第 9 卷　第 4 期
2001 年 12 月

含　能　材　料
ENERGETIC MATERIALS

Vol. 9, No. 4
December, 2001

Article ID: 1006-9941(2001)04-0165-03

Incremental Pressing Technique in Explosive Charge

TIAN Li-yan, XU Geng-guang, WANG Ting-zeng
(*School of Mechatronic Engineering*, *Beijing Institute of Technology*, *Beijing* 100081, *China*)

Abstract: A pressing technique has become available that might be useful for compressing granular explosives. If the height-diameter ratio of the charge is unfavorable, the high quality charge can not be obtained with the common single-action pressing. This paper presents incremental pressing technique, which can obtain the charge with higher overall density and more uniform density.

Key words: explosive; pressing; incremental pressing; density distribution
CLC number: TQ560　　**Document code**: A

1 Introduction

The pressing of explosive charge is a well-known procedure in ammunition technology. The pressure distribution in pressed charge depends on the friction force that occurs between the die surface and the granular explosive. The density gradient strongly influences the shape and velocity of detonation wave in the pressed charge. An ideal explosive charge should have certain density and density gradient so as to ensure a required detonation velocity.

In this paper we present an incremental pressing technique, which can increase the overall density, decrease the density gradient and improve the density distribution of the charge, by the way of reducing the contacting area to decrease the friction between the die surface and the granular explosive.

2 Theoretical analysis

Pressed body of granular explosive has density anisotropy, which is caused by the pressure distribution in the charge. Compaction force is normally transferred from the punch into the explosive. Part of them is expended as friction against the die wall[1]. The friction force between the die surface and the granular explosive has a remarkable influence on the pressure distribution, which results in pressure gradient within the charge. Once the pressure distribution in pressed charge is known, local charge density can be calculated.

2.1 Pressure distribution in cylindrical charge

The pressure distribution in cylindrical charge can be calculated if the following assumptions are used[2]:

(1) The friction force between the die surface and the explosive has been fully mobilized; i. e. the friction force is proportional to the normal force.

(2) The axial and radial stresses are considered as the principal stresses.

(3) To ensure a constant radial stress, the cylinder radius is much smaller than the cylinder height.

By analyzing the force balance over the differential element in cylindrical charge, the following equation is obtained

$$p = p_0 \cdot e^{-2f \cdot \eta \frac{h}{R}} \quad (1)$$

where, p, pressure experienced, MPa; p_0, pressure applied, MPa; f, coefficient of friction; η, coefficient of lateral pressure transmission; h, distance from the interface of punch, mm; R, radius of the charge, mm.

Eq. (1) presents that the local pressure decreases with the relative height (h/R) of the charge with an exponential relationship.

2.2 Density as a function of pressure

The density in compacted charge increases with the pressure . There seems to be a logarithmic relationship

Received date: 2001-06-25; **Revised date**: 2001-09-24
Biography: TIAN Li-yan (1970 –), female, doctoral student, research field: charge technology.

between pressure and density. An empirical equation is often used[3,4].

$$\rho_r = a + b \cdot \ln p \quad (2)$$

where, ρ_r, relative density of the charge; p, pressure experienced; a, b, compressibility factor.

2.3 Density distribution in cylindrical charges

Integrating Eq. (1) with Eq. (2), the following equation can be obtained

$$\rho_r = A - B \cdot \frac{h}{R} \quad (3)$$

where, A is the relative density on the end surface of the charge near the punch under a certain pressure, relating to the bulk density, compressibility of the granular explosive; B is the coefficient relating to the compressibility of the granular explosive and the friction force between the die surface and the granular explosive.

Because the relative density of each layer in the charge decreases with the growing relative height (h/R) of the charge with a linear relationship, there is a limitation on the height-diameter ratio. Generally, the ratio of the height to the diameter is 2. If it is more than 2, a satisfactory charge can not be obtained in the usual single-action pressing.

2.4 Incremental pressing

Incremental pressing is a new pressing technique. The amount of the granular explosive is divided into several shares. As soon as the first share is put into the die, the punch will be acted on the explosive and then the second share is compressed until the entire shares are pressed. Decreasing the friction between the die surface and the granular explosive though reducing the contacted area the expending of the compaction force on the die wall will be decreased. Then the overall density of the charge will be increased and the density gradient will be improved.

3 Experiments

Several samples were produced as follows. An amount of 25 g powder was divided into five shares. Each share was added into the die with 20 mm inner diameter respectively and a plastic film was placed between the two shares. In the single-action pressing, after the whole five shares were added into the die, a dead load of 130 MPa was applied for a dwell time of 10 s. In the incremental pressing, after each share being added into the die, the pressing operation was carried out as described above.

After pressing, the charge was ejected from the die and split into 5 segments along the section of plastic films. The density of each segment was measured by using Archimedes' principle. The samples were coated with wax to prevent water penetration. The mass and volume of the coating charge were compensated in calculating the density of the sample. The average relative density of each segment was regarded as the mid-height density of the segment. The results of experiments are given in Fig. 1 ~ 3.

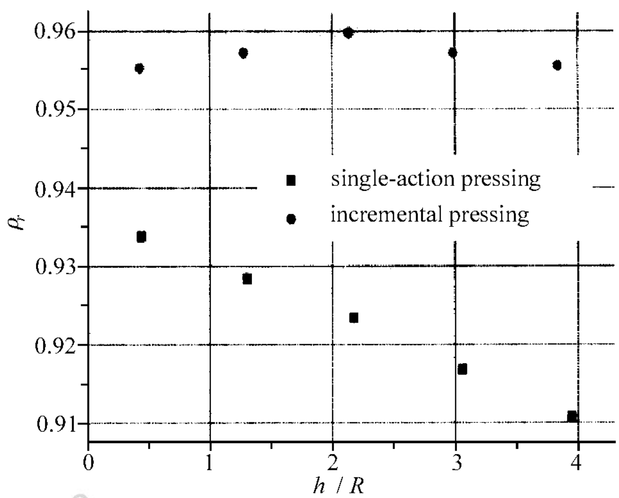

Fig. 1 Comparison of relative density distribution of JHL-2

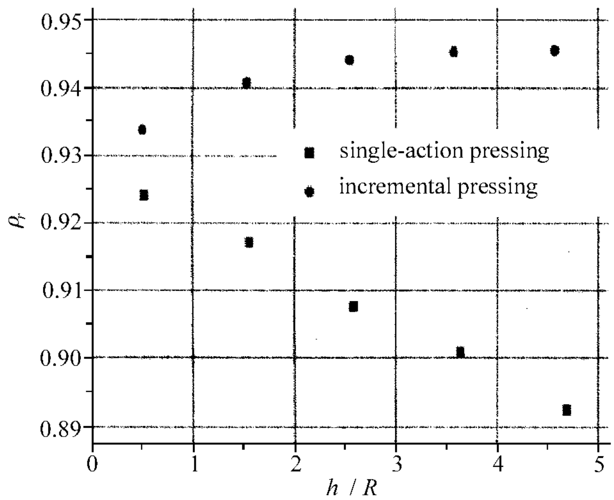

Fig. 2 Comparison of relative density distribution of TNT

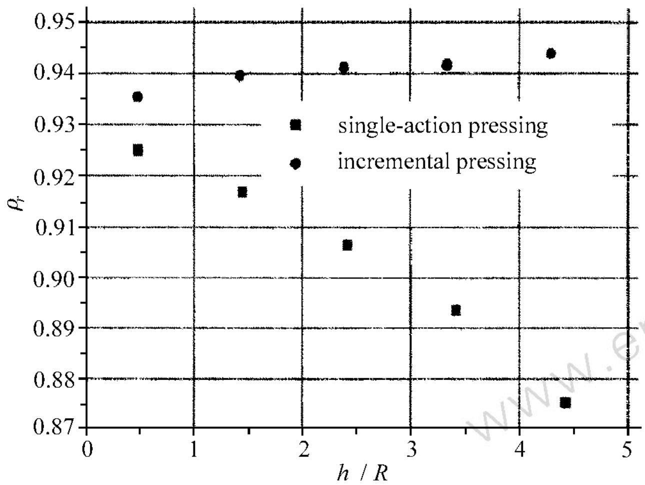

Fig. 3　Comparison of relative density distribution of 8701

Table 1 shows the results of average relative density of the charge and the maximum relative density spreading between each layer in the single-action pressing and incremental pressing. The explosives of JHL-2, TNT, and 8701 were used.

Fig. 1 ~ 3 and Table 1 show that in the incremental pressing the overall density is higher and the density spread between each layer is much smaller than that in the single-action pressing.

Table 1　The average relative density and maximum spread

	Single-action Pressing			Incremental Pressing		
	JHL-2	TNT	8701	JHL-2	TNT	8701
Average Density	0.9226	0.9083	0.9031	0.9570	0.9419	0.9404
Density Spread, max	0.0231	0.0317	0.0498	0.0046	0.0116	0.0085

4　Conclusion

The incremental pressing technique can increase the overall density, decrease the density gradient and improve the density distribution by the way of reducing the friction force between the die surface and the granular explosive.

The results of experiments indicate that the incremental pressing technique produces better density and homogeneity, eliminates the density gradient in cylindrical charge, ultimately improves the performance of the shaped charge.

Although the quantitative relationship of density in each increment is not determined up to now, it is obvious that the overall density and density uniformity of the charge are improved.

REFERENCES:

[1]　Haviell J D. Pressing Technology[R]. Acct. No: 22 – 2 – 44 – 01 – 207.

[2]　SaBmannshausen U, Essig W, Osswald T A. The density distribution in pressed charges: An analytical approach [J]. Propellants, Explosives, Pyrotechnics, 1989(14): 24 – 27.

[3]　XU Geng-guang. The Performance and Application of Explosives[M]. Beijing Institute of Technology. 1991.

[4]　LIU De-run. The Technology of Explosive Charge[M]. Beijing Institute of Technology. 1991.