Studying on Burning Rate of Propellant under Diverse Parameters

Hung-Ta Chu

Abstract - An experimental investigation on the burning rates and mechanical properties of HTPB propellants with Fe_2O_3 and AP is carried out at pressure in the range from 10 to 14 MPa and universal tester. The content of Fe_2O_3 and the oxidizer particle size distribution have a considerable effect on the burning rate of the propellant.

Keywords: AP, burning rate.

I. INTRODUCTION

With the rising of operating pressure of solid propellant grain, it is necessary to study the burning characteristics of solid propellant grain under different pressure [1-3]. Ammonium Perchlorate (AP) used in composite propellants consists of diverse particle sizes for the high loading density and steady combustion procedure. Three particle sizes of Ammonium Perchlorate are used in this article.

II. Experimental Process

Materials and Specimens Fabrication

Ammonium Perchlorate (AP), hydroxyl terminated polybutadiene (HTPB), aluminum (metal fuel), and isophorone diisocyanated (IPDI, curing agent) were used as the propellant ingredients for formulation experimental fabrication. A small vertical mixer was used for mixing the propellant slurry and the slurry were casted in the vacuum desiccators and cured at 75℃ in the oven for five days. The testing specimens used were known as JANNAF Class C as shown in Fig.1, developed by the JANNAF committee, and are particularly suited for highly loaded materials [4]. Uniaxial tensile loading tests were performed with the Cometech QC-506LWC extensimeter at 50mm/min crosshead speed. The JANNAF specimens were tested using grips applying the displacement through the shoulders of the specimens as shown in Fig 2 and 3.

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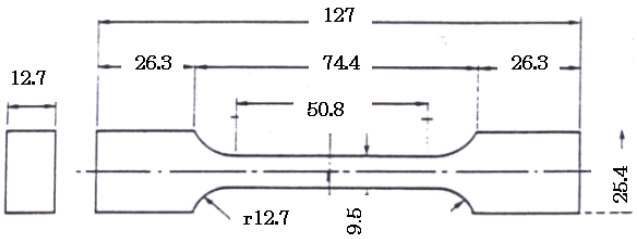

Fig.1 Uniaxial tensile JANNAF testing specimen. (all dimensions: mm)

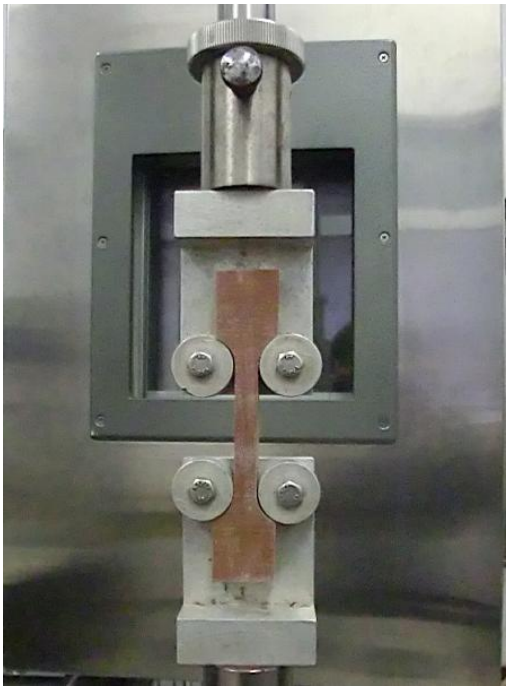

Fig.2 JANNAF specimen with load cell grip.

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Fig. 3 JANNAF specimen with Cometech QC-506LWC extensimeter

The effect of diverse AP particle sizes and content of Fe_2O_3 on propellant burning rates were studied. The mass average diameter of AP were stated as 225μ, 90μ, and 20μ respectively. The proportions of Fe_2O_3 and diverse AP particle sizes with burning rate at 10MPa and 14MPa and mechanical properties were given in table 1, 2 and Fig. 4.

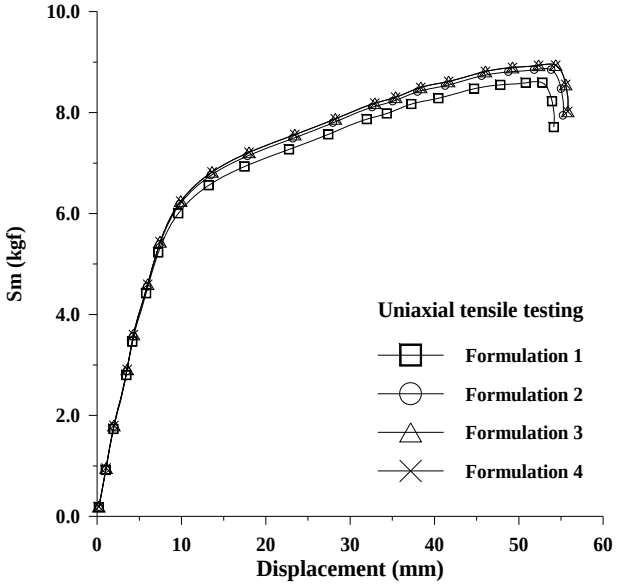

Fig. 4 Uniaxial tensile testing of loading-displacement curve

The burning rate increases noticeably with the percentage of 20μAP increasing, but the influence of 90μAP is not so obvious as shown in Fig. 5 and 6.

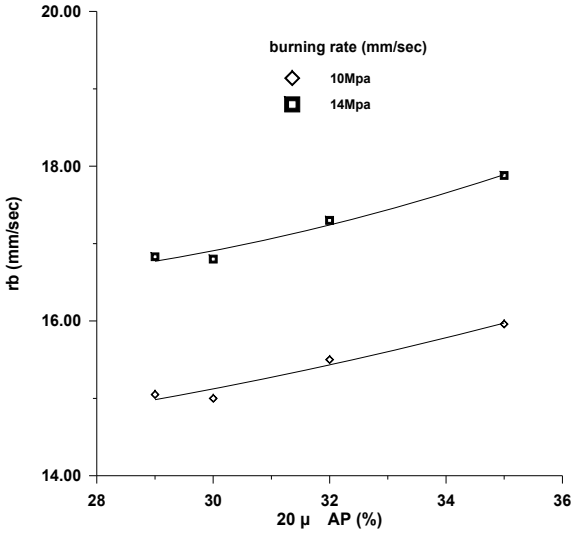

Fig. 5 Variation in propellant burning rate with diverse proportion AP

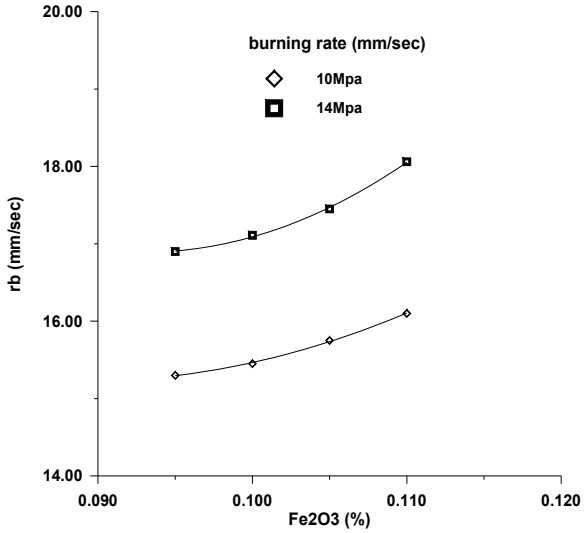

Fig. 5 Variation in propellant burning rate with diverse proportion Fe_2O_3

III. Results and discussions

According to the relevant measurement results from HTPB/AP propellants, the propellant burning rate is able to appropriately controlled by means of AP and Fe_2O_3 proportion, at the same time, the smaller particle size of AP is, the greater effect to burning rate could be; furthermore, the influence to burning rate from proportion of Fe_2O_3 is bigger than AP.

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Table 1 Diverse formulation with burning rate and mechanical properties

		Formulation 1	Formulation 2	Formulation 3	Formulation 4
Fe_2O_3 (%)		0.095	0.095	0.095	0.095
AP	225μ	25	25	25	25
	90μ	30	31	28	25
	20μ	30	29	32	35
Burning Rate (mm/sec)	10MPa	15	15.05	15.5	15.96
	14Mpa	16.8	16.83	17.3	17.88
Sm (kgf)		8.2	8.7	8.85	8.9
Elongation (%)		52	53	53.6	54.5

Table 2 Diverse formulation with burning rate

		Formulation 1	Formulation 2	Formulation 3	Formulation 4
Fe_2O_3 (%)		0.095	0.1	0.105	0.11
AP	225μ	25	25	25	25
	90μ	30	30	30	30
	20μ	30	30	30	30
Burning Rate (mm/sec)	10MPa	15.3	15.45	15.75	16.1
	14Mpa	16.9	17.11	17.45	18.06

REFERENCES

[1] M.M. Li, Y. Wang, X.D.Guo, ”Numerical simulation for burning rate of GAP high-energy propellant,” JOURNAL OF SOLID ROCKET TECHNOLOGY, Vol.32, No.5,2009, pp.535-538.

[2] Z.B.,Liu, L.Wang, and C.B.,Hu, “Prediction of burning rate of solid motor by static burning rate of strands,” JOURNAL OF SOLID ROCKET TECHNOLOGY, Vol.3, No.2, 2008, pp.149-167.

[3] M.M., Iqbal, L.Wang, “Propellant burning rate calculation with improved predictions,” **J**OURNAL OF SOLID ROCKET TECHNOLOGY, Vol.25, No.1, 2002, pp.51-54.

[4] Biggs, G.L., ”Solid Propellant Aging kinetics,” 45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, 2-5 August 2009, AIAA 2009-5423.

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