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Granulation Methods of Double Base Propellant for Small Caliber Ammunition

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Abstract

One of the most essential unit procedures in propellant production is granulation, or particle enlargement through agglomeration. The granulation process transforms small fine or coarse particles into huge agglomerates known as granules. The granulation process converts fine powders into free-flowing, dust-free granules that are easier to compress, affecting propellant grain size. The propellant industry expects produce quality propellant which can increase the performance of weapon. Method of propellant granulation should have optimized in accordance with the size of grain. One of the most active areas of double base propellant research is the development of granulation method. The literature review method was used to obtain data, by using the keywords double base propellant research, and the criteria for granulation method. The data obtained in the form of the results of the development granulation method to produce qualify size grain of propellant to increase performance. The data shows that the method of granulation can be conventional or modern based on development of technology. Production on laboratory scale widely uses sieving or mesh to form granules of propellant. This method widely known as conventional method. Development of technology influence method of granulation in manufacturing propellant, for example extrusion with vertical hydraulic press, ram extruder, screw extruder, and cutting uses rotary cutting machine.

Keywords: *Granulation; Double Base Propellant; Grain; Technology*

Introduction

A propellant, often known as gun powder, is a material that produces pressurized gas that fills the chamber of a gun or the interior of an ammunition cartridge, causing a bullet or shell to explode (Yolhamid *et al*., 2018). The propellant divide into liquid, solid, or hybrid (Da Silva *et al*., 2013). Solid propellant is type of propellant that useful for aircraft, antiaircraft weapon, tank, howitzers, small arms, and cannons (Steinhauser, 2008).

Conventional gun propellants are generally classified based on the chemical formulation into various categories like single base, double base, triple base and nitramine base depending on the major ingredients such as nitrocellulose (NC), nitroglycerine (NG), nitroguanidine and nitramines which are used as major ingredients (Pillai *et al*., 2000). The principal energetic element found in single-base propellants is nitrocellulose. Other materials and additives are added to provide the required shape, burning properties, and stability. The multi-base propellants are split into two categories: double-base and triple-base propellants, both of which contain nitroglycerin to aid in the dissolution of the nitrocellulose and improve its energetic properties. Nitroglycerin also raises sensitivity, flame temperature, linear burn rate, and detonation risk. Higher flame temperatures reduce smoke and residue, but they also enhance flash and gun-tube erosion. Triple-base propellants are double-base propellants with nitroguanidine added to reduce flame temperature, resulting in less tube erosion and flash (Straathof, 2016).

Since propellant is designed to produce a high amount of gas at a controlled rate, it can have an impact on weapon performance. Some rocket casings and gun barrels are built to withstand a specific maximum gas pressure. Controlling the rate of propellant combustion can limit the pressure created to this maximum value. The linear burn rate is controlled in the art by altering the following factors: (1) the shape and size of the grain, as well as perforations, (2) the thickness of the web or the amount of solid propellant between the burning surfaces; the thicker the web, the longer the burn time, (3) the linear burn rate, which depends on the gas pressure and the chemical composition of the propellant, including volatile materials, inert matter, and moisture present (Straathof, 2016). Manufacturing or production process lead the main key to produce qualify propellant. Specific facilities and equipment are necessary for preparing the different compounds of the mixture, executing the mixing process and handling the propellant doughs (Martinez-Pastor *et al*., 2018).

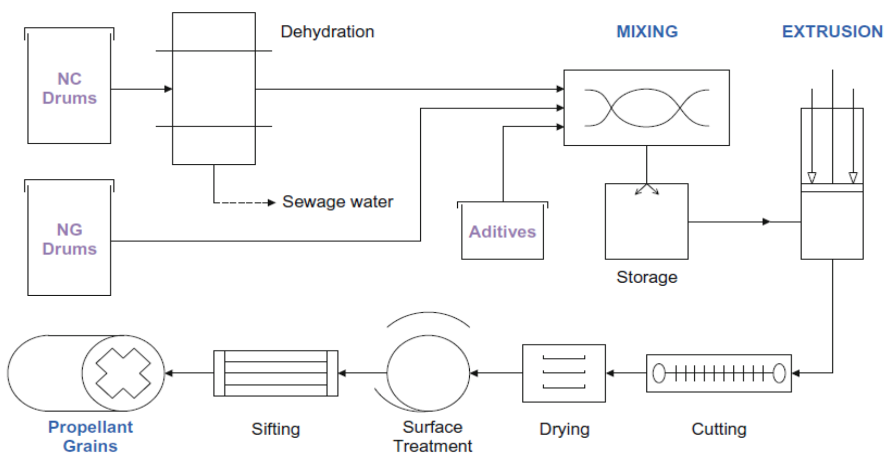

Fig.I. Flow chart Double Base propellant production process (Martinez-Pastor *et al*., 2018).

One of the most essential unit procedures in propellant production is granulation, or particle enlargement through agglomeration. The granulation process transforms small fine or coarse particles into huge agglomerates known as granules (Shanmugam, 2015). Granulation process changes the size of the grains in a propellant by converting them into free-flowing, dust-free granules that are simpler to compress. The propellant industry expects produce quality propellant which can increase the performance of weapon. Method of propellant granulation should have optimized in accordance with the size of grain. One of the most active areas of double base propellant research is the development of granulation method. The objective of the research is to find the best granulation methods of double base propellant for small caliber ammunition. This paper expected give contribution for development double base propellant, especially in Indonesia.

Methodology

This study uses a descriptive qualitative approach by exploring or explaining more about propelan granulation method. The literature review method was used to obtain data, by using the keywords double base propellant research, and the criteria for granulation method. The data obtained in the form of the results of the development granulation method to produce qualify size grain of propellant to increase performance. There have some publications related to granulation method of double base propellant for small calibre ammunition like books, journals, website pages and other references that are considered relevant to the theme in this study.

Results And Discussion

Single-base which made entirely of nitrocellulose and double-base which consisting of a combination nitroglycerin and of nitrocellulose gunpowder are the most common types of gunpowder today. Using appropriate solvents to plasticize nitrocellulose, cutting the granules or grains into little squares after they have been rolled out to thin sheets, then they're dried, are used to make both types. Variations in propellant grain geometric form, size, and composition, as well as the grain's surface treatment or coating, are used to control the rate of burning. The objective is to develop a propellant that progressively converts to gas during the early phase of combustion and more quickly transformed as the combustion progresses. From the data obtained, the research of granulation method double base propellant can be summarized as follows:

Table 1. Summary of research granulation method double base propellant

Author	Methode
Cieślak, 2020	Sieving/mesh
Pillai *et al*., 2000	Extrusion (Vertical Hydraulic Press)
	Cutting (Rotary Cutting Machine)
Martinez-Pastor *et al*., 2018	Ram extruder
	Screw extruder
Botelho *et al*, 2015	The spherical powder manufacture process

From table 1, shows that production on laboratory scale widely uses sieving or mesh to form granules of propellant. This method widely known as conventional method. Development of technology influence method of granulation in manufacturing propellant. Ram extruders and screw extruders are the two kinds of extrusion machinery in use in this industry. This work focuses on colloidal propellant extrusion using ram extruders, which extrude using a ram press. The ram inside the extrusion press's cylinder moves the gelled material (propellant doughs) to the extrusion die; the finished result then adopts the cross-sectional geometry dictated by the extrusion die's hole (Urbanski, 1986). Screw extruders are also capable of using colloidal propellants. There are two or one screw on these machines (for extrusion with twin or single screws, individually), which are responsible for kneading the propellant formulation ingredients, then move the gelled material in a circular motion to the extrusion die, which is placed at the screw extrusion machine's end of the axis (Giles *et al*., 2005).

Spherical smokeless powder is generally made from nitrocellulose as the base material. The nitrocellulose may be derived from purified cellulose, such as from cotton linters or wood, which is then nitrated by being treated with nitric and sulfuric acids (Valenca *et al*., 2013). The coating may comprise nitroglycerin which acts as an accelerator; in that it allows the powder to be more readily ignitable and also acts as a waterproofing agent, rendering the powder non-hygroscopic. A suitable deterrent such as dibutylphthalate may be used along with the nitroglycerin or other accelerator and waterproofing agent.

The grains may be then dried and glazed in the usual manner and thereafter blended if desired (Olsen, 1940). Although the spherical powder starts as pure nitrocellulose, the finished product is a double-base propellant, since nitroglycerin is added after shaping and its content is created by surface impregnation (Botelho *et al*., 2015).

Combustion begins on the outer surface of solid propellants and progresses into the center core, with the charred surface expanding outward in a radial pattern. Propellant granules may burn regressively, neutrally, or progressively, depending on their combustion surfaces. Variations in propellant particle size have an impact on the final propellant's burn rate. In general, a central core is the grain of neutral combustion. Regressive burning occurs when the grain is cubical, cylindrical, or spherical. Multi-perforated grains, on the other hand, tend to burn in a more gradual manner (Kubato, 2002).

The rate of burning was calculated as a function of particle size, temperature, and pressure. Increased bullet velocity, internal barrel pressure, and burn rate were seen as fuel temperature and particle size decreased (Degirmenci, 2015). The burn rate and pressure increased as the temperature of the propellant increased and the grain size decreased. In an experiment conducted by Degirmenci (2015), a 7.62 mm NATO standard rifle was used to evaluate the samples, with a custom-made barrel at a shooting range. Strain gauges were used to detect stresses along the barrel, and a Doppler radar was used to calibrate the exit velocity of the muzzle. The bullet velocity, internal pressure and burn rate all rose in the shooting tests when propellant temperature and grain size were reduced.

Based on data shows in table 1, all method was started with mixing ingredients and ends with drying of granules that has been formed. Cieslak (2020), start the mixing process with NC, water, ethyl acetate, and sodium sulfat, the granules were then sieved in a stream of water using sieves with diameters of 0.385 and 0.75 mm. Pillai (2000) used two separate procedures, the first of which involved desensitizing the material with the plasticiser coating before combinating it with the inert binder. A two-stage process technology was used in the second procedure. The basic composition is prepared in the first step by a wet mixing process, and the dry basic mix is solvent incorporated in the second stage for extrusion into the required form and size.

Conclusion

The research conducted is to find the granulation method to produce qualify size grain of propellant to increase performance. The data shows that the method of granulation can be conventional or modern based on development of technology. Production on laboratory scale widely uses sieving or mesh to form granules of propellant. This method widely known as conventional method. Development of technology influence method of granulation in manufacturing propellant, for example extrusion with vertical hydraulic press, ram extruder, screw extruder, and cutting uses rotary cutting machine. Granulation method can affect burn rate of propellant. Grain size, temperature, and pressure all played a role in determining burn rates. It can be shown that as the temperature of the fuel rises and the particle size decreases, bullet velocity rise, internal barrel pressure, and the burn rate.

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