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THE EFFECT OF THE TEMPERATURE AND COMPACTING PRESSURE ON THE PROPERTIES OF WC–25 MASS% CO HARD ALLOY

The effect of temperature and compacting pressure upon density, structure and mechanical properties of a hard alloy of WC–25 mass% Co is investigated. A standard powder mix with a size of carbide particles of 0.7–1.0 microns was tested, previously condensed without plasticizer at the room temperature and pressure of 100 MPa. The obtained powder billets were compacted by the method of impact hot pressing in vacuum at temperatures of 1190, 1240, 1290, 1330 and 1370°C. The isothermal holding before consolidation at specified temperatures was 10 min. Consolidation at each temperature was carried out with different energy. Thus the maximum compacting pressure corresponded to the values of 640, 960 and 1280 MPa, but for temperatures 1290, 1330 and 1370°C the pressure of 320 MPa was applied. For comparison, the samples were sintered at specified temperatures and with isothermal holding of 20 min. The samples obtained at different temperatures and pressure, were tested with respect to the density, specific electrical resistivity, quantitative characteristics of structure, and also transverse rupture strength (TRS), fracture toughness, Vickers hardness, impact strength. It was established that the method of impact hot pressing in vacuum allows obtaining almost pore-free samples of an alloy of WC–25% Co at rather low temperatures, i.e. in solid-phase area of sintering where traditional hard alloys possess high porosity. Thus specific resistivity of the samples condensed in a solid phase, was the same in size, as resistance of samples after liquid-phase sintering. The change of the densification temperature of samples at impact pressing provides extreme character of the change of mechanical properties. The maximum values of various properties are reached at consolidation the region of temperature of 1290°C. At the lower consolidation temperatures, the samples have non-uniform structure and lowered properties even in the case of high density and low specific resistivity. At higher consolidation temperatures, the lowered characteristics of strength and fracture toughness are caused probably by some replacement of the melted cobalt from a sample and formation of microdestructions in a carbide skeleton. When using high level of compacting pressure at the impact consolidation, there is a decrease in mechanical properties of the samples, probably, because of the increased defectiveness of a carbide skeleton. Therefore there are optimum parameters of impact consolidation at which the samples have the best complex of properties. In particular, at the temperature of 1290°C and the maximum pressing pressure of 640 MPa, the samples have transverse rupture strength 3000–3400 MPa, Vickers hardness – 10–10.5 GPa, fracture toughness – 20–24 MPa·m$^{1/2}$ and the impact strength – 6–11 J/cm^2.

Keywords: impact pressing, hard alloy, mechanical properties

Fig. 1. Impact time dependence of the pressing effort at impact consolidation with different energy of powder briquettes of the WC–25 mass% Co hard alloy: *а* – maximum effort is 400 kN, *б* – 800 kN, *в* – 1200 kN, *г* – 1600 kN. One cell on an axis of ordinate is 200 kN, on an axis of abscissae – $2.5 \cdot 10^{-4}$ s

Fig. 2. Dependence of the density (*а*) and electrical resistivity (*б*) of the WC–25 mass% Co hard alloy on the temperature, the method and pressure of consolidation *P*, MPa: ■ – 320, ● – 640, ▲ – 960, ▼ – 1280, ◇ – conventional sintering

Fig. 3. The structure of the WC–25 mass% Co samples obtained by conventional sintering at different temperatures *T*, °C: *а* – 1240, *б* – 1330

Fig. 4. The structure of the WC–25 mass% Co samples obtained by impact hot pressing with the maximum pressure of 640 MPa at the temperatures *T*, °C: *а* – 1240, *б* – 1290, *в* – 1330, *г* – 1370

Fig. 5. The structure of the WC–25 mass% Co samples obtained by impact hot pressing at the temperature of 1290°C and the pressures 320 MPa (*а*) and 960 MPa (*б*)

Fig. 6. Dependence of the transverse rupture strength (*а*) and fracture toughness (*б*) of the WC–25 mass% Co samples on the temperature, method and pressure of consolidation *P*, MPa: ■ – 320, ● – 640, ▲ – 960, ▼ – 1280, ◇ – conventional sintering

Fig. 7. The fracture surface of the WC–25 mass% Co samples obtained by impact pressing with the pressure of 640 MPa at temperatures *T*, °C: *а* – 1190, *б* – 1290

Fig. 8. Dependence of the dimension of conditional critical defect of the structure a_c of the WC–25 mass% Co samples on the temperature, method and pressure of consolidation *P*, MPa: ■ – 320, ● – 640, ▲ – 960, ▼ – 1280, ◇ – conventional sintering

Fig. 9. Dependence of the hardness (*а*) and impact strength (*б*) of the WC–25 mass% Co samples on the temperature, method and pressure of consolidation *P*, MPa: ■ – 320, ● – 640, ▲ – 960, ▼ – 1280, ◇ – conventional sintering