Safety Science 50 (2012) 588–592

Contents lists available at SciVerse ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Special Issue Article: The First International Symposium on Mine Safety Science and Engineering

Numerical simulation on foam ceramic blasting block device under the action of explosion transform ☆

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ARTICLE INFO

Article history:
Available online 22 September 2011

Keywords:
ANSYS finite element simulation
Euler equation
Explosion destructive
Foam ceramic blasting block device
Blasting block numerical calculation

ABSTRACT

The responsive behaviour of the action of under explosion blasting block damaging device structure was investigated based on quality equation, energy conservation equation and thermodynamics equation, using the ANSYS finite element simulation and Euler form of momentum equation. This paper analyzed the destructive situation of the inside and outside of the foam ceramic device. The research shows that the finite element simulation results and the numerical calculation results agree, which provides important reference basis in the anti-explosion design and improvement of cut off the device for blasting.

1. Introductions

In recent years, Serious accidents always occur in the coal mines. The most harmful accident is no doubt gas explosion. Because of its sudden and huge damage, society pays the high attention and there are many corresponding prevention measures, including the effective explosive device most widely used in the coal mines. Now the blasting explosive device can be divided into passive and active according to blasting mechanism. But the existing explosive device was restricted by underground environmental limitations. When the action pressing of blasting explosive device is set too low or too high, or it advances or delays to release inhibitors before the flame reaches, the blasting explosive device does not work and lead to restricting secondary explosions. Wei et al. (2011) developed the solid automatic explosive device, which is used foam ceramic as the main resistance materials. It can be installed more explosive devices that can well cut off the hazards and influences of the gas explosion with the repeat function and kits; It is also very useful when the second explosion or even more times were happened.

As Bomb blast has some characteristics such as spread fast, shock wave peak is large and time is short, which makes the dynamic response of the gas explosive device structure under the impact loads is very complicated. The experimental results are quite comprehensive and specific with high cost which usually was analyzed through the experiment, and it is not easy to attain because of the influence by underground environment. This paper is based on the analysis of Sun Jianhua's and Wei Chunrong's paper about air recoil type solid block critical device structure design, and through simulating the ANSYS finite element analysis software on gas explosion and analyzing destructive power, combining with the Euler equation. The theory that the degree of influence and change rule can be attained which the gas explosive destructions acted on foam ceramic explosive device and it is further to simulate the transient dynamic process that the gas explosive destructions to the blasting explosive device which provides effective evidence of studying the performance and improvement directions of the gas blasting explosive device, and it is significant for the research and design of the ore difficult lifesaving system.

2. Numerical calculate to gas explosion

2.1. Calculating by using Euler equations

After the gas blasting shock wave produced in roadway, it is supposed that the spread of wave flow does not change (that is

☆ The First International Symposium on Mine Safety Science and Engineering (ISMSSE2011) will be held in Beijing on October 26–29, 2011. The symposium is authorized by the State Administration of Work Safety and is sponsored by China Academy of Safety Science & Technology (CASST), China University of Mining & Technology (Beijing) (CUMTB), Datong Coal Mine Group, McGill University (Canada) and University of Wollongong (Australia) with participation from several other universities from round the world, research institutes, professional associations and large enterprises. The topics will focus on mines safety field: theory on mine safety science and engineering technology, coal mine safety science & engineering technology, metal and nonmetal mines safety science & engineering technology, petroleum and natural gas exploitation safety science & engineering technology, mine safety management and safety standardization science & technology, occupational health and safety in mine, emergent rescue engineering technology in mine, etc.

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doi:10.1016/j.ssci.2011.09.011

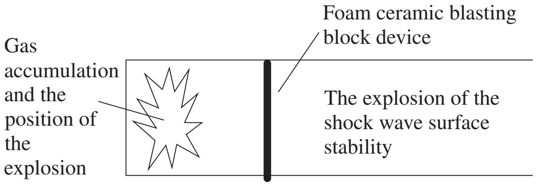

Fig. 1. Roadway excavation in gas explosion schemes.

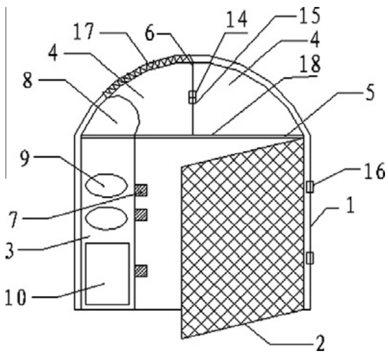

Fig. 2. Round arch type of explosive device solid block recoil of structure schematic drawing. (1) Support framework. (2) Resistance door. (3) Resistance blasting explosive board. (4) Resistance critical window. (5) Beams. (6) Vertical hang beam. (7) Crash pad. (8 and 9) Mouth about the pipeline through the hole. (10) Open cut way. (11) Control module. (12) Infrared sensors. (13) Gas created device. (14) Electromagnetic bit. (15) Spring. (16) Fixed a. (17) Sealing device. (18) Locking bolt. (19) Swinging motor. (20) Limit switch.

usually thought each parameter only in one direction has a significant change, and the change is continuous, not according to the time) (Sun, 2003), and roadway excavation can be simplified as one pipe, as shown as in Fig. 1.

Using the Euler form of mass, momentum and energy conservation laws of thermodynamics for determining the following several parameters such as pressure, temperature, density, size which are all the functions of t and x (Qu et al., 2005). So the Euler forms of gas explosion flow equation in shock wave propagation as follows:

$$\frac{\partial\rho}{\partial t}+v\frac{\partial\rho}{\partial x}+\rho\frac{\partial v}{\partial x}=0 \tag{1}$$

$$\frac{\partial v}{\partial t}+v\frac{\partial v}{\partial x}+\frac{1}{\rho}\frac{\partial P}{\partial x}=0 \tag{2}$$

$$\frac{ds}{dt}=\frac{\partial s}{\partial t}+v\frac{\partial s}{\partial x}=0 \tag{3}$$

Plus state equation:

$$PV=nRT \tag{4}$$

$$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2} \tag{5}$$

Based on the Euler equation and according to experience values, when gas explosion was happened, pressure is commonly from 10 to 20 atmospheric pressure, namely 1–2 MPa, general cross-sectional area is about 4 m long, 2 m wide, so roadway cross-sectional area $S = L \cdot W = 2 \times 4 = 8\ \text{m}^2$, namely when happened the gas explosion, the minimum destructive is $F = P \cdot S = 8 \times 10^6$ N, the biggest destructive is

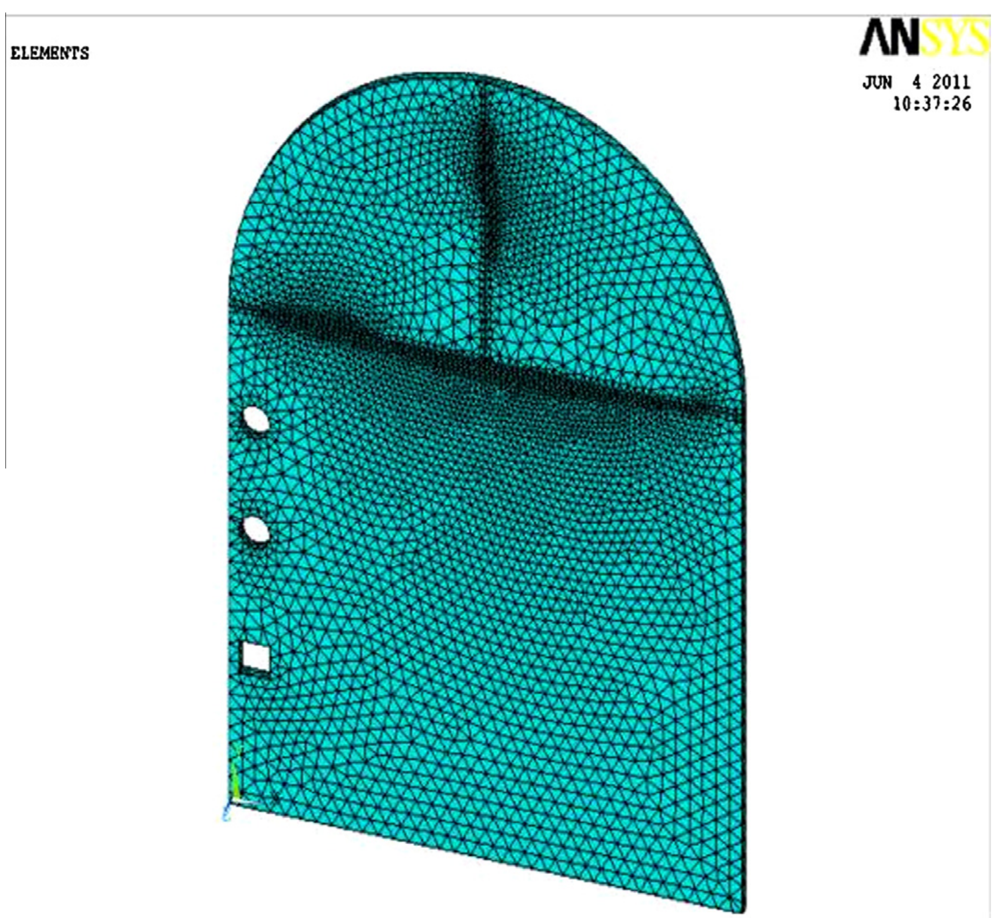

Fig. 3. Foam ceramic blasting block device mesh.