Table 1 Results on mean drop size and drop-size distribution

Atomizer flow number	Air velocity (m/s)	Fuel-injection pressure ($10^5 N/m^2$)	Distribution parameter (x)	SMD (light scattering technique) (μ)	SMD (nitrogen freezing technique) (μ)
		13.8	3.06	63	63.6
0.0182	19.0	20.7	3.22	58	58.8
		34.5	3.48	53	55.8
		13.8	3.10	55	61.1
0.0182	33.0	20.7	3.48	52	52.8
		34.5	3.92	47	49.3
		13.8	2.68	69	73.4
0.0273	23.00	20.7	2.88	64	66.2
		34.5	2.82	57	59.8

$SMD = \bar{d}\ \{\Gamma(1-1/x)\}$, where Γ is the gamma function.

Results

The results of the drop-size measurements carried out with the light-scattering technique are shown plotted in Fig. 2. Not surprisingly, they indicate that atomization quality is improved by increases in fuel injection pressure and reduction in atomizer flow number, but they also demonstrate the marked effect of an increase in air velocity in reducing the mean drop size. This result could be very relevant to the design and performance of many practical combustion systems.

Correlation of the experimental data yields an equation of the form

$$SMD = 13{,}500[(FN)^{0.34}/(\Delta P)^{0.27}] - 1945[V/(\Delta P)^{0.56}]$$

Detailed analysis of the drop-size date provided by the nitrogen-freezing technique yielded the results listed in Table 1 and shown plotted in Fig. 3. They show that increase in fuel-injection pressure and air velocity, and reduction in atomizer flow number, all tend to produce a higher value of x, indicating a more uniform drop size in the spray. Also of interest in Table 1 is the close agreement between the drop sizes measured by the light-scattering and nitrogen-freezing techniques.

Conclusions

The results of drop-size measurements carried out on a number of swirl atomizers when injecting fuel into a flowing airstream show that atomization quality is improved by: 1) increase in fuel-injection pressure, 2) reduction in atomizer flow number, 3) increase in air velocity.

The following relationship satisfactorily correlates the measured values of SMD.

$$SMD = 13{,}500\ [(FN)^{0.34}/(\Delta P)^{0.27}] - 1945\ [V/(\Delta P)^{0.56}]$$

It is also found that all the factors which reduce the SMD of a spray also end to make the drop size more uniform.

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Correlation between Combustion and Decomposition in Solid Propellants

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Introduction

THE understanding of the heterogeneous condensed phase reactions during the combustion process could be greatly facilitated by a study of the thermal decomposition of the solid propellant and its ingredients. Some attempts have been made in the past regarding the heat release estimations of the condensed phase.[1-4] However, very few attempts have been made to correlate the rate of thermal decomposition of the propellant and the oxidizer to the propellant combustion behavior.[5] In view of the aforementioned, the objective of the present Note is twofold. First, to seek a correlation between the burning rate and the thermal decomposition of the propellant and oxidizer, and second, to see whether the burning rate increases when the oxidizer is doped with potassium chromate. It may be mentioned here that ammonium perchlorate decomposition is sensitized by chromate doping.[6]

Experimental

Recrystallized ammonium perchlorate (AP) was used for doping. AP and potassium chromate solutions were made in definite proportions and the coprecipitation was done by cooling the saturated aqueous solution at 70°C to room temperature. Particle size of doped and undoped AP was kept constant. Making of the propellant strands and the burning rate measurements were done as described earlier.[7] Thermal decomposition studies of AP and the propellant at 276°C were done in a home made TGA assembly.[8] The results of burning rate, AP decomposition and the propellant decomposition are presented in Figs. 1 and 2.

Results and Discussion

Figure 1 shows that burning rate of the propellant at ambient pressure increases by increasing the dopant concentration and so is the behavior of AP decomposition. Figure 2 shows that burning rate bears a linear relationship to the propellant decomposition. Thus, the data presented in Figs. 1 and 2 reveal that not only is the burning rate of the propellant related to the thermal decomposition of the propellant, but it is also related to the thermal decomposition of its oxidizer AP. This, in fact, supports our earlier observation from DSC studies that AP decomposition plays a significant role in the propellant decomposition, and that condensed phase reactions are important in the combustion of the propellant.[9,10]

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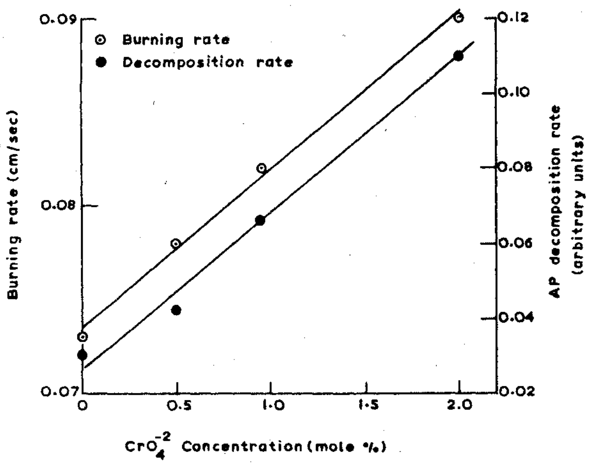

Fig. 1 Dependence of the burning rate on the thermal decomposition of the propellant.

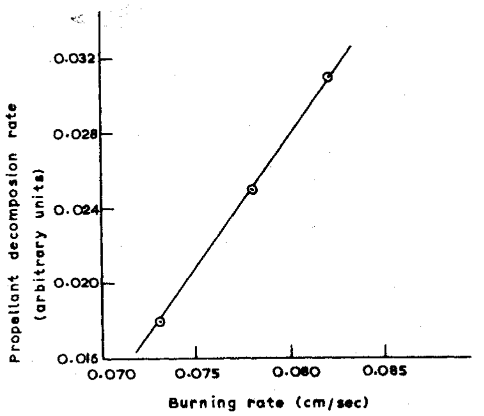

Fig. 2 Dependence of the burning rate and the thermal decomposition of AP on the concentration of the dopant.

Table 1 Burning rate data of polyester/AP propellant at higher pressures

Pressure (psi)	Burning rate (cm/sec)	
	Undoped	1M% $CrO^{-2}{}_4$ doped
300	0.410	0.435
500	0.461	0.538
700	0.563	0.717
900	0.589	0.819

Table 2 Thermal decomposition data of doped and undoped AP and polyester/AP propellant

AP/Propellant	% decomposition at 350°C (TGA) heating rate 4°C min^{-1}	
	Undoped	1 M% $CrO^{-2}{}_4$ doped
Propellant	25	45
AP	12	30

To check the validity of the burning rate data at higher pressures, a typical propellant (polyester/AP) was prepared from undoped and doped AP, and the burning rate and TGA were run at Vikram Sarabhai Space Center, Thumba, India.[11] Results presented in Table 1 and Fig. 1 show that when oxidizer is doped with CrO_4^{2}, the burning rate is increased. Similarly, the correlation of burning rate to that of AP and propellant decomposition is also confirmed in polyester/AP systems (see Fig. 2 and Table 2). The quantitative assessment of the contribution of AP decomposition and the propellant decomposition to the combustion will undoubtedly need more detailed study.

It is interesting to point out here that Hartman,[12] in his work on the effect of doped AP on burning rate, has said that doping does not have a significant effect on burning rate. However, an analysis of his results reveal that his method of preparation of the strands (uncured) in soda straw is significantly different from the actual method of making the strands.

In conclusion we can say that: 1) Burning rate depends upon the thermal decomposition behavior of the propellant itself and the oxidizer contained in it; and 2) Chromate doped AP samples increase the burning rate according to the amount present in the crystal.

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