文章编号：1006-9941(2012)04-0397-03

An Assembly of Exploding Foil and Flyer

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Abstract: An assembly of exploding foil and flyer for slapper squib was invented. The flyer is a type of heat melting gooey, can integrate the exploding foil at about 230 ℃ to form the assembly. The assembly conquered the difficulty of the 5000V insulation of minitype slapper squib with full metallic shell, improved the ignition reliability and might improve the shelf life of the slapper squib, and had no effect on the output performance of the slapper squib.

Key words: engineering and technique of product application; slapper squib; insulation
CLC number: TJ45 **Document code**: A **DOI**: 10.3969/j.issn.1006-9941.2012.04.003

1 Introduction

The ability of 5000 voltages insulation in 1 minute is a basic character of insensitive electric pyrotechnics[1], for which the slapper squib must be designed. The slapper squib was made up of exploding foil, flyer, acceleration barrel, metal shell, charge, etc. As the minimum distance between the exploding foil and the metal shell of the slapper squib is only approximately 1.35 mm, the air gap between which is discharged when the voltage is less than 4000V[2]. Many methods had been tried, such as insulation coat and anode polarization of metal surfurce, exploding foil rounding, and so on. But none was done for high voltage of 5000V/1min. Through thoroughly analysis, we found that the most feasible way is cutting off the air channel between the exploding foil and the metal shell. In-situ formation of insulation flyer and gluing were two basic methods to cut off the air channel between the exploding foil and the metal shell.

In-situ formation of insulation flyer includes gas phase doposition and liquid flyer material coating. By gas phase doposition, the flyer material could be deposited on the surface of the exploding foil, but the density and adhesion force of the formed flyer were not so strong as the usual flyer, and this method needed complex and costly equipments[3]. Coating liquid flyer material on the exploding foil and solidification at about 300 ℃ was the other way, but converging of the liquid material to the center of the exploding foil while solidification was difficult to control, the flyer was not even and its thickness was not uniform.

The liquid, uncoagulated and heat melting gooey could be used to glue the flyer to the exploding foil[2]. The liquid gooey glued orbicular fringe of the flyer to the exploding foil, it functioned when controlled well. However, it was not easy to control well. As able to be flowing, it would flow to the center of the foil. As a result, the fire sensitivity of the slapper squib could be affected. The uncoagulated gooey could be a good choice as it is simple, insulates well and does not affect the ignition, howerver it affected the pressure output of the slapper squib. Until now, the heat melting gooey is the best choice, for it insulated well and could not affect the other performaces of the slapper squib. The principle of the method of the heat melting gooey and its effects on the performaces of the slapper squib were introduced.

Received Date: 2010-09-26; **Revised Date**: 2012-02-02
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2 Experimental sample

The heat melting gooey used is a kind of Polyimide-*PI* complex film, not stick and dry at normal temperature. And when heated to about 230 ℃, the complex film could be glued to surface of ceramic, metal and so on. And as it showed in Tabel 1, the *PI* complex film was comparable to the pure *PI* film on performances of insulation and mechanics, it might not affect the ignition and pressure output performace of the slapper squib. Based on these characteristics, it was used to cut off the air channel between the exploding foil and metal shell of the slapper squib and form an integrative part[4]. The samples made showed in Figure 1.

3 Performances

3.1 Resistance and appearance

The resistance variation of the exploding foil after gluing at high temperature might affect the ignition of slapper squib. So the resistances before and after gluing were measured which showing in Table 2, there was no significant variation about the resistance after gluing.

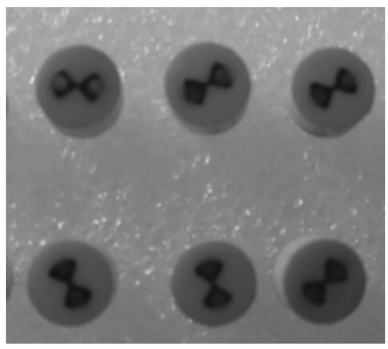

Fig.1 Sample of the assembly

Table 1 Performances of the complex film and the pure film

	complex film	pure film
appearance	translucent golden dry film at normal temperature	translucent or transparent golden film
density/g·cm^{-3}	–	1.42 ±0.02
extended strength/MPa	≥110	≥135
elongation rate at raputure	≥45%	≥45%
average insulation intensity/(MV/m)	≥150	≥150
surface resistivity at 200 ℃/Ω	≥1.0×10^{14}	≥1.0×10^{13}
volume resistivity at 200 ℃/Ω·m	≥1.0×10^{13}	≥1.0×10^{10}
relative dielectric constant at 50 Hz	3 ~4	3.5 ±0.4
dielectric decaying factor at 50 Hz	≤1.0×10^{-3}	<1.0×10^{-3}
strength of peeling off	≥7.5 N/25 mm	–

Since the complex film could react with the exploding foil and the ceramic plug during long preservation to affect the igniton and insulation of the slapper squib, the resistance and apperance variation of the assembly of exploding foil and complex film could reflect this. The 71 ℃ accelerating ageing test[5] was used to simulate the long preservation, and as it shown in Table 3, there was no apparent change on the resistance and the appearance. According to GJB 736.8-90 Method of the test at 71 ℃, the life of the assembly at 25 ℃ is 22 years at least.

3.2 Ignition

The igniton ability of the assembly of exploding foil and complex film was tested by "go" and "no go" method[6]. The assembly was used to initiate 1.55 g·cm^{-3} HNS-IV pellet by 0.3 μF capacitor discharge in the test. The results are in Table 4. Calculation based on the results shows 50% exploding peak current is about 1750 A, which is less than the slapper squib with usual film 300 A, owing to the integration and thinner film. The radius expansion decreasing of the the exploding foil plasma by integration and the thinner film can increase the impinging velocity of the flyer.

3.3 Insulation and output performance

Five slapper squib with *PI* complex film were fired on various initiation current after 5000 V/1 min test. The output pressure of the pyrotechnics were measured in the close bomb of 0.6 cm^3, and the result was shown in Table 5. It can be concluded that the complex film had no effect on the output performance of the slapper squib. Because even the initiation current less than 2500 A, the first peak pressures still satisfied the demanded 150 MPa to 230 MPa and the times of the first peaks still satisfied the demanded less than 200 μs, owing to the initiation ability increase of the exploding foil and flyer assembly.

Table 2 The resistance of the exploding foil before and after gluing

No.	1	2	3	4	5	6	7	8	9	10
resistance before gluing/mΩ	31.90	32.32	33.30	32.18	32.62	33.26	32.68	32.14	32.21	32.05
resistance after gluing/mΩ	32.43	32.86	32.94	33.32	31.65	31.55	33.24	31.99	32.35	32.52

Table 3 The resistance and the appearance before and after 71 ℃ accelerating ageing test

No.	1	2	3	4	5	6
resistance before test/mΩ	38.09	30.21	31.49	35.47	35.06	35.65
resistance after 28 days ageing/mΩ	37.36	29.48	31.15	33.91	34.81	35.36
apperance after 28 days ageing	no significant variation					
resistance after 56 days ageing/mΩ	39.15	30.29	31.69	34.97	34.30	35.18
apperance after 56 days ageing	no significant variation					
resistance after 84 days ageing/mΩ	37.7	32.6	34.1	36.3	36.7	36.7
apperance after 84 days ageing	no significant variation					

Table 4 The results of "go" and "no go" tests

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1900A											1		1		1														
1800A				1		1		1		0		0		0			1			1		1		1		1			
1700A	1		0		0		0		0								1		0		0		0		0		1		0
1600A		0																0										0	

Table 5 Pressure output of slapper pyrotechnics with complex film

No.	initiation current /A	output delay /s	time of first pressure peak /s	first pressure peak /MPa	pressure at 200 s /MPa	note
1	3000	57.6	38.4	190	216	all pass 5000 V/1 min
2	3000	60.0	40.0	169	200	
3	2780	61.6	35.2	181	210	
4	2540	60.0	38.4	174	206	
5	2260	60.8	41.6	157	196	

4 Conclusions

The complex film had no negative effect on the resistance, appearance, fire sensitivity and output performance, so it was pleasible for 5000 V/1 min of the slapper squib. Moreover, the complex film could improve the reliability of the slapper squib, simplify the assembly of the slapper squib and make the slapper squib be more adaptive to abnormal environment.

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一种爆炸箔飞片组件

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摘　要: 为了实现小型全金属壳冲击片点火器满足 5000 V/1 min 的介质耐压要求,研制了一种爆炸箔飞片组件。该组件采用复合聚酰亚胺薄膜作飞片,在 230 ℃高温条件下与爆炸箔陶瓷基片形成一体化组件。研究结果表明,按 GJB 344A –2005 的要求,该组件能够很好地实现小型全金属壳冲击片点火器 5000 V/1 min 的介质耐压要求;高温处理不会对爆炸箔电阻、外观带来影响;71 ℃加速老化 84 天,组件电阻、外观无明显变化; 爆炸箔组件升降法 50% 发火电流峰值 1750 A,比相同条件下采用普通聚酰亚胺薄膜飞片降低 300 A 以上; 组件对小型全金属壳冲击片点火器输出性能无明显影响。

关键词: 产品应用相关工程与技术; 冲击片点火器; 高压绝缘
中图分类号: TJ45　　**文献标识码:** A　　**DOI:** 10.3969/j.issn.1006-9941.2012.04.003