A New Method for Correcting Deviation of Volatiles Content and Chamber Pressure for Single Base Propellant

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Abstract

In this study, special treatment was applied to two production batches of single-base propellant to correct three of the most important properties in the final product. These properties are internal and external volatile content (IV%, EV% respectively) and chamber pressure, the special treatments depend on mixing two batches with different percentages of mixing starting with sieving and ended with blending to guarantee the homogeneity of the final batch. The batches under study (A and B), batch A with (IV% 0.53%) which must be not less than 0.6%, so it deviated from standard requirement and Batch B with (IV = 0.88%), the treatment applied for these batches to generate (C and D) batches. Batch C was a mixture composed of (25% of batch A and 0.75% of batch B). batch D was a mixture composed of (50% batch A and 50% of batch B). Six samples were subjected to sieving and blending according to calculations to correct internal and external volatile content and chamber pressure. For all samples lab, ballistics test, and executive calculations were done. After the test observed that no significant difference between the test and the results of calculations for all samples with different mixing ratios either volatiles content or chamber pressure so according to the result achieved the procedure (Method) was dependable for correcting the deviation of volatiles content and chamber pressure. The selectivity of the optimum mixing ratio can be controlled by using the equation used in this study. The importance of this study in reducing material losses due to the non-conformity of the final product with the specification.

Key words- *Volatile; Chamber Pressure; Single Base Propellant; Method and Mixing*

I. INTRODUCTION

A single-base propellant (SBP) one of advanced Chemical Industry Complex (AIC) products and classified as kind of propellant which used in rifle and guns with single energetic material nitrocellulose. Gelatinized by adding ether alcohol mixture to produce improved shape [1]. Single base propellant is a seasonal process that means the final properties affected by humidity and high weather temperature the adjusting of these parameters need some kind of thinking to predict the final result which must fulfill the standard requirement [2], during the production the manufacturer controls the volatile contents and geometrical shape dimension to avoid the deviations from the standard, lab tests have been done during production step by step to keep the product parameters in requirement limits, the deviation may arise from lab's results or other factors such as bad storage conditions or metal box not well tested, so one of these deviations which cannot be treated with the normal process was internal volatile content, these remaining volatiles were adjusted through special production stage (water soaking stage)[3] so, if it became lower than the limits that mean no way to get it back the value of an acceptable range.

On the other hand, specific procedure to treat the deviated single base products from the standard are not available because the possibility of this happening is up to normal due to continually checking, monitoring, and availability of foreign experts, but due to limitations of information and skills some deviations occur. The volatile content under study mainly included ethyl ether, ethyl alcohol, and moisture.

Batch A was produced with stipulated parameters especially an internal volatiles content but after it was packed and testing proceeded for final approved certificates the test resulted that a lower value of the internal volatiles 0.53% and the requirement is 0.6%, so to solve this deviation the author was proceeded some experiments to generate special procedure which was depended on theoretical calculation and preparation of experimental quantities with different component ratios from (Batch A) and (Batch B) supported by all safety precautions.

The flowing controlled blending procedure was available in the plant as the main production step especially through a static blender, and chamber pressure depending on many factors so mixing procedure has a great effect on it and the change is observable because the changing of volatiles content of final mixture itself change the chamber pressure values [3].

A. Statement of the problem

The main problem in single-base propellant manufacturing is the deviation of final specification of product from the requirement after blending and packing, and due to security of this type of production some limitations in information will lead to such problems and there is unknown treating procedure set for that. The problem under study is a deviation from requirements for two batches, finished product (Batch A); have a lower value of IV% than the requirements, and the finished product (Batch B) have chamber pressure higher than the requirements. It was important to know that both two above parameters were related to safely use of this single-base propellant by end-user.

II. LITERATURE REVIEW

The dynamics of mixing were tested by continuous sampling, and by the flowability of the material for different mixture types. The results of experiments were mathematically calculated to obtain the necessary data for each specific design [4]. Another study conducted on the mixing of solid This study focuses on investigating the mixing state by different mixing indices for different pre-organized particles. We also try to propose a new mixing index and discuss the advantages and disadvantages of different cases [5]. Also, the efficiency of mixing studied without sampling in this study the model product have Variety size of particles and color to observe the mixing and analyzed by image analysis [6], so from studies mentioned above all these studies depend on investigating blender selection and efficiency and the solid materials used not tested for its internal proprieties through chemical tests so, due to security nature of production procedure and products no such specific researches related to blending operation were published for correcting the deviation of chemical properties of propellant, here the author study new procedure affecting internal content of product and behavior through blending times.

III. METHODOLOGY

The procedures have three stages: stage one is set of work instruction included safety measures related to the safety of handling and processing of these dangerous materials. Stage two using the equations below to set the optimum mixing ratio. Stage three applying operational steps (sieving & blending). So, to guarantee homogeneity, the blending has been done four times and the job was executed according to recorded procedure and taking of the sample.

Depending on representatives of each batch the theoretical calculations were done for final IV% and EV% based on equations below for equal mixing ratio:

$$IV\% = \frac{(IV\%_C + IV\%_B)}{2} \quad (1)$$

$$EV\% = \frac{(EV\%_A + EV\%_B)}{2} \quad (2)$$

For other different ratios of batch (A and B) the flowing equations have been applied:

$$IV\%_C = 0.25IV\%_A + 0.75IV\%_B \quad (3)$$

$$EV\%_C = 0.25EV\%_A + 0.75EV\%_B \quad (4)$$

For chamber pressure of batch (A + B) the flowing equation as below:

$$P_C = \frac{(P_A + P_B)}{2} \quad (5)$$

$$P_D = 0.25P + 0.75P_B \quad (6)$$

Where: IV%: Internal Volatile content value. EV%: External Volatile content value. A: Single base propellant batch name B: Single base propellant batch name C: mixed single base

propellant batch name. D: mixed single base propellant batch name P: chamber pressure value.

These equations were applied for six (6) samples for both volatile content and chamber pressure. For (Batch C - 5/2020-T), the sample quantity was (480 kg) of single-base propellant. So sieving operation was applied for batch B (actual batch name 6/2017) to adjust grain size then it was blended with batch A (actual batch name 9/2018) according to Equations (1, 2, and 5) and the mixing ratio (1:1). And for (Batch D - 6/2020-T), the sample quantity was (140 kg) of single base propellant, the Batches (A/B) have been blended and mixed according to Equations (3, 4, and 6); the mixing ratio (1:3). The overall blending procedure has been controlled according to Fig. 1 and the blending operation was repeated four (4) times for more homogeneity using the blending procedure [9] in Fig. 1.

Fig. 1. The blending procedure

For sieved (Batch B) safety precautions were strictly flowed to avoid accidents due to the risky nature of propellant, the procedure included all safety measures that must be considered before starting any operations.

IV. RESULTS

A. Internal and external volatile content:

Calculations were showed that the value of internal volatile well corrected to the standard requirements and for more confirmations, the two samples were taken after mixed (1:1 ratio and 1:3 ratio), and the tests were repeated after the big batch was formed, the Table I was showed the results of matter.

Note:

- 1) All batches were treated with a ratio of 1:1 after testing for batch 5/2020-T and batch 6/2020-T as batch C.

B. Chamber pressure correction

Calculations were showed that the value of chamber pressure change was affected with mixing ratio but not out of the standard requirement because the value for all batches was meeting, the requirement for confirmation the two samples was taken after mixed (1:1 ratio and 1:3 ratio); and the tests were repeated after the big batch was formed, the Table II. Was showed the results of matter.

TABLE I
COMPARING BETWEEN CALCULATED RESULTS AND LABROTARY RESULTS

Sample name	IV calculated	% tested	EV% calculated	tested	Remarks (Ratio)
5/2020-T (C)	0.73	0.73	1.4	1.4	1:1
6/2020-T (D)	0.81	0.68	1.3	1.2	1:3
5/2020 (C)	0.73	0.75	1.4	1.31	1:1
3/2021 (C)	0.85	1	1.38	1.12	1:1
2/2021-T (C)	0.75	0.73	-	1.17	1:1
1/2021-T (C)	0.63	0.6	1.43	1	1:1

V. DISCUSSION

A. Internal and external volatiles

This special procedure is designed to solve actual problems which can lead to safety problems during disposal and financial losses. Single base propellant manufacturing depending on labor skills which must be developed over the years of success and failure in addition to safety issue so the deviation in the first period of skills development was rather expected and happened, for treated the product back to the standard no documented procedure was set for such problems. The lab results were showed that the IV% and EV% can be treated with optimum selection of ratio and depending on calculations took with customizing ratio the batch A has IV% 0.53 and the new batch for C batch becomes 0.73 % with in the requirement ,also the chamber pressure in Table II batch 3/2021 correct the batch 5/2017 from 324.8 MPa above the standard by mixing procedure using the equation 5, the final result equal to 295.5 which meeting the requirement limit.

This procedure must make the treatment safely by offering the correct decision before trying any quantity of target product. Raising or lowering contents have limits and equations will give specific answer, from the results above it becomes clear that the correction of volatile content can be done by well mixing two products by selecting the right value which can contribute to correction. From above the procedure success and value. Fig. 2,3 and 4 shows the trend of treatment for IV%, EV%, and chamber pressure, but for EV% some chins because of sensitivity of EV% to outside condition such as humidity and temperature especially in Sudan the EV% value of product decreasing if not packed in tightly closed iron boxes, so it shows different behavior from IV

Fig. 2. Comparison between measured and calculated values of external volatiles

Fig. 3. Comparison between calculated and measured values of internal volatiles

TABLE II
THE COMPARING BETWEEN CALCULATED RESULTS AND SHOOTING RANGE TESTING RESULTS .

Sample name	Chamber pressure MPa calculated	tested	Standard	Remarks (Ratio)
5/2020-t (C)	288.05	286.2		1:1
6/2020-t (D)	286.6	290.2		1:3
5/2020 (C)	288.05	285.8		1:1
1/2021-T (C)	295.25	296.1	≤304.5	1:1
2/2021-T (C)	298.546	298.3		1:1
2/2021 (C)	298.546	-		1:1
3/2021 (C)	-	295.5		1:1

B. Chamber pressure

For chamber pressure results became clear that the pressure can be control to some limits and the calculated results and tested values reflect that it is important to control the pressure during calculation in safe value to avoid deviations and wasting the mixed batches which will be more the two batches.

The differences between calculated and tested samples were important and put into considerations because the chamber pressure depends on many factors such as total volatiles (IV%+EV%), grain size control, quality of forming cutting and sieving, nitration degree of nitrocellulose, and bulk density. So, during mixing no guarantee for the controlling all these complicated items but finally, the formula can correct these

Fig. 4. Comparison between tested and calculated values of chamber pressure

deviations to some limits.

VI. CONCLUSION AND RECOMMENDATIONS

A. conclusion

The values for both lab and ballistics tests prove that the special procedure achieved the required results and it can be used as one of the good solutions for deviation correction of volatiles content and chamber pressure, so two mixing ratios applicable but it depends on the correction limit to be achieved for volatile content and some factor must be taken into account when choosing mixing ratio such as calculated chamber pressure of mixed products and the calculated value must have good margins from requirement to avoid exceeding the standard.

B. Recommendations:

Further studies must be conducted to:

- 1) Studying effect of storage conditions on volatiles contents.
- 2) Storing sample of mixing batched in aggressive control condition to study the availability of this procedure for a long time of storing for mainly IV%, EV, stability, and chamber pressure because this material manufactured to use the time of need may early of many years according country stagnation.

Abbreviations

AIG: ADVANCED INDUSTRIES GROUP.

AIC: ADVANCED CHEMICAL INDUSTRIES COMPLEX.

EV: EXTERNAL VOLATILE.

IV: INTERNAL VOLATILE

SBP: SINGLE- BASE PROPELLANT.

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