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Determination of wet cutting length and shrinkage of sticky single base propellant

HAIDER ABD ELGADIR ELBASHER
Assistant professor
haider20ac@gmail.com
HUSAM ELDIN MUSTAFA
Assistant professor
husamustafa@gmail.com
MOHAMED ELAMIN ELGAALI
Chemical engineer
mohammedalgali777@gmail.com
EASA ABDELRAHMAN ABD ELGADIR
Chemical engineer
eissaabdalrahman589@gmail.com

Abstract

This study investigated the shrinkage rate of tubular single base propellant with single perforation and length of (25.8 - 27) cm to determine the rate of shrinkage in length for the design of a fixed cutting tool. The author first designed four temporary cutting tools with lengths of 26.0, 26.3, 28.0, and 28.3 cm. These lengths were based on a shrinkage rate of 4-6% for the minimum and maximum length of the propellant under study (25.8-27) cm. However, the cutting tools with lengths of 26 and 28.3 cm did not obtain the required length after drying.

To determine the acceptable wet cut length, the author extrapolated from the results of the first four cutting tools. The wet cut length was found to be 27.8 cm, which gives the dried length in the range of 25.9-26.8 cm. This is within the standard range. From the experiment with a length of 27.8 cm, it was found that the shrinkage rate ranged from 2.1 to 4.9%. The cutting tool was designed based on this shrinkage rate and it gave the required length after drying. The author's findings show that the shrinkage rate of tubular single base propellant with single perforation can vary depending on the process conditions. The author's method of determining the shrinkage rate is a reliable way to ensure that the cutting tool is designed correctly.

Keywords: single base propellant, shrinkage rate, web thickness, nitrocellulose, ballistics.

1-INTRODUCTION

Single-base propellants are considered one of the most important products whose specifications must be controlled due to the risks involved, such as destruction of weapons due to the high pressure of the gases corresponded to un control geometrical shape, as well as the propellant's inefficiency. In the solvent process for manufacture of propellant, nitrocellulose (NC) is gelatinized to desired consistency with the help of the solvent is removed by drying process after the extrusion of gelatinized mass (dough) [1]. In this process[2], as the solvent leaves the system - the solid ingredients (NC, etc.), non-volatile materials (Plasticizers, modifiers, etc.), and the volatile solvent - the dimensions of extruded material shrink [3].

The most important things that the designer and the user must take into account is the accurate propellant dimensions, which affects the internal ballistic, and turn leads to the selection and determination of the ammunition as well as the weapon used. Therefore, the dimensions of the propellant must be determined accurately before drying to control internal ballistics[4], taking into account the shrinkage rate after drying. Single base propellants are produced in different shapes according to its uses [5]. Such as granular or sticky shape, which is produced in a length from 1.1 mm up to two 720 mm, as shown in the Fig.**1** Based on the aforementioned, this scientific paper has been prepared, which contains practical experiments coupled with scientific evidence to determine the cut lengths of the propellant before drying, as well as determining the shrinkage rate and influencing factors for SBP 12/1-27 described as Sticky single base propellant with single perforation, this type of smokeless powder used as charge for artillery howitzer[6][7]. .

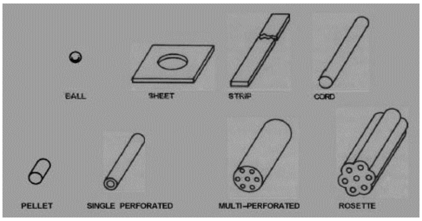

Fig.1. Single base propellant forms

Present in research paper general equation to make propellant manufacturer avoid trial and error to produce propellant with certain dimension through extrusion mold depending on mathematical calculations. The paper discusses how to select forming dimension outer diameter and hole diameter selection for green propellants (wet product before drying) but did not setting data for the cutting procedure because this is different process the shrinkage in length is different from shrinkage in diameter. Author depends on density calculation for wet and dry propellant [8]. No specific data published in this top just best practice data available which need more exponential work to set up formula for selecting the ratio of shrinkage rate with acceptable error. The shrinkage rates in some textbooks are not applicable to all conditions, so the author used a different method to determine the acceptable shrinkage rate of the design cutter. So, this paper aim to participate in this by more experimental works and comparison between results.

1.1 Marking of single base propellant:

In this sector of propellant there is huge types and number of propellant products so it very important to give This product some mark [2] to be clear in processing and use in general the making depends on shape, web thickness[3] (see fig.**2**.), length, number of hole, type, additives and length such as flow:

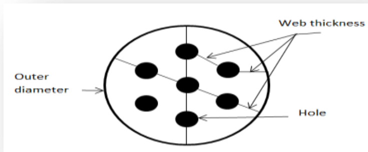

Fig. 2. Web thickness 12/1-27 ,12/1-72 used in this paper

Where:
The figure in the point (a)12 represent 1.2 mm web thickness multiply by 10.
The number 1 represent number of perforation (in this case is 1 perforation).
The number 27 represent total length 27 cm, 72 cm respectively.

2- STATEMENT OF THE PROBLEM

No specific shrinkage rate considers the cutting length to be used as main figure for design cutting tool depending on available cutting tool which may lead to drying length more the requirement for SBP -12/1-27 with dimensions bellow:
Length 250~270 mm and 5.3 mm as outer diameter this geometrical data for 122 mm howitzer charge.

3-RESEARCH OBJECTIVES

1. Determine specific wet cutting length for single base propellant have sticky shape with final minimum and maximum length 250 to 270 mm respectively after dried.
2. Effect of the length on the cutting wet length.
3. Avoid over and under size of propellant length after drying .

4 - MATERIALS AND METHODS

1. The permissible dried length for the product under study (25-27 cm)
2. Taking shrinkage rate 4 to 6 % of other sticky single base propellant as refinance that have dried length 72 ,
3. Design temporary cutting tool depending on shrinkage rate mentioned in point above from 4 to 6 % based on production condition a gelatinizing solvent ratio as flow (4% ,5%,6%) calculated cutting tool for wet cutting length depending on dried length 25-27 cm as flow
4. Calculating expected length based on shrinkage rate (4% to 6%) and design temporary cutting to for each limit as in table 1.
5. Cut product with temporary cutting tool as in table 1 and then dried and measured to specify shrink percentage see fig 3.
6. Generate acceptable cutting length and design the final cutting tool.
7. Redesign new cutting tool to produce and then measured the results see fig 4,5.

Fig. 3. Cut strand single base propellant with temporary cutting tool

Table .1. Shows shrinkage rate for temporary cutting tool

Idea	Sample lower limit 25 cm		Sample upper limit 27 cm	
	4%	6%	4%	6%
Cutting tool length	26 cm	26.3	28	28.3

5-RESULT AND DISCUSSION:

5-1Result

Table 2. Measured length for cut strand from four tools as in table 1 (26, 26.3, 28 and 28.3).

Sample type	Wet length for lower length 25 cm (4%) shrinkage rate		Wet length for lower length 25cm (6%) shrinkage rate		Wet length for upper length (4%) shrinkage rate		Wet length for upper length 27cm (4%) shrinkage rate	
sample number	Cutting length 26cm	Shrinkage rate % 26tool	Cutting length 26.3cm	Shrinkage rate% 26.3tool	Cutting length 28cm	Shrinkage rate % 28tool	Cutting length 28.3cm	Shrinkage rate % 28.3 tool
1	25.3	2.7	25.3	3.8	27.4	2.1	27.5	2.8
2	25.3	2.7	25.3	3.8	27.4	2.1	27.5	2.8
3	25.3	2.7	25.3	3.8	27.4	2.1	27.5	2.8
4	25.3	2.7	25.3	3.8	27.4	2.1	27.5	2.8
5	25.3	2.7	25.2	4.2	27.2	2.9	27.4	3.2
6	25.3	2.7	25.2	4.2	27.2	2.9	27.4	3.2
7	25.3	2.7	25.2	4.2	27.1	3.2	27.3	3.5
8	25.2	3.1	25.2	4.2	27.1	3.2	27.3	3.5
9	25.2	3.1	25.1	4.6	27.1	3.2	27.3	3.5
10	25.2	3.1	25.1	4.6	27.1	3.2	27.3	3.5
11	25.2	3.1	25.1	4.6	27.1	3.2	27.3	3.5
12	25.2	3.1	25.1	4.6	27	3.6	27.2	3.9
13	25.2	3.1	25.1	4.6	27	3.6	27.2	3.9
14	25.1	3.5	25.1	4.6	27	3.6	27.2	3.9
15	25.1	3.5	25.1	4.6	27	3.6	27.1	4.2
16	25.1	3.5	25.1	4.6	27	3.6	27.1	4.2
17	25.1	3.5	25.1	4.6	27	3.6	27.1	4.2
18	25.1	3.5	25	4.9	27	3.6	27.1	4.2
19	25.1	3.5	25	4.9	27	3.6	27.1	4.2
20	25.1	3.5	25	4.9	27	3.6	27.1	4.2
21	25.1	3.5	25	4.9	27	3.6	27.1	4.2
22	25	3.8	25	4.9	27	3.6	27	4.6
23	25	3.8	25	4.9	27	3.6	27	4.6
24	25	3.8	25	4.9	27	3.6	27	4.6
25	25	3.8	25	4.9	26.9	3.9	27	4.6

From the table above there are different values of shrinkage rate that affected by many conditions such as solvents ratio and time of cutting after forming so author depend on average value for each cutting tool and select 27.6 as cutting length and using corresponding shrinkage rate to each cutting tool to select acceptable cutting tool length form four tool as flow:

Table. 3. Calculated cutting length dimension in cm

Description	Cutting length 27.6 with 26.0 tool shrinkage rate	Cutting length 27.6 with 26.3 tool shrinkage rate	Cutting length 27.6 with 28.0 tool shrinkage rate	Cutting length 27.6 with 28.3 tool shrinkage rate
Max calculated dried length cm	26.9	26.6	26.9	26.7
Min calculated dried length cm	26.7	26.3	26.6	26.5
Avg calculated dried length cm	26.8	26.45	26.75	26.6

From the above calculations to achieve cutting limist for 12/1-27 with range (25 -27 cm) the acceptable cutting length is should be 27.8 for new cutting tool with 4 cutter rail B,C,D and E figure 3 shows cutting tool and figure 4 .

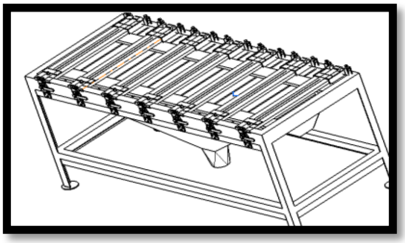

Fig. 4.Cutting equipment with 4 rails

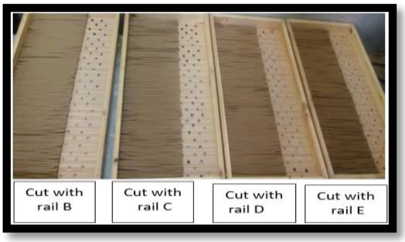

Fig. 3 .Cut strand with 4 cutter rail

The cutting tool in fig 4 designed with four cutting rails to minimize waste of propellant when exit from mols of forming machine with total length two meter, construction material of this cutting tool depended on safety requirements related to nature of the propellant . the product cut and measured.

Table 4. Result of cutting with modified cutting tool in fig 4 with cutting length 27.8 cm

Cutting too / S/N	calculated length	Measured length rail B	Measured length rail C	Measured length rail D	Measured length rail E	average
1	26.8	26.6	26.6	26.5	26.7	26.6
2	26.8	26.5	26.5	26.4	26.5	26.5
3	26.8	26.5	26.4	26.4	26.5	26.5
4	26.8	26.4	26.4	26.3	26.4	26.4
5	26.8	26.4	26.4	26.2	26.4	26.4
6	26.8	26.4	26.4	26.2	26.3	26.3
7	26.8	26.3	26.4	26.2	26.3	26.3
8	26.8	26.3	26.4	26.2	26.3	26.3
9	26.7	26.3	26.3	26.2	26.3	26.3
10	26.7	26.3	26.3	26.1	26.3	26.3
11	26.7	26.3	26.3	26.1	26.3	26.3
12	26.7	26.2	26.3	26.1	26.3	26.2
13	26.7	26.2	26.3	26	26.3	26.2
14	26.7	26.2	26.3	26	26.2	26.2
15	26.7	26.2	26.2	26	26.2	26.2
16	26.7	26.2	26.2	26	26.2	26.2
17	26.7	26.2	26.2	26	26.2	26.2
18	26.7	26.2	26.2	26	26.2	26.2
19	26.6	26.1	26.2	26	26.2	26.1
20	26.5	26	26.2	25.9	26.2	26.1
21	26.5	26	26.2	25.9	26.1	26.1
22	26.5	26	26.2	25.9	26.1	26.1

23	26.5	26	26.2	25.8	26	26.0
24	26.5	26	26.1	25.8	25.9	26.0
25	26.4	25.9	26.1	25.8	25.8	25.9

4.2 Dissection:

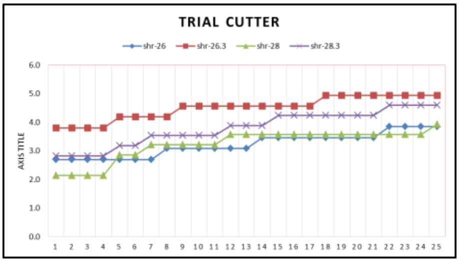

Fig. 4 . Shrinkage rate for trial cutter

As in figure (5) above the trend of shrinkage is similar for 4 cutting length with some different reflect cutting condition and solvent ration that affect swelling of strand also cutting time but in the last the trend is one so the average value will be represent the shrinkage rate.

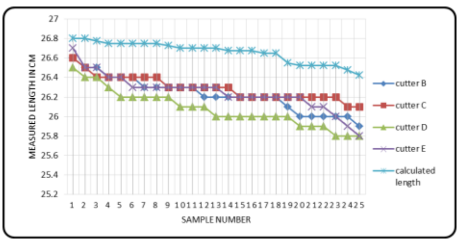

Fig. 5. Shrinkage rate for cutting tool with length 27.8 cm

Figure shows the cutter B have less shrike because of cutting operation the strand when but over cutter need time to fill cutter space depending on forming time so it take waiting time more than c,d and e .but in one word the shrinkage between 25.8 and 28.8 cm fall in the actable range (25~27)cm.

5-CONCLUSION AND RECOMMEDATION

5.1 CONCLUSION

Many factors affect shrinkage rate after drying such as solvents ratio in the dough and forming condition quality of raw material waiting time before cutting so depending on specific ratio specially for un adjustable cutting tool will not achieve required length so it's better to try before design or design adjustable cutting tool to modify cutting length in case of not meet the required value, in general the shrinkage rate according to this study fall in the range (2.1~4.9) %.

5.2- RECOMMEDATION

This study conducts on cutting with shrinkage rate only so many many rates achieved because of variable conditions so further study should be conduct effect of the flowing:

1. cutting conditions (temperature, weather and ventilations) on final length.

2. waiting time before cutting on final length.
3. Solvent ratio on final length.

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