite grains. The average hardness of the steel base after brazing is 200 HV_1, of cemented carbide particles 1980 HV_1 and of the braze 110 $HV_{0.1}$.

3.3 A comparison of both brazing joints

For the first brazing couple (structural steel/cemented carbide particles) only a marked Co and Fe rich compound layer at the interface cemented carbide/braze was observed. At the second brazing couple (low alloy hardening steel/cemented carbide particles), however, the marked enrichment with Co at both formed interfaces is observed. Here, the marked Co diminishment in the cemented carbide particle region close to the compound layer formed during brazing is also observed. Because of Cr presence in steel, the diffusion of Cr to the interface braze/cemented carbide occurred. The diffusion of Mn for the first brazing couple is insignificant, but it is evident for the second brazing couple. Therefore, on the basis of our investigations, it can be concluded that the low-alloy low-carbon structural steel for the brazing of cemented carbide particles with the steel base is a better option.

The most important parameters of brazing are the brazing temperature (including heating and cooling rate) and the soaking time at this temperature. Too high temperature and too long holding time of the brazing couple at this temperature enable the formation of a thicker layer of a hard and brittle compound phase at the interface braze/cemented carbide. It also causes the diminishment of the Co content at the cemented carbide border zone as well as formation of voids because of the Kirkendall effect and the resulting weakness of the brazing joint. The decomposition of WC because of C and W diffusion at interface cemented carbide/braze is also possible. Therefore lower temperatures (close to the melting point of the braze) and shorter soaking times at this temperature are more suitable for both selected steel bases. However, the brazing conditions have to be selected in such a manner that sufficient strength of the diffusion bonded joint is already formed.

4. Conclusions

The usability of Cu-2%Ni water atomized powder for the brazing of cemented carbide and steel base was investigated. On the basis of our investigations it can be concluded that water atomized Cu-2%Ni alloy-powder is suitable brazing agent. A vacuum brazing procedure for the manufacturing of grinding wheels containing cemented carbide particles was developed. The investigations show that for these types of grinding wheels, soft structural steel as a metal base seems to be the most convenient solution.

The aim of future experiments and investigations is to optimise the brazing procedure as well as to develop new shapes of grinding wheels. Future investigations should show which combination of selected materials (steel/braze/WC-C) will give a joint with the highest strength. We have in mind brazing experiments with different steels (structural steels, tool steels, etc.), brazes (pure Cu, Cu-Ni with different Ni contents, etc.) and different sorts of cemented carbide particles.

By metallographic examinations, analysis with EPMA and hardness measurements the brazing joints between structural as well as low-alloy hardening steel and cemented carbide particles using Cu-2%Ni brazing agent were partly evaluated. The diffusion joint is sufficiently strong and without noticeable defects. Its microstructural feature is a thin layer of intermetallic compound from the system Fe-Co(-W-Cr-Cu-Ni) or, more probably cementite phase M_xC type at the interface braze/cemented carbide formed during the brazing and intercrystalline diffusion of Cu at the interface braze/steel. However, only more detailed and systematical investigations with analysers (SEM/EDX, WDX, EAS) sensible for the light elements (O, C) distribution could fully explain the occurrence of multi phase diffusion and take into account all thermodynamic and kinetic aspects in order to answer what kind of compound is formed at the interface steel/braze and especially at the interface braze/cemented carbide during the brazing.

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