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The Weighted Average Functionality of HTPB Binder and its Correlativity With the Best Curing Parameter of Solid Propellants

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Weighted average functionality possesses additivity by an equivalent number fraction. With a statistical handling method for experiment data, it is observed that there is a linear relation between the weighted average functionality of HTPB and the optimum curing parameter of solid propellants. Thereby a better method is provided for the choice of the optimum curing parameter of solid propellant formulation and charge.

Subject Term: Hydroxy terminated polybutadiene propellant; Curing; Gelation; Weighted average functionality.

I. Concept of the Weighted Average Functionality

The gelation theory was first presented by Carothes in 1936 [1]. It was continuously developed by Flory [2] and Stockmayer [3], et al and became a rigorous theory during the forties and the early fifties. Since the sixties, the scientists of our country (China), Tang Aoqing, Tang Xinyi, Jiang Yuansheng, Yue Guocui and Chen Xinfang further developed this theory. A generalized model which covers all individual cases was developed by them. This model gives not only the necessary conditions but also the sufficient conditions — the gelation zone [4]. The distribution of gelatin and sol beyond the gelation point [5], as well as the effects of the inner ring chemical reaction on gelation points and molecular weight [6] were also specified.

During the establishment and development of the theory, a condensation polymerization reacting system with a uniform functionality is the study topic. Although a poly-divergent functionality model in which a weighted average functionality was presented, was considered by Stockmayer as early as 1953, it did not bring sufficient attention from the world. This is because the science and technology level at that time was so poor so that this theory could not be applied. In the late sixties, polymerization science was rapidly developed. A gelation condition often could not be achieved when one studied the curing reaction by adopting the habitual arithmetic average functionality; a better mechanical performance, however, could be obtained in experiments. All these facts motivated scientists' thinking. Twenty-five years later, French became familiar with Stockmayer's poly-divergent functionality model and accepted the weighted average functionality concept. A method of measuring polymer weighted average functionality, which was derived from the Aa-B2 type gelation chemical formula, was presented by him [1]. However, both French and Stockmayer did not prove the reason why functionality in the gelation theory was a weighted average functionality in a broad sense. Stockmayer showed its concept and definition only, ($\bar{f}_w = \Sigma n_i f_i^2 / \Sigma n_i f_i$) while French discovered a method of measuring this form. Several theories and methods were used to proved this theory by Tang Aoqing, Tang Xinyi and Chen Xinfang et al [8]. In this paper, an experiment which uses poly-tetrahydrofuran glycol, the only polymer whose functionality is known so far, to prove the theory. [9].

In summary, the functionality in the gelation theory is a weighted average functionality. For the reaction of a condensation polymerization whose functionality distribution is uniform, the weighted average reduction is an arithmetic average. This is a special case of the functionality poly-divergent system model. A weighted average functionality is an ensemble average of all samples based on their functionality, $\bar{f}_w = \Sigma N_i^* f_i$; therefore, there exist relationships between the weighted average functionality and gelation theory as well as between the gelatin and sol. The arithmetic average functionality is the statistical mean of the molecular number based on the the samples' functionality, $\bar{f}_n = \Sigma n_i^* f_i$; Generally, the arithmetic averaged functionality (arithmetic average molecular weight x functionality group value) is the arithmetic average functionality which includes zero functionality, and it is not a characteristic function with respect to the gelation and the grid structure. The effective arithmetic average functionality, the one excludes the zero functionality molecule, has a relation with the theoretical value of the coupling density of curing products. The coupling density is affected by the weighted average functionality and the reaction degree by changing the gelation and sol distribution of the system. Under a certain curing agent, the coupling density of the curing product is a function of the polymer functional group value, effective arithmetic average functionality, weighted average functionality, reaction degree and the curing parameters [10, 11]. Since the zero functionality molecular weights of the hydroxy terminated polybutadiene binder (HTPB) and the polyether binder are very small, their effects on the arithmetic average functionality are large. Consequently, the functionality distribution of a polymer which contains functional group molecules will not be too wide; generally, its effective arithmetic average functionality is close to the weighted average functionality and far removed from the arithmetic average functionality. Under the present condition of being unable to efficiently determine the effective arithmetic average functionality and (or) the functionality distribution, studying the curing product grid structure and its associated mechanic behaviors by using the weighted average functionality is a feasible method of approximation.

II. Additivity of the Weighted Average Functionality

Based on the definition of the weighted average functionality

$$\bar{f}_w = \Sigma n_i f_i^2 / \Sigma n_i f_i = \Sigma N_i f_i$$

where i= 1, 2, 3, ······. f_i in s_o is sole-divergent. Here we want to prove that the above equation is still valid even if the

f_i is poly-divergent. This means that the weighted average functionality possesses additivity by an equivalent number fraction and can be expressed as $\bar{f}_w = \Sigma N^*_i f_{Wi}$, where N^*_i is the equivalent number fraction of the component, and $\bar{f}_{Wi}$ is the weighted average functionality of the component.

Suppose that the mixed system is composed of two samples, $A^{(p)}_i$ and $A^{(p)}_j$.

The sample $A^{(p)}_i$ consists of $A^{(p)}_1$, $A^{(p)}_2$, $A^{(p)}_3$, ..., $A^{(p)}_i$ while the sample $A^{(q)}_j$ consists of $A^{(q)}_1$, $A^{(q)}_2$, $A^{(q)}_3$, ..., $A^{(q)}_j$

N^*_p is the equivalent number fraction of $A^{(p)}_i$ in the mixed system.

$$N^*_p = \Sigma n_i f_i / (\Sigma n_i f_i + \Sigma n_j f_j)$$

N^*_q is the equivalent number fraction of $A^{(q)}_j$ in the mixed system.

$$N^*_q = \Sigma n_j f_j / (\Sigma n_i f_i + \Sigma n_j f_j)$$

Thus $N^*_p + N^*_q = 1$.

Based on the definition $\bar{f}^{(p)}_w = \frac{\Sigma n_i f_i^2}{\Sigma n_i f_i}$, $\bar{f}^{(q)}_w = \frac{\Sigma n_j f_j^2}{\Sigma n_j f_j}$

Therefore

$$N^*_p \bar{f}^{(p)}_w = \frac{N^*_p \Sigma n_i f_i^2}{\Sigma n_i f_i} \quad (1)$$

$$N^*_q \bar{f}^{(q)}_w = \frac{N^*_q \Sigma n_j f_j^2}{\Sigma n_j f_j} \quad (2)$$

Add Eq. (2) to Eq. (1), and substitute the definitions of N^*_p and N^*_q into the right hand sides of the equations, then

$$N^*_p \bar{f}_w^{(p)} + N^*_q \bar{f}_w^{(q)} = \frac{\sum n_i f_i^2 + \sum n_j f_j^2}{\sum n_i f_i + \sum n_j f_j} = \frac{\sum_{i,j} (n_i f_i^2 + n_j f_j^2)}{\sum_{i,j} (n_i f_i + n_j f_j)}$$

Since i, j are independent.

$$\begin{array}{ll} A_i^{(p)} & i=1,\ 2,\ 3,\ \cdots\cdots,\ s \\ A_j^{(q)} & j=1,\ 2,\ 3,\ \cdots\cdots,\ t \\ A_K^{(p+q)} & K=s,\ s+1,\ s+2,\ s+3,\ \cdots\cdots,\ s+t \end{array}$$

therefore,

$$N^*_p \bar{f}_w^{(p)} + N^*_q \bar{f}_w^{(q)} = \frac{\sum_{K=1}^{s+t} n_K f_K^2}{\sum_{K=1}^{s+t} n_K f_K} \qquad (3)$$

The right hand side of Eq. (3) is the weighted average functionality definition of the mixed sample which is expressed according to the functionality class. Thus

$$\bar{f}_w^{(p+q)} = N^*_p \bar{f}_w^{(p)} + N^*_q \bar{f}_w^{(q)}$$

Based on the symmetry of the number of the components and the number of corresponding terms, this equation can be easily expanded to a weighted average functionality expression for a multi-component mixture,

$$\bar{f}_w^{(\overbrace{p+q+r+\cdots+s}^{m})} = \sum_{K=2}^{m} N^*_K \bar{f}_{wK}$$

It is worth noting that when applying this equation, the functional group activity of each component must be equal or at least very close. For those mixtures with a large variation of component activities, this simple additivity does not exist.

III. The Correlativity of the HTPB functionality and the Best Curing Parameter of Solid Propellants

The actual coupling curing reaction of the HTPB propellant is extremely complicated. Nevertheless, it can still be sorted into two types based on its grid structure. The reaction of one type is consistent. As long as the formula does not change, the number of these reactions will not change. The reaction of another type changes with the material lot number. A different lot HTPB has a different molecule weight and functionality; therefore, its reaction number with Toluene-di-isocyanic ester (TDI) varies. Additionally, there is another reaction which is associated with ambient humidity, and varies with the temperature. Since the ambient temperature is controllable, the amount of water absorbed by the material is fixed under a constant humidity. Basically, it belongs to the first type of reaction. Effects of humidity on the reaction can be adjusted by using the interpolation method. Therefore, the total coupling density can be written as

$$x_d = x_{d1} + x_{d2}$$

where x_{d1} is the contribution of the fixed reaction to the grid structure while x_{d2} is associated with the HTPB functionality and its curing parameter r. According to the governing equation of the grid structure [10, 11], the relation of r and $\bar{f}_w$ has to be a certain function in order to maintain a constant coupling density which means the reoccurrence of its mechanical performance.

(1) Based on the theory stated above, the author has examined the HTPB curing parameter and its mechanical performance by samples taken from various lots. The curing parameter definition in the formula study is r = curing agent - NCO equivalent number/HTPB - OH equivalent number. Under a certain formula, a series of experiments with different r values has to be conducted in order to find out the maximum percentage elongation which satisfies a certain strength. Under a constant strength, the one which has the highest percentage elongation is the optimum curing parameter. The weighted average functionality is measured by following the method presented in Ref [12]. The arithmetic average functionality is calculated by multiplying the arithmetic average molecular weight (measured by the VPO method [13]) with hydroxy value (measured by the method of anhydride — acetate — toluene sulfonic acid [14]). The mechanical performance data (this paper is only a guideline for judging the optimum r value) is measured by a IM100 strain-stress gage (Japan, Igitsu). The above data are provided by three laboratories.

For formula A, the binders from thirty-three lots were examined, totalling 80 odd testing points. Among them, if three or more r data are available, the best r value is then selected. Those with a total of 22 points have the best r values, as listed in Table 1. For formula B, the binders from thirteen lots were examined, and those with thirteen points have the best r values, as listed in Table 2. For formula C, the binders from twenty-one lots were examined, and those with twenty-one points have the best r values, as listed in Table 3.

Table 1 Data of the best r and HTPB $\bar{f}_w$ and process for Formula A

(1) 图1中编号	(2) 胶批号	$\bar{f}_w$	r	$\bar{f}_w^2$	$r\cdot\bar{f}_w$
1	80021	2.51	0.72	6.300	1.807
2	94	2.66	0.72	7.076	1.915
3	93	2.66	0.72	7.076	1.862
5	96	2.67	0.70	7.129	1.869
6	05	2.69	0.75	7.236	2.018
7	137	2.71	0.70	7.344	1.897
8	19	2.73	0.67	7.453	1.829
10	138	2.80	0.68	7.840	1.904
13	23	2.85	0.70	8.123	1.995
14	79-12	2.87	0.69	8.237	1.980
15	80013	2.87	0.68	8.237	1.952
16	95	2.88	0.67	8.294	1.930
17	145	2.89	0.69	8.352	1.994
18	12	2.94	0.67	8.644	1.970
19	92	2.97	0.64	8.821	1.901
20	79-11	3.07	0.66	9.425	2.026
22	78-16	3.33	0.62	11.089	2.065
23	78-64	3.42	0.58	11.834	1.995
25	703-6	3.47	0.60	12.041	2.082
30	78-08	4.19	0.50	17.556	2.095
32	-05	4.42	0.50	19.536	2.210
33	-13	4.74	0.45	22.468	2.133
Σ 22		68.34	14.31	219.972	43.4698

$$r = K\bar{f}_w + C$$

Key: (1) No. in Fig. 1; (2) Binder lot no..

$$K=\frac{\Sigma r\Sigma J_w-n\Sigma rJ_w}{(\Sigma J_w)^2-n\Sigma J_w^2}=\frac{68.34\times 14.31-22\times 43.4698}{68.34^2-22\times 219.972}=-0.1279$$

$$C=\frac{\Sigma J_w\Sigma rJ_w-\Sigma r\Sigma J_w^2}{(\Sigma J_w)^2-n\Sigma J_w^2}=\frac{68.34\times 43.429-219.972\times 14.31}{68.34^2-22\times 219.972}=1.048$$

Table 2 Data and process for Formula B

(1) 在图2中编号	(2) 胶批号	J_w	r	J_w^2	$r\cdot J_w$
1	143	2.16	0.84	4.6656	1.8144
2	140	2.20	0.82	4.8400	1.8040
3	142	2.25	0.80	5.0625	1.8000
4	144	2.40	0.75	5.7600	1.8000
5	146	2.40	0.75	5.7600	1.8000
6	145	2.40	0.73	5.7600	1.7520
7	138	2.41	0.75	5.8081	1.8075
8	139	2.42	0.75	5.8564	1.8150
9	155	2.48	0.73	6.1504	1.8[illegible]04
10	157	2.48	0.73	6.1504	1.8104
11	R-45M	2.48	0.73	6.1504	1.8104
12	156	2.49	0.73	6.2001	1.8177
13	158	2.50	0.73	6.2500	1.8250
13		31.07	9.84	74.4139	23.4668

$$r=KJ_w+C$$

$$K=\frac{\Sigma r\Sigma J_w-n\Sigma rJ_w}{(\Sigma J_w)^2-n\Sigma J_w^2}=\frac{31.07\times 9.84-13\times 23.4668}{31.07^2-13\times 74.4139}=-0.3244$$

$$C=\frac{\Sigma J_w\Sigma rJ_w-\Sigma r\Sigma J_w^2}{(\Sigma J_w)^2-n\Sigma J_w^2}=\frac{31.07\times 23.4668-74.4139\times 9.84}{31.07^2-13\times 74.4139}=1.532$$

Key: (1) No. in Fig. 2; (2) Binder lot no.

Table 3 Data and process for Formula C

(1) 图3中编号	(2) 胶批号	ξ_w	r	ξ_w^2	$r \cdot \xi_w$
1	80099	2.59	0.72	6.7081	1.8648
2	98	2.62	0.72	6.8644	1.8864
3	146	2.64	0.75	6.9696	1.9800
4	3	2.66	0.72	7.0756	1.9152
5	93	2.66	0.72	7.0756	1.9152
6	94	2.66	0.72	7.0756	1.9152
7	96	2.67	0.71	7.1289	1.8957
8	5	2.69	0.71	7.2361	1.9099
9	137	2.71	0.70	7.3441	1.8970
10	012	2.71	0.67	7.3441	1.8157
11	80019	2.73	0.70	7.4529	1.9110
12	143	2.79	0.68	7.7841	1.8972
13	7909	2.80	0.68	7.8400	1.9040
14	80138	2.80	0.68	7.8400	1.9040
15	134	2.84	0.70	8.0656	1.9880
16	95	2.88	0.63	8.2944	1.8144
17	7912	2.89	0.69	8.3521	1.9941
18	80145	2.89	0.69	8.3521	1.9941
19	158	2.89	0.66	8.3521	1.9074
20	92	2.97	0.67	8.8209	1.9899
21	7911	3.07	0.62	9.4249	1.9034
Σ 21		58.16	14.54	161.4012	40.2026

$$r = K\xi_w + C$$

$$K = \frac{\Sigma r \Sigma \xi_w - n \Sigma r \xi_w}{(\Sigma \xi_w)^2 - n \Sigma \xi_w^2} = \frac{58.16 \times 14.54 - 21 \times 40.2026}{58.16^2 - 21 \times 161.4012} = -0.2035$$

$$C = \frac{\Sigma \xi_w \Sigma r \xi_w - \Sigma r \Sigma \xi_w^2}{(\Sigma \xi_w)^2 - n \Sigma \xi_w^2} = \frac{58.16 \times 40.2026 - 161.4012 \times 14.54}{58.16^2 - 21 \times 161.4012} = 1.256$$

Key: (1) No. in Fig. 3; (2) Binder lot no.

Table 0 Values of K and C of each formula

(1) 配方代号	(2) K值	(3) C值	(4) 对应数据表	(5) 对应数据图
A	−0.1279	1.048	1	1
B	−0.3244	1.532	2	2
C	−0.2035	1.256	3	3

Key: (1) Formula; (2) K value; (3) C value; (4) Corresponding table no.; (5) Corresponding figure no.

The best r values can then be plotted against the weighted average functionality; the linear relationship between r and $\bar{f}_w$ is clearly shown in Fig. 1, 2, and 3. The linear function $r = K\bar{f}_w + C$ is found by using the best curve fitting method, where r is the best curing parameter; $\bar{f}_w$ is the weighted average functionality of the binder; C is a constant associated with the formula and its mechanical performance; K is the sensitivity coefficient of the formula system coupling density against the HTPB weighted average functionality. Obliviously, each formula has its own K and C values, as shown in Table 0. In order to make a comparison, the relationship between the arithmetic average functionality of HTPB and its best r value is also investigated. Only a general trend is found; however, there is no regularity, as shown in Table 4, Fig. 4, Table 5, Fig. 5, Table 6, and Fig. 6. Unfortunately, it is a fact that the best curing parameter can be found only through massive experiments.

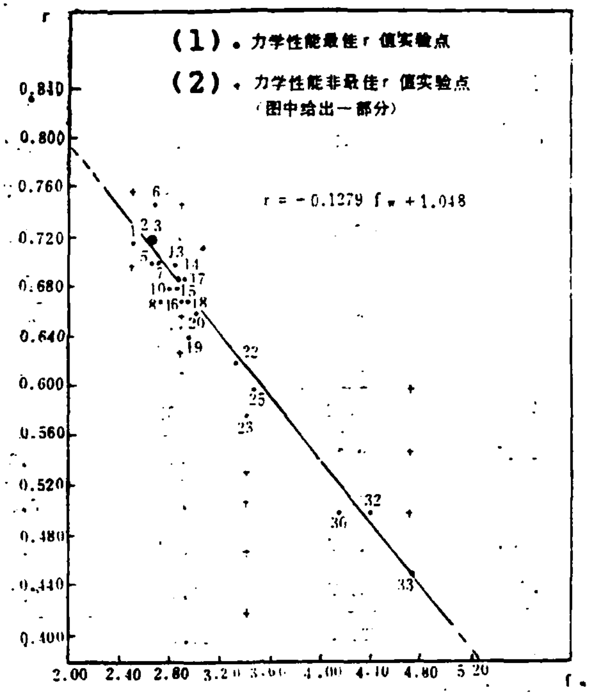

Fig. 1 The correlativity of the best r with $\bar{f}_w$ of HTPB for formula A.
Key: (1) Testing point whose mechanical performance has the best r; (2) Testing point whose mechanical performance does not have the best r. (Only part of data shown in this figure.)

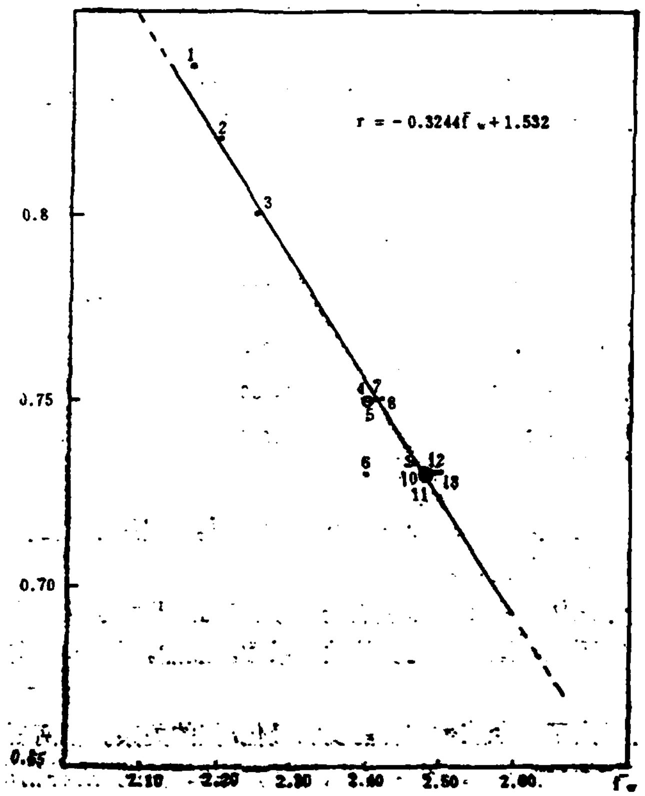

Fig. 2 The correlativity of r with $\bar{f}w$ for Formula B

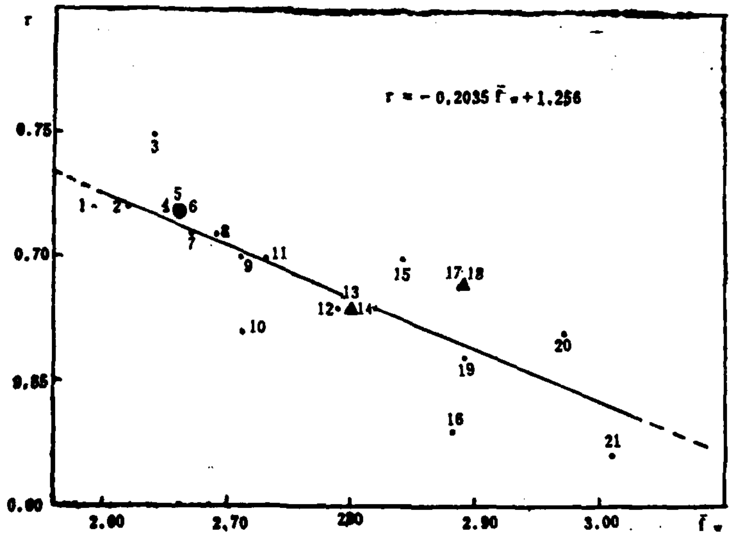

Fig. 3 The correlativity of r with $\bar{f}w$ for Formula C

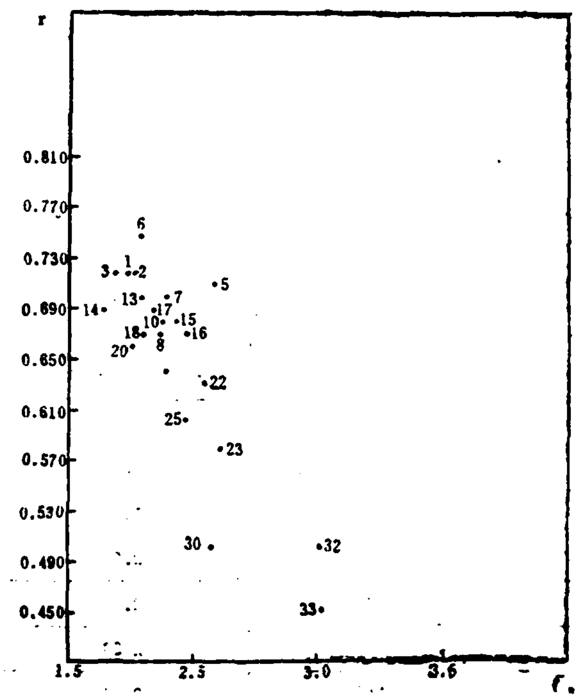

Fig. 4 HTPB arithmetic average functionality, $\bar{\bar{f}}n$ and the best curing parameter, r in Formula A.

Table 4 HTPB arithmetic average functionality and r values in Formula A

(1) 在图4中编号	(2) 胶的批号	(3) 数均官能度 $\bar{f}_n$	(4) 配方最佳 r 值
1	80021	1.99	0.72
2	94	2.00	0.72
3	93	1.87	0.72
5	96	2.61	0.70
6	05	2.27	0.75
7	137	2.28	0.70
8	19	2.22	0.67
10	138	2.35	0.68
13	23	2.08	0.70
14	79-12	1.76	0.69
15	80013	2.36	0.68
16	95	2.44	0.67
17	145	2.17	0.69
18	12	2.10	0.67
19	92	2.28	0.64
20	79-11	2.05	0.66
22	78-16	2.59	0.62
23	-64	2.72	0.58
25	703-6	2.43	0.60
30	78-08	2.66	0.50
32	-05	3.03	0.50
33	-13	3.04	0.45

Key: (1) ID in Fig. 4; (2) Binder lot no.; (3) Arithmetic average functionality, $\bar{f}n$; (4) The best r in the formula.

Table 5 HTPB fn and r in Formula B

(1) 在图5中编号	(2) 胶批号	(3) 数均官能度 $\bar{f}_n$	(4) 配方最佳γ值
1	143	2.14	0.84
2	140	1.84	0.82
3	142	1.92	0.80
4	144	2.22	0.75
5	146	2.10	0.75
6	145	2.39	0.73
7	138	2.10	0.75
8	189	2.21	0.75
9	155	2.03	0.73
10	157	2.00	0.73
11	R-45M	2.21	0.73
12	156	1.89	0.73
13	158	2.60	0.73

Key: (1) ID in Fig. 5; (2) Binder lot no.; (3) Arithmetic average functionality, $\bar{f}n$; (4) The best r in the formula.

Table 6 HTPB fn and r in Formula C

(1) 在图6中编号	(2) 胶 批 号	(3) 数均官能度 $\bar{f}_n$	(4) 配方最佳γ值
1	80099	2.03	0.72
2	98	2.22	0.72
3	146	2.67	0.75
4	3	2.24	0.72
5	93	1.87	0.72
6	94	2.00	0.72
7	96	2.61	0.71
8	5	2.30	0.71
9	137	2.28	0.70
10	012	2.08	0.67
11	80019	2.22	0.70
12	143	2.26	0.68
13	7909	2.32	0.68
14	80138	2.45	0.68
15	143	2.43	0.70
16	95	2.44	0.63
17	7912	1.76	0.69
18	80145	2.27	0.69
19	158	2.24	0.66
20	92	2.28	0.67
21	7911	2.05	0.62

Key: (1) ID in Fig. 6; (2) Binder lot no.; (3) Arithmetic average functionality, $\bar{f}n$; (4) The best r in the formula.

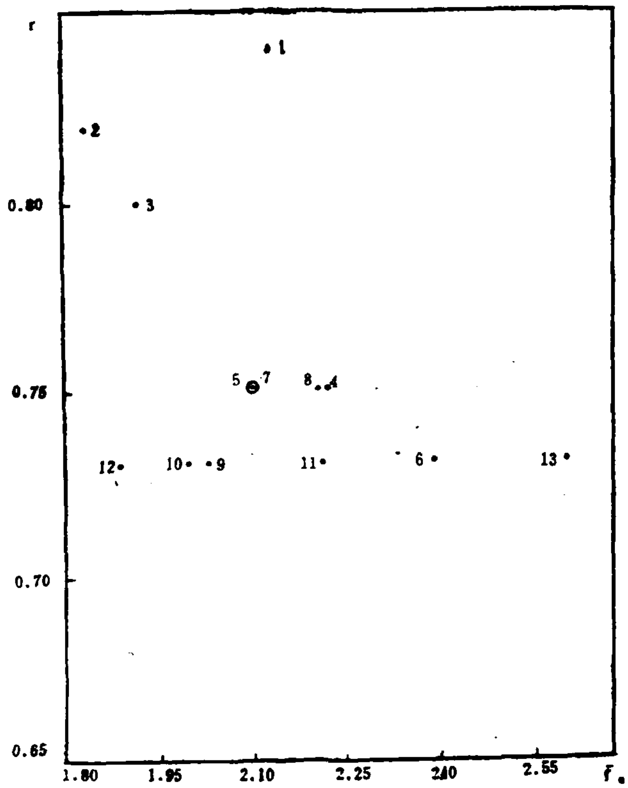

Fig. 5 HTPB $\overline{f}n$ and the best r in Formula B

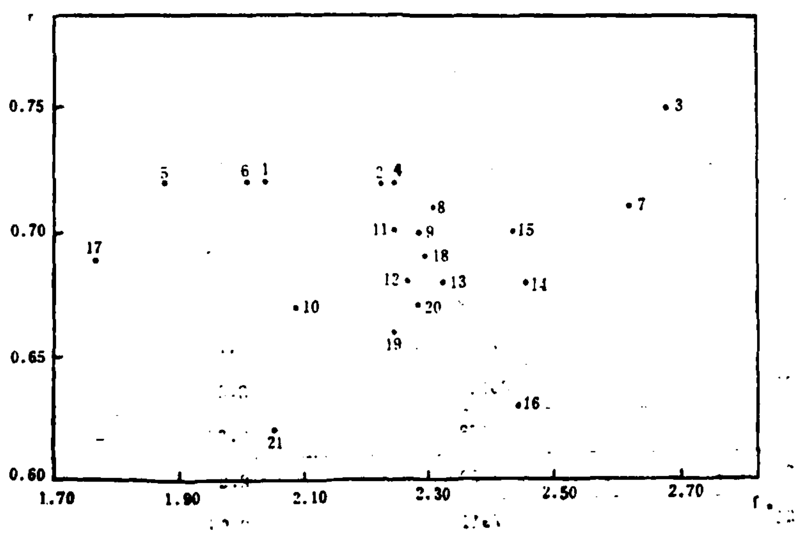

Fig. 6 HTPB fn and the best r in Formula C

(2) Discussion

Among the above results, Formula A was selected and examined by F-inspection; the correlativity shows strong linearity if the confidence level is set to 0.99; however, the experiment points of the best r show a certain divergence. The reasons are:

1. During the development of a formula, the only requirement is mechanical performance, thus the adjustment of r is coarse. The best r stated in this paper represents the best mechanical performance among the selected r values, and it is still some distance away from the optimum value. For instance, the difference among the three r values in No. 1 (80021) is great. Although the curing product of one of r whose mechanical performance meets the requirement, that r value is not the one which has the best mechanical performance. The studying process for the binder of both No. 33 (78-13) and No. 23 (78-64) lots is very convincing. Based on experience, the r value of 0.6 is chosen for Binder 78-13 and 0.4 for Binder 78-64. First, slight adjustments were made around these two r values. The results, however, show poor mechanical performance of the propellant column, and they were considered to be unqualified binders. The results of this study show the best mechanical performance appears at r = 0.45 for Binder 78-13 and r = 0.61 for Binder 78-64. Based on this prediction, various r, r = 0.54, 0.50, 0.45 were set to test Binder 78-13; the results show that the mechanical

performance of r = 0.45 meets the requirement. Various r, r = 0.42, 0.47, 0.51, 0.53, 0.58 were also set to test Binder 78-64, the results show that the mechanical performance of r = 0.58 meets the requirement. Unfortunately, there is no further comparison which can be made because there are no results of $r < 0.45$ for Binder 78-13 or $r > 0.61$ for Binder 78-64. However, the statistical results from the large amount of data show the cancellation between the positive and the negative errors. Although the test points show divergence, the statistical results are reliable.

2. Effects of ambient humidity were not considered during data processing, and all curing reactions of HTPB were treated as Type $B_2 - \Sigma Aa_i$, A'_2, A''_2 (A''_{x+2}) [A'_2 (active auxiliary), A''_2 (A''_{x+2}), phosphonium trioxide (2-Methyl-nitrogen-propyl- binding) and its polymer, x is polymerization degree]; however, the ambient humidity variation is large during the actual formula processing. Effects of water can be large or small, thus the constant C is not repeatable.

3. Effects of the hydroxy measurement bias is obvious. It affects r and the weighted average functionality. All methods currently used for measuring the hydroxy value of the HTPB binder are not precise [15], and their accuracies are still unknown.

IV. Applications of the Correlativity Equation of the Weighted Average Functionality Additivity with Its Best Curing Parameter r on the Motor Propellant

The correlativity equation of the weighted average functionality of HTPB and its best curing parameter r not only provide a better method of approximation to characterize the mechanical performance for each formula, but also connect the formula study and the charging of the large scale motor propellant together. While studying the formula, values of K and C are obtained; the weighted average functionality of mixing propellant is then calculated according to its additivity, or a binder can be mixed based on its assigned weighted functionality. This procedure can guarantee the propellant quality and also eliminate large trial and error experimental efforts before propellant charging.

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SOLID ROCKET PROPULSION CONFERENCE

by Wen Shilin

The Solid Rocket Propulsion Conference organized by the Solid Rocket Committee of the Chinese Astronautic Association and the Propulsion Committee of the the Chinese Aeronautical Association was held from October 13 to 17, 1986 at Jiujiang City. A total of eighty-five academic and technological papers were presented at the meeting. Among them were conclusive reports of years of experiences and research of new technological theories. Ninety-four representatives from thirty-five departments nationwide attended this meeting. Among them were the first line engineers, senior engineers in the solid rocket research field who had fought against this topic for years, and professors, associate professors, and instructors, as well as outstanding young research engineers and graduate students.

The meeting was hosted by the vice chairman of the Solid Rocket Committee of the Chinese Astronautic Association, professor of Beijing Aeronautical Institute, Mr. Lee Yiming. An important speech was made by the chairman of the Solid Rocket Committee of the Chinese Astronautic Association, Director of the Fourth

Research Institute of the Ministry of Astronautics (MOA), Mr. Xing Quhen. He reviewed the thirty-year history of solid rocket development and affirmed the contributions made to our country's (China) aerospace industry by all solid rocket engineers, and also presented the common objectives for the years to come. After that the Vice-chairman, Secretary of the Fourth Research Institute Technology Committee of MOA, Mr. Ruan Chongzhi, presented a paper named "The Prospect of Solid Rocket Development for the Nineties and Our Tasks". The report showed the wonderful prospect of our country's rocket technology development for the nineties which greatly encouraged all representatives. Meanwhile, differences of aerospace technology compared with advanced countries were analyzed, and tasks for tackling this problem were also proposed. Additionally, Ms. Gu Xuelin, Engineer from the Fourth Division, Forty-first Departement of MOA, also presented a technical paper named "The Motor Flight Test at Apogee for Dongfonghong (The East Is Red) II Satellite". A videotape was also shown in her presentation.

The meeting was divided into three groups according to the specialties, and discussions were conducted for three days. The discussion atmosphere was enthusiastic in each group, and scrupulous attention was paid to every detail of the technical subjects. Discussions continued even after dark. Especially for the propellant group, several in-depth topics such as the aluminum power combustion problems, questions concerning the ployether propellant plasticated by ester nitrate, combustion speed of butyl hydroxy composite solid propellant, etc. were brought up.

The meeting came to a close on the afternoon of the 17th, Professor Lee Yiming made the closing remarks, and he said "This meeting achieved the purpose of stimulating academic activities through academic exchange and discussion of issues. Academic exchange is extremely important. Any field can progress only through discussion, comparison, inspection, evaluation, mutual enlightenment and mutual learning". Director Xing Qiuhen said " I expect that we will present good papers in the International Aerospace Conference in 1989". After that, Mr. Liu Qiban, Deputy of the Forty-sixth Department, Fourth Division of MOA and Mr. Feng Wenlan, Assistant Professor of Beijing Aeronautical Institute also spoke enthusiastically. They thanked the host of this meeting, Jiangxi National Defense Unit 620 and Jiujiang City Government for their support and assistance; they also thanked all attendees for their supports, and wishes to have another successful meeting next time.

"ASTRONAUTIC JOURNAL" CALLING FOR PAPERS

I. Astronautic Journal is a composite academic journal edited by the Chinese Astronautic Association. This journal mainly publishes the achievements of the astronautic science and technology of China, promotes academic exchange between domestic and overseas regions, and provides services for achieving the four modernizations.

II. Astronautic Journal is a quarterly publication and is distributed throughout the country and overseas. This journal is intended for science researchers, engineering and technological personnel, the cadre of the science and technology administration and college faculty and students.

III. The major contents of this journal are flight theories, flight vehicle systems, guided missile systems, aerodynamics, surveys and communications, guidance and control, flight vehicle energy resources, remote sensing, flight vehicle design and manufacture, inertial technologies, propulsion technologies, computer applications, material and crafts, special facility, launching engineering, structure strength, target and environment, measuring and test, optoelectronic technologies, quality and reliability as well as aerospace medical engineering etc., including:

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1. Making the key points stand out, succinct writing, precise quotation, clear figures and tables; no more than 5000 words in each article; an abstract is required at the beginning of the paper (including the author's name and affiliation), key words and their English translation (the author's name need to be translated by following the phonetic transcriptions of Chinese characters). Both

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2. Submit two copies for each paper. The text in the draft is proofed and finalized based on publication requirements. The author takes sole responsibility for his views. The texts have to be written on one side of the paper with pen. Each character or punctuation occupies a grid. The writing has to be neat, and no running hand is allowed. The simplified character is according to the national standard. The measurement symbols and units used in the text have to adopted by the national legal measurement unit.

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