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Hard alloy metal regeneration in shock waves

Didyk R.P.

National mining university
Dnipropetrovsk, Ukraine

Abstract
The principled capability of shock wave processing of massifs from supersolid materials is considered with the purpose of their grinding and defect formation in conditions of operating of high gradients of pressure and loading rates. The outcomes, introduced by researches, are the basis for mining high-performance technology of reactivation of hard alloys.

Key words: SHOCK WAVE, SUPERSOLID MATERIAL, HIGH-PERFORMANCE TECHNOLOGY.

Considerable progress of the contemporary science and technology is connected with achievements and development of extreme physical parameters. Nuclear and conventional explosions, laser and electron beams, high-energy electrical discharge in liquid, magnetic fields of high intensity allow developing record temperature and pressure combinations under terrestrial conditions. Among the mentioned high-energy resources, loadings generated by detonation of condensed explosives are the most efficient and advanced ones; they allow achieving 50 GPa pressure in detonation products at the rate of their expansion velocity of 10 kilometers per second. According to their parameters, blast loads within the nearest zone exceed the stress limits of all known materials. These factors, defining mechanical work of an explosion, have found diverse application in engineering.

Cemented carbide alloys are classified as heterogeneous mixtures in the environment of which there are surfaces on which abruption of any microscopic parameters takes place. The known results of theoretical and experimental research show that the presence of components with different compressibility, density, capacity distribution irregularity in the environment conditions a substantial difference in the nature of shock wave distribution compared to homogeneous unobstructive environments [1]. It is worth mentioning that unlike classical processing methods, shock wave processing makes fundamental changes in the structure at every scale level. In this respect, the following idea appeared to be fruitful: to stimulate processes of defect formation and destruction of wolframium containing alloys under conditions of effect of high gradients of pressure and loading rate [2,3] as the first stage of the technology chain of processing the material into ultradisperse powder of high chemical activity [4].

Explosive processing is conducted in hermetically-sealed metal cylindrical capsules which were preliminarily filled with samples from WC-Co alloy.

Figure 1 shows a shock wave pattern initiated by detonation of a ring charge of the explosive occurring while crimping the reaction mixture of the capsule in mode of converging conic shock wave.

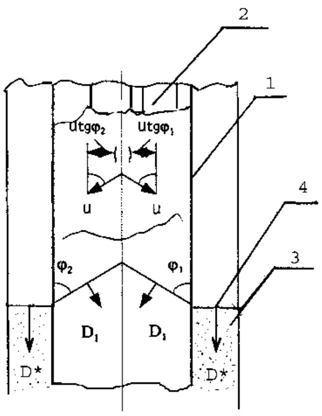

Figure 1. Tangentional discontinuity of material particle movement rate (u) with converging front of the shock wave (D_1) in a cylindrical capsule – 1; 2 – the material processed; 3 – BB charge; 4 – detonation front (D[1])

As a result of interaction between an incident blast wave and free side boundary of the material, depression waves appear; they cause transverse motion of particles leading to tangentional discontinuity of mass rates and, subsequently, shifts which precede a fracture process. The pressure of the samples studied was calculated according to known equations of the component status and experimental data and made up 30-35kilobar. The percussive adiabat of the WC-Co alloy was identified with an electrical contact technique [3] and was described with a known linear relationship for shock wave rate:

$D = C_0 + \lambda U$, where

D is shock wave rate;

C_0 – 4.51±0.12 is sound rate, mps;

λ=2.2±0.31

U is particle mass rate beyond the pressure-shock front, mps.

The peculiarities of the structure changes of WC-Co alloy exposed to explosive processing were studied with techniques of electron and optical microscopy, an X-ray structural analysis, and microhardness testing (Fig. 2)

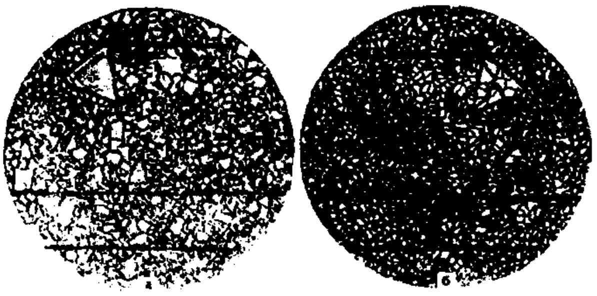

Figure 2. The sample microstructure of VK-6 hard alloy: a) – before explosive processing; b) – after explosive processing.

By researching VK alloy micro-structure before and after explosive processing, considerable refinement of carbide grains and cobalt cluster thinning was defined. Sharp increase of microhardness was recorded. Moreover, the microhardness keeps its high rating 1875 kg per mm across the whole width of the samples (5.5 mm).

The study of the thin structure showed changing of the width of X-ray lines from the surfaces (111) and (211). The line width changes as well as hardness increased gives evidence of hardening of the binding components in the cobalt alloy. The zone of local cobalt deformation shows formation and accumulation of micropores in the shape of tetrahedron which are effects emergence of dislocations. The dislocation concentration and density increase and make up 3.9x10^{-1}1cm^{2}. As an apt defect generation mechanism, we can consider chaotic lattice disorder of tungsten carbide due to multiple reflections of shock waves at intercrystalline interfaces and grain junction lines.

Thus, being processed with shock waves with 30-35kilobar intensity, the defect accumulation mechanism of metal-ceramic alloy of VK type is conditioned by large lattice micro disorder of cobalt, increasing dislocation density, growth of micro-hardness and tungsten carbide grain disorder. The latter is connected with effect of unloading waves resulting mainly in tangentional discontinuity of mass rates of material particles.

The research conducted regarding the influence of loading on the reactive capacity of powder has shown that the internal energy and chemical activity increase considerably in processed powders. The peculiarities concerned allowed accomplishing finely dispersed structure refinement of the alloy, except physical and thermal regeneration processes. The finely dispersed grind method was applied for BK-6

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[1] During the experiment there was used a utilized piped instrument – VK-6 alloy die

powders which had been preliminarily made in capsules of impact compression with size 0.8÷1mm.

Table 1 gives characteristics of the WC-Co powder regenerated by explosion.

Table 1. Characteristics of sintered alloy from explosion regenerated WC-Co powder

Alloy grade	Size of original grains, mm	Size of final product grains, micrometers	Density, g/cm^3	coercive force, KA/m	Hardness, HRC	Flexural stress, mPa	Void volume – pore content up to 50 mcm, %
WC – 94% Co – 6%	0.8÷1	1÷2	14.6÷15.0	11.9÷13.5	88.5	1500	0.2÷0.3

Figure 3 gives the data regarding the results of wet grinding of the BK-6 powder exposed to the shock wave processing stage. The figure also illustrates the duration of the powder grinding to the same degree without exposure to the shock wave processing.

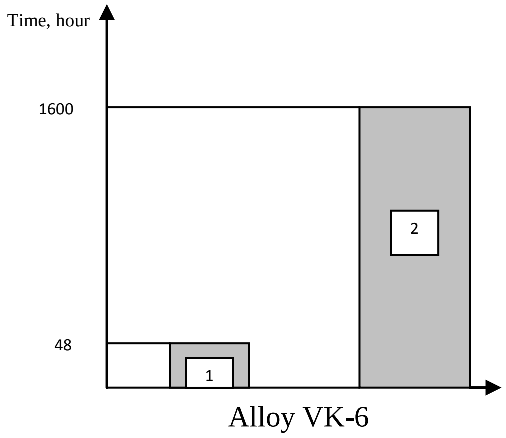

Figure 3. Time grinding alloy VK-6: 1 - processed in shock waves; 2 - without the shock-wave treatment

The graph provided shows that the grinding duration for the powder processed by explosion is 20 times as short as that for the current grinding technology; this allows decreasing energy consumption for grinding process by 7.75 megawatt for one aggregate only.

Thus, the article demonstrates the principle possibility of applying the shock wave processing as a factor which stimulates defect formation processes for hard alloy massifs of any configuration to get high quality original material for further processing, forming and baking while producing tools for various purposes.

References

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