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Combustion of nitrate ester plasticized polyether propellants

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Key words: NEPE propellant, Combustion, Free radical model, Experimental study

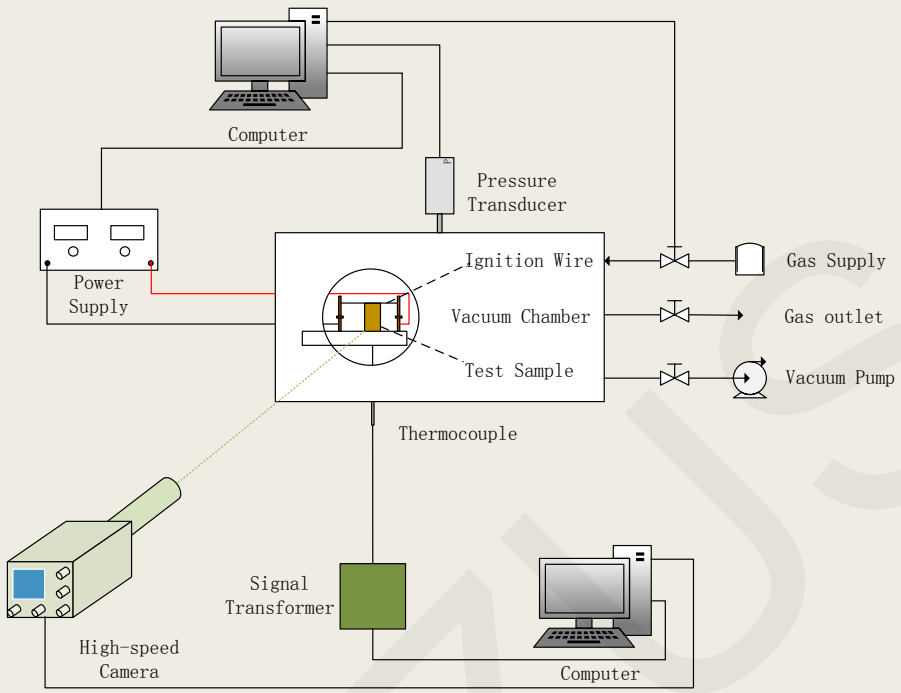
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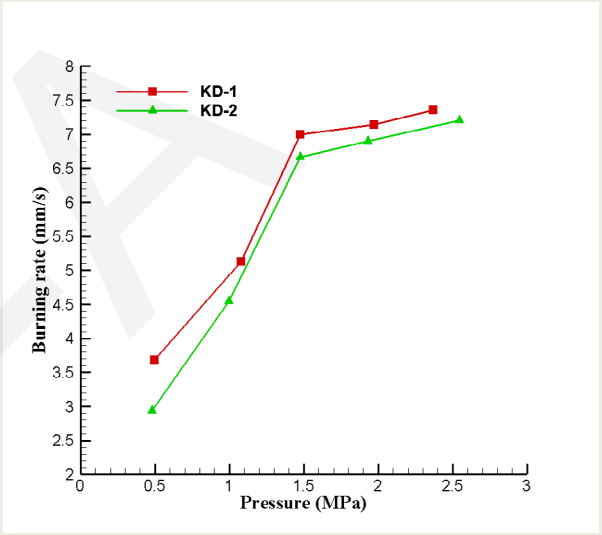
Introduction

- Nitrate Ester Plasticized Polyether (NEPE) is a kind of high-energy solid propellant that has both good mechanical properties and high specific impulse.
- However, its unique composition makes its combustion mechanism different from both double-base propellants and com-posite propellants.
- In this paper, we propose a combustion model of NEPE propellants based on the free radical cracking model to study the effect of grain size, grain size distribution and the content of AP, HMX and Al on the burning rate of NEPE propellants under different pressure conditions.
- To study the combustion characteristics and provide data support for the model, an experimental system was built and four kinds of NEPE propellants with different compositions and grain size distributions were tested.

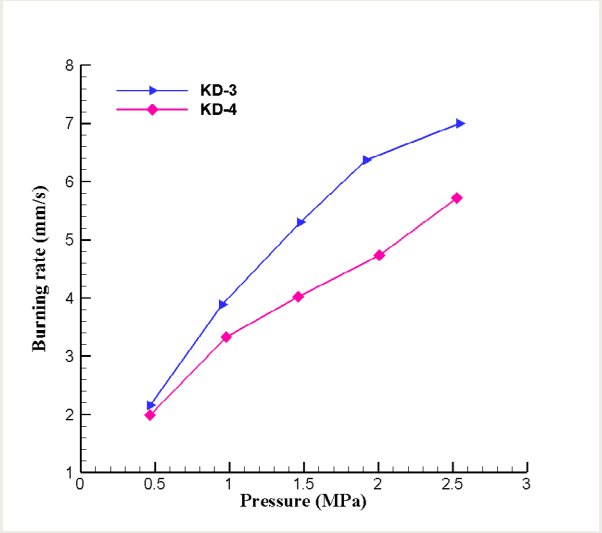
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Experimental Method and Results





(a) Aluminum-free NEPE propellants

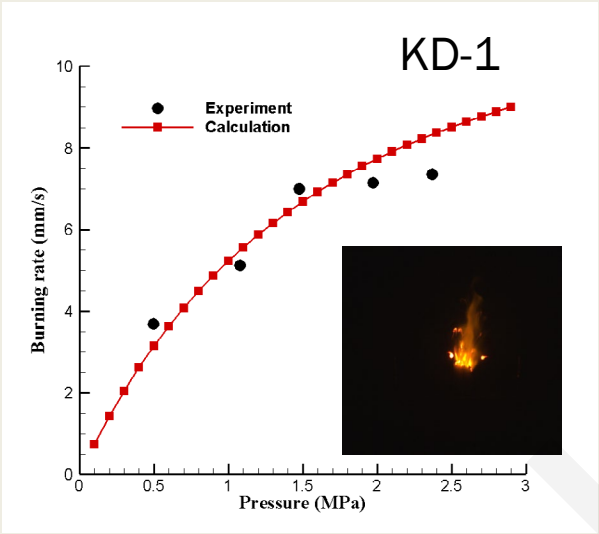


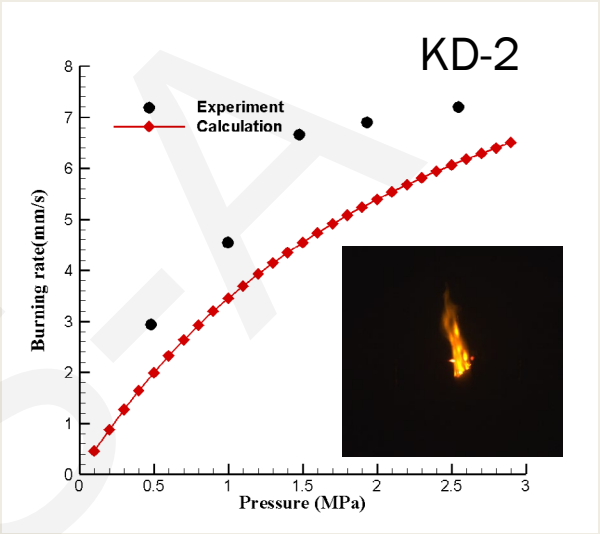
(b) Aluminum-contained NEPE propellants

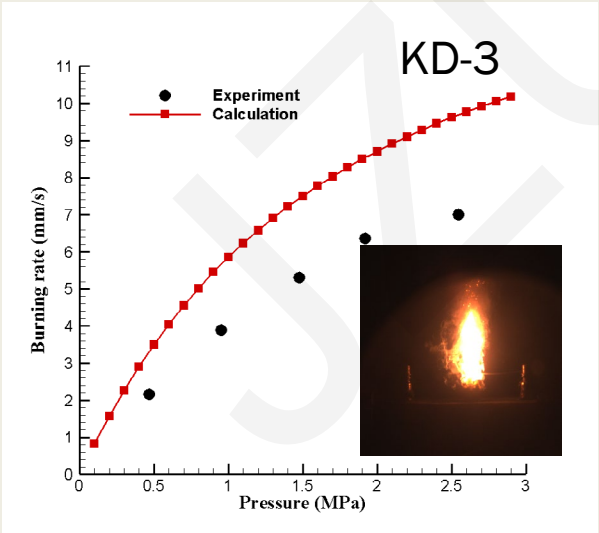
Ingredients, weight mixture ratio and grain size of tested NEPE propellants.

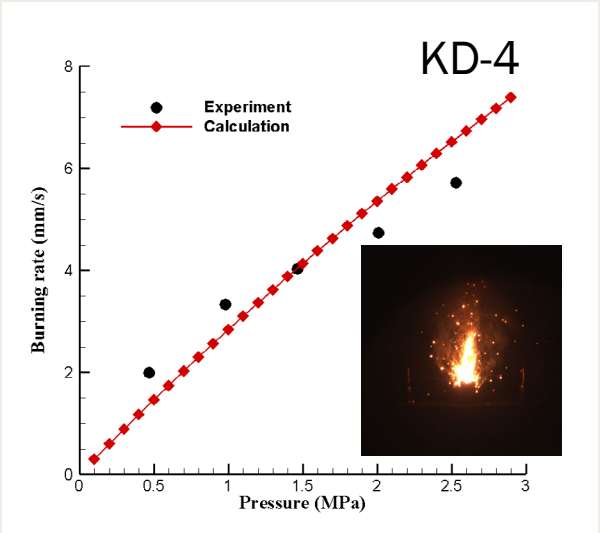
Propellant Name	AP-1/% (130 μm)	AP-2/% (13 μm)	HMX-1/% (86 μm)	HMX-2/% (12 μm)	Al-1/% (28 μm)	Al-2/% (3 μm)	Binder/%
KD-1	10	10	48	\	\	\	32
KD-2	20	\	24	24	\	\	32
KD-3	8	8	20	20	18	\	26
KD-4	16	\	40	\	9	9	26

Simulation and Experiment Results









Conclusions

- (1) As the backpressure increases, the burning rate of NEPE propellants increases and the combustion flame becomes increasingly homogeneous and bright. An obvious diffusion flame structure appears for the Aluminum-free NEPE propellant while adding Aluminum into the propellant causes more severe reactions in the reaction zone.
- (2) As oxidizers, the grain size of AP has more impact on the burning rate and the burning rate pressure exponent than the grain size of HMX. In comparison with the grain size of Aluminum, both oxidizers' grain sizes have more impact on the burning rate but lighter impact on the burning rate pressure exponent.
- (3) For Aluminum-free NEPE propellant, the reaction in the gas phase is dominant in the combustion. For Aluminum-containing NEPE propellant, the reaction in the solid phase is dominant in the final stage since Aluminum particles react both on the burning surface and in the gas phase reaction zone.
- (4) The addition of Aluminum particles with smaller grain size makes the aluminum particle combustion zone closer to the burning surface and clearly increases the burning surface temperature. As a result, the heat feedback of the combustion of Aluminum particles to the burning surface plays an essential role in the combustion process.
- (5) The improved free radical cracking model can be used to predict the burning rate of NEPE propellants and provide qualitative guidance, to some extent, for the composition design of NEPE propellants. However, its accuracy needs improvement.