New Applications of Emulsion Explosives

A. S. Yunoshev, S. I. Rafeichik, A. V. Plastinin, V. V. Sil’vestrov

Abstract: This paper considers the use of emulsion explosive compositions to join building bars and replace worn thread in the railway wheel axle. The compositions do not contain individual explosives and greatly increase the safety in explosive working of metals.

Keywords: emulsion explosives, joining of bars, explosive cladding.

INTRODUCTION

There has been steady interest in the use of explosive technologies to work various materials, mainly metals, as evidenced by the proceedings of symposiums on explosive production materials [1]. These applications use mainly mixtures of ammonites with various additives that lower the detonation velocity and/or increase their detonability. In addition to ammonium nitrate, ammonites, as a rule, contain TNT, a powerful secondary explosive banned for commercial use in many countries.

Emulsion explosives (EMX) containing no secondary explosives [2] represent a large proportion of commercial explosives produced at present. Advantages of these compositions are: the possibility of their production from inexplosive components just at the explosive working site (without expensive transportation of explosive materials); high resistance to bullet penetration; low impact and thermal sensitivities and, hence, high safety in use [3]; low cost; low environmental pollution (the amount of harmful nitrogen and carbon oxides are 5–15 times less than that in the explosion of commercial explosives consisting of mixtures of ammonium nitrate with TNT or hydrocarbon fuels) [2, 3]. Laboratory-produced emulsion explosives are characterized by small values of the critical diameter and thickness and the possibility of varying the parameters of EMXs for a particular task [4, 5].

Below, we consider the use of EMXs to solve applied problems such as the joining of building bars or the replacement of worn thread in the railway wheel axle. Both problems have been posed and solved by researchers from the Paton Institute of Electric Welding (Kiev, Ukraine) using standard explosives [6, 7]. We propose to solve these problems using emulsion explosive compositions that do not contain hazardous explosives, which would simplify the implementation of possible technologies.

EXPLOSIVE JOINING OF BUILDING BARS

During construction of high reinforced-concrete structures (hydroelectric dams, tall buildings, towers, bridge piers, etc.), it is required to join individual building bars in a single unit up to a few tens of meters long. This is usually achieved by means of thermal welding, threaded joints or hydraulic pressing tools, but, in many cases, these methods are expensive and ineffective. Dobrushin and Bryzgalin [6] proposed to solve the problem by explosive compression of a cylindrical steel sleeve into which the ends of building bars are introduced. The explosive charge consisted of 2–3 layers of a detonating cord (DC) wound on the outer surface of a sleeve 200–300 mm long. A similar approach using a DC and an aluminum sleeve to be compressed was employed earlier in the Lavrent’ev Institute of Hydrodynamics,
Fig. 1. Diagram of explosive joining of building bars (a) and photographs of samples after explosion (b): (1) building bars; (2) compressed sleeve (steel 20; a diameter of 41/29 mm to 57/36 mm for bars Nos. 25–32; length 150 mm); (3) EMX layer 5–20 mm thick; (4) initiating turn of the detonating cord.

Fig. 2. Sections of the joints obtained using a detonating cord (a) and an EMX layer (b): The top row corresponds to bars No. 25, the conditions of the experiments are given in lines 1 and 3 in the table; the bottom row corresponds to bars No. 32; lines 8 and 10 in the table.

Siberian Branch, Russian Academy of Sciences, to develop a technology for joining aluminum open wires for high-voltage overhead lines [8].

In the present work, this problem was solved using an EMX containing 8% (by weight) physical sensitizer (domestic MS-V glass microballoons); the composition of the emulsion matrix is given in [4]. The physical state of the EMX is a viscous paste sensitive to initiation by a detonator or a DC; the density is 1.03–1.05 g/cm³, and the allowable thickness is 2 mm. In a layer more than 5 mm thick, the detonation velocity is 4.3–4.5 km/s and the pressure is about 5–6 GPa.

An EMX layer of the required thickness was produced by rolling the explosive on a flat surface between two polyethylene films. Then, the flat EMX layer of the required size was applied to the sleeve surface and was fixed with an adhesive. The structure of two bar segments introduced into the steel sleeve was subjected to an explosion (Fig. 1). The EMX was initiated by a DC turn which enclosed the end of the cylindrical explosive layer. For comparison, experiments were performed with a DSh-V detonating cord using the technology of [6]. In both cases, the building bars were mechanically compressed by the sleeve material.

After the explosion, the joint was cut in the longitudinal direction so that the longitudinal ridges of the bars did not lie in the plane of the section. The cut surface was ground. It is known that for the joints produced using a DC (Fig. 2a), all tests satisfy the condition of equal strengths of the bars and the joint under uniaxial tension [5]. Therefore, the quality of the joint obtained using the emulsion explosive was estimated by visual comparison of the cuts of the joints obtained using the emulsion explosive and the DSh-V detonating cord (Fig. 2).

The conditions of the experiments are shown in the table. The optimal thicknesses of the EMX layer required to obtain qualitative joints are in bold. The fourth column of the table shows the weight of the explosive per 1 dm of the sleeve length and (after a slash