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New Nitrocellulose-Diethylene Glycol Dinitrate (NC-WITH) Propellant to Support the Development of Munition Independence in Indonesia (Case Study: PT. Pindad)

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ABSTRACT

PT Pindad, a prominent defense industry leader in Indonesia, is renowned for its high-quality, small-caliber munitions, contributing significantly to the achievements of the Indonesian National Army both nationally and internationally. In the face of globalization and the imperative for robust national defense capabilities, self-sufficiency in munitions production and development is crucial. PT Pindad has been at the forefront of munitions innovation, particularly in addressing challenges related to the supply of propellant materials. This study uses a Feasibility Study approach to explore the innovative use of waste paper as a raw material in producing nitrocellulose (NC) and nitroglycerine (NG). Given NG's sensitivity and volatility, diethylene glycol dinitrate (DEGDN) is proposed as an alternative component in developing an efficient and reliable NC-DEGDN propellant blend. This research supports the strategic goal of advancing Indonesia's munitions independence.

Keywords: *Defense Industry, Propellant Innovation, Munitions Development, Sustainable Materials*

Introduction

Gemah ripah loh jinawi, a phrase that is often pinned to Indonesia, the word has the meaning of abundant natural wealth. As an agricultural country, Indonesia is endowed with abundant natural resources, plus Indonesia's strategic position from a geographical perspective. With such conditions, defense, and security are important strategic aspects to maintain so that economic and social activities can always run well. To improve the quality of national defense and security, one of the steps that can be taken is to master good defense technology. National defense is an important aspect of maintaining the sovereignty of a country. One of the key components of national defense is the ability to produce and develop reliable munitions. Having independence in munitions production will provide strategic advantages, such as reducing dependence on imports and increasing operational flexibility. The development of autonomy in munitions production has become a strategic goal for Indonesia in facing national security challenges and ensuring the defense industry's sustainability. As an archipelagic country with diverse conflict potentials and threats, Indonesia realizes the importance of having the ability to produce and develop munitions independently. In this context, PT Pindad, a leading defense company in Indonesia, plays an important role. PT Pindad has extensive experience and technological capabilities in producing various munitions, including firearms, guided missiles, and other weapon systems. This capability makes PT Pindad a strategic asset in achieving independence for munitions in Indonesia. Developing munitions production capabilities independently has many significant benefits. First, it will reduce dependence on munitions imports from other countries, reducing the risk of supply shortages in emergencies or changes in international trade policy. The independence of munitions production also provides a tactical advantage in terms of national security and ensures the availability of reliable munitions.

In addition, by having the ability to produce munitions independently, Indonesia can increase the competitiveness of the defense industry at the global level. The ability to produce high-quality and innovative munitions will give Indonesia a competitive advantage in meeting domestic defense needs

and offering munitions products to the international market. The development of munitions production independence also plays an important role in building knowledge and technical expertise in the national defense industry. PT Pindad, with its experience and qualified human resources, can develop new research and development in producing more efficient, safe, and environmentally friendly munitions. This will increase the innovation power of the national defense industry and strengthen Indonesia's position in the global defense industry map. Overall, developing independence in munitions production is a strategic goal for Indonesia. PT Pindad, with its role and capabilities, plays an important role in achieving these goals. Through the development of munitions independence, Indonesia can improve national security, strengthen the defense industry, and contribute to stability and peace at the regional and global levels. Indonesia is endowed with abundant natural wealth plus Indonesia's very strategic position from a geographical perspective. With such conditions, defense, and security are important strategic aspects to maintain so that economic and social activities can always run well. To improve the quality of national defense and security, one of the steps that can be taken is to master good defense technology. The progress of the Propellant Industrial Independence Program is very slow and far from the Road *Map* that has been determined.

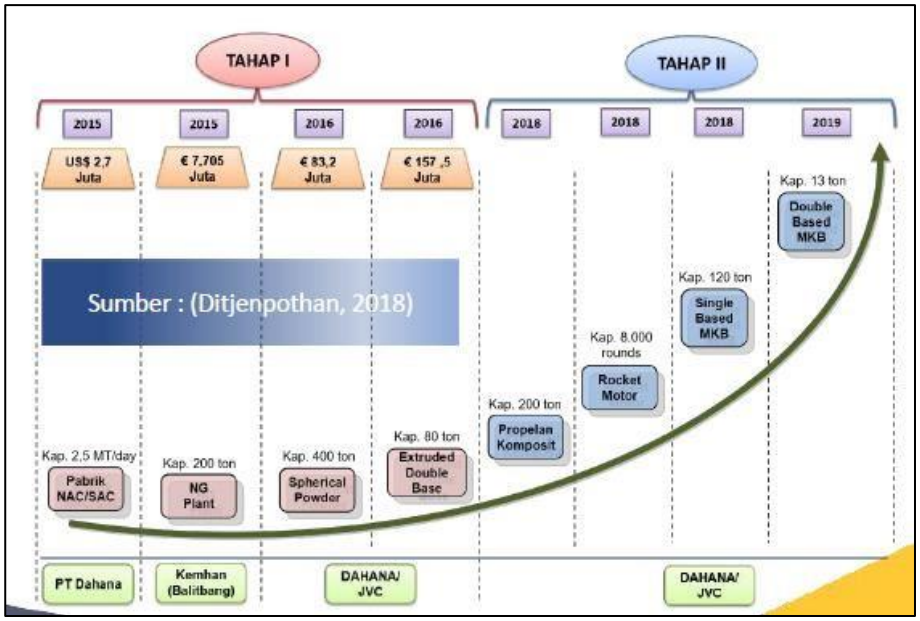

Figure 1. Road Map for the development of the propellant industry
Source: *Directorate General of Defense – Ministry of Defense of the Republic of Indonesia, 2018.*

According to the Indonesian Ministry of Defense, the dependence on technological development in other countries will affect the nation's defense capability. Building a good strategic defense industry is necessary to improve defense technology, such as weapons technology, ammunition, and combat vehicles. Based on what has been mentioned above, the Defense Industry Policy Committee (KKIP), together with the Ministry of Defense, formulated seven strategic programs in the defense sector consisting of the development of Medium Tanks, Fighter Aircraft, Submarines, Propellants, Missiles, Rockets, and Radars. In the context of technology development and innovation, PT Pindad, as a strategic industrial SOE in the field of defense and security equipment (alpalhankam), will contribute to the development of fuel through the innovation of the propellant pilot plant design concept to support the development of ammunition in Indonesia.

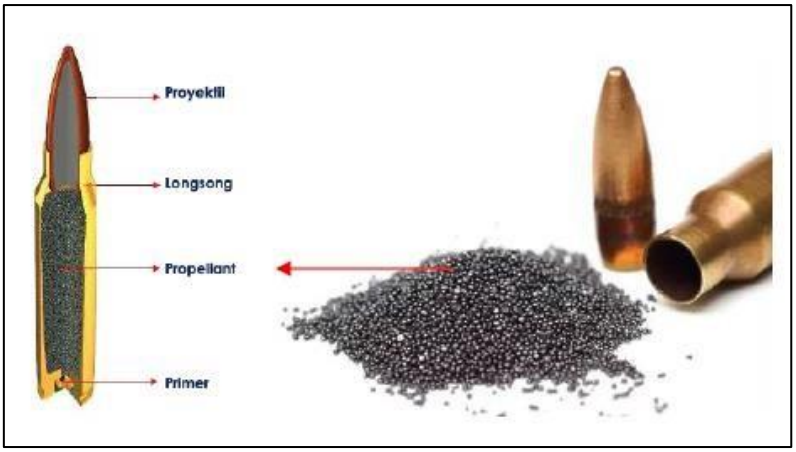

Figure 2. Propellant powder and exploded view munitions caliber 5.56 x 45 mm

The *Propellant* is a chemical material that functions as a thrust charge on munitions and rockets by converting the chemical energy contained in the propellant material into kinetic energy to provide thrust on the projectile of ammunition or rockets[1]–[3]. Based on its application, the classification of propellants is very diverse, and in this pilot plant design innovation, the discussion will focus on propellants for small-caliber munitions (MKK).

One of the competencies of PT. Pindad is a high-quality MKK production. This is proven by the various achievements that have been achieved by the Indonesian National Army (TNI) by using munitions produced by PT Pindad, which has become the overall champion in various international championships such as the Asian Armies Riffle Meet (AARM) and the Australian Army Skill at Arms Meets (AASAM). Good MKK quality is always supported by good propellant quality. The current problem is that Indonesia cannot produce fuel independently and is still dependent on imports from several countries, such as South Korea, Australia, Belgium, China, and South Africa.

As the main producer of munitions in Indonesia, PT Pindad is required to meet the needs of the TNI and POLRI as much as 500 million munitions/year, equivalent to the need for fuel of 821 tons/year. The high number of propellant import needs has several potential risks both in terms of procurement and munitions production, including:

1. Policies from exporting company countries often hamper propellant imports, such as the potential for a trade embargo and the non-issuance of export licenses.
2. Risks from the transportation side that can cause delays or delivery failures. This is because fuel is a B3 (dangerous goods) category material, so special permits and special transportation are needed with a limited amount. Freight costs are high, and each propellant manufacturer requires a minimum quantity order for each purchase. Therefore, meeting propellants' needs for munitions' production and development takes months or even years.
3. The price of propellant imports has the potential to rise and is also influenced by the rupiah exchange rate, affecting the cost of munitions production.
4. The continuity and sustainability of domestic munitions production are highly dependent on the productivity of propellant supply companies.
5. Each propellant manufacturer has different product characteristics, so PT Pindad, as a user, needs time to optimize the quality of munitions products. Not to mention that foreign manufacturers cannot all meet the special specifications of fuels required by the new munitions. This is an obstacle to developing munitions in Indonesia, so the marketing process of the new munitions cannot be carried out immediately.

The government started a propellant development and industrialization project in Indonesia in 2010, with the initiation of the propellant development project carried out by the Ministry of Defense. 2013, the Propellant Plant was groundbreaking, and the Nitroglycerine (NG) Plant was inaugurated in 2018. Meanwhile, the inauguration of the supporting facilities of the Propellant Factory was only carried out in early 2019. This program has been running for ten years, but until now, it has not followed the specified roadmap. In the background, the problems faced by PT are as follows: Pindad to obtain propellant supplies to meet the needs of munitions production and development, as well as how it relates to the national strategic program for developing the propellant industry in Indonesia. This motivates the millennial innovators of PT. Pindad will carry out various discussions and brainstorming processes to solve the problem. So that creative ideas can be obtained as solutions to problems in the company.

Research Methods

In this research, the author conducted quantitative research using the feasibility study method by collecting data and analyzing and interpreting numerical data into words so that readers can understand what the author means in this paper. The author gathers research data by conducting interviews during field studies, books, presentations, and various references that can be used according to the research topic the author wants to research.

Results And Discussion

Munitions cannot be separated from propellants. With the increasing orders for munitions production every year, the need for propellants also increases. Benyak is a new type of munition developed to meet the needs of the TNI and POLRI and was specifically designed by PT. Pindad. In large-scale propellant production, it won't be easy to support the research and development process of new munitions because the need for fuel is relatively small, and a special composition is used to meet the ballistic specifications required by munitions. This is where the propellant pilot plant plays an important role in accelerating the development of new munitions in Indonesia. This will also accelerate the munitions certification process so that it can be immediately marketed to the TNI and POLRI. The innovations carried out do not only stop here, PT. Pindad also developed a new propellant composition with a better level of safety with better munition performance. In addition, to improve environmentally friendly manufacturing processes, PT. Pindad uses waste paper as a raw material for cellulose for the Nitrocellulose (NC) production process as the main material that makes up propellants.

From the background explanation above, three main points were obtained on this propellant pilot plant innovation, namely: (1) The pilot plant acts as a bridge to master propellant technology in Indonesia while accelerating the development process of large-scale propellant manufacturing, (2) The development of a new propellant composition with better performance and safety level, (3) An environmentally friendly manufacturing process by utilizing paper waste as a raw material for propellant manufacturing. This makes the propellant pilot plant innovation a strategic and important innovation to be developed in Indonesia, especially PT. Pindad.

The propellant used to support the production of 5.56mm caliber ammunition PT. Pindad is a double-base propellant with the main composition of nitrocellulose (NC) and nitroglycerine (NG). NG is a very sensitive liquid explosive, so the handling process is dangerous, and the safety level of the propellant process is relatively low. To overcome this problem, a substitute agent, namely diethylene glycol dinitrate (DEGDN), is used. DEGDN has more stable properties and is relatively less sensitive than NG[4]–[11]. This improves the safety and ease of handling in the propellant manufacturing process. In addition, DEGDN also provides better propellant performance than NG when applied to munition thrust fills.

Environmentally friendly manufacturing processes are an important aspect of increasing PT's contribution. Pindad is a green industry. One of them is the innovation of the pilot plant propellant of PT. Pindad by using waste paper as raw materials for NC production. With high paper consumption in Indonesia, abundant paper waste will be produced. Based on one of the Journal of Environmental Technology studies, Jakarta is estimated to create 2,989 m3 of paper waste per day, or 10.11% of the total waste (29,568 m3 per day). One type of major newspaper in Indonesia is also estimated to produce 16 tons of paper waste per day. The data shows a high potential for using paper waste as a raw material for NC production.

Development of New Propellant Composition

Based on its application, the propellant can be used in small-caliber munitions (MKK), large-caliber munitions (MKB), pyrotechnic munitions, and rockets.[12]–[15]. For the initial stage of this innovation, the discussion will focus on MKK, especially PT Pindad's 5.56 mm caliber munitions. The propellant used in MKK, often referred to as gun propellant, is classified based on its main constituent composition, namely:

- Single base: main composition of nitrocellulose (NC)
- Double base: main composition of nitrocellulose (NC) and nitroglycerine (NG)
- Triple base: the main composition of nitrocellulose (NC), nitroglycerine (NG), and nitroguanidine (NiGu)
- Multi base: main composition of nitrocellulose (NC), nitroglycerine (NG), nitroguanidine (NiGu), and nitramine
  (RDX/HMX)

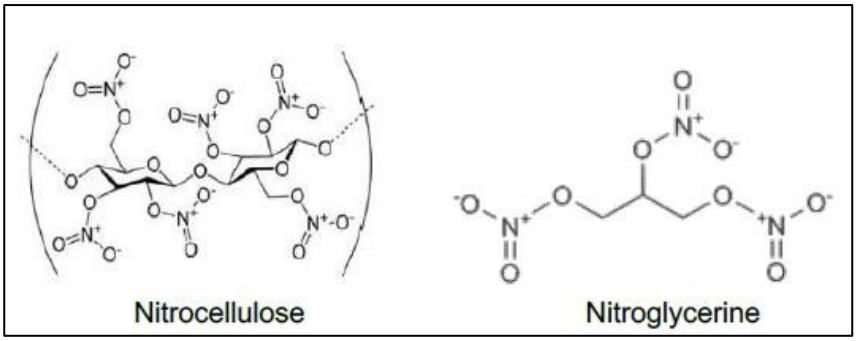

Figure 3. Stages of propellant industry development

The propellant is popular in Indonesia, TNI/POLRI munition products, and MKK production at PT Pindad. It is single-base and double-base fuel in the form of spherical propellant or ball powder. Propellant has a unique composition; each material contained in propellant has the following functions:

1. Nitrocellulose (NC) is a polymer fiber compound that provides mechanical strength to the propellant grain.
2. Nitroglycerine (NG) functions as an energetic plasticizer in propellants, which can increase energy content while providing plastic properties to grain propellants.
3. Additive materials include stabilizers, coolants, surface mode rants, deciphering agents, and reducing agents.

Research for the improvement of propellant constituent materials has always been interesting research. Using NG in propellant composition does not free the propellant from problems. NG, an explosive with very sensitive and explosive properties, often makes it difficult for propellant and munitions manufacturers to handle and manufacture. Based on the data on the number of occupational accidents in the explosives industry in Europe in Table 1, the highest number of occupational accidents occurred in industries involving the processing of Nitroglycerine (NG) compounds.

Table 1. Data on the number of explosives industry work accidents in Europe in 2018

Explosive	No of accidents
Black powder	60
Nitrocellulose	20
Nitroglycerine and other Nitric esters	156
Nitroglycerine-based Blasting Explosives	188
Ammonium Nitrate, AN/FO, Slurries, and Water Gels	18
Primary Explosives, Detonators	31
Pentaerythritol Tetranitrate	10
Trinitrotoluene	26
Safety and Detonating Fuse	6

With the characteristics of NG mentioned above, it is necessary to develop a propellant composition that uses safer explosives. In this innovation, PT. Pindad uses an energetic material, diethylene glycol dinitrate (DEGDN), with chemical and physical characteristics similar to NG. The advantage of DEGDN over NG is that the material is more stable than NG, so the handling and manufacturing process will be safer. In addition, ballistically, DEGDN also provides good performance when used as a substitute for NG in the composition of propellants.6 The following is a comparison table of some of the parameters of NG and DEGDN:

Table 2. Comparison of chemical characteristics and ballistic performance of NG and DEGDN

Parameter	Nitroglycerine (NG)	Diethylene Glycol Dinitrate (DEGDN)
Oxygen Balance	+3.5 %	-40.8 %
Detonation Velocity	7600 m/s	6600 m/s
Volume Gas (Explosion)	716 L/kg	991 L/kg
Heat of Explosion	6214 Kj/kg	4141 Kj/kg
Specific Energy	1045 kJ/kg	1178 kJ/kg

Friction Sensitivity	No Reaction >360N	No Reaction >360N
Impact Sensitivity: Limiting Impact Energy (LIE)	10.7 J	13.9J
Pressure (MPa)	283.1	286.0
Relative Pressure (%)	100	103.7
Initial Velocity (Vo)	890.4 m/s	898.3 m/s

In the composition of double base propellant, NG and DEGDN act as energetic plasticizers. Based on the comparison table above, it can be concluded that several things are:

1. DEGDN has a higher volume of combustion gas compared to NG. This will provide a better thrust for the munition.
2. DEGDN has a higher specific energy value than NG, thus providing better propellant performance.
3. Heat of Explosion indicates the heat produced when a compound burns. The comparison of values in Table 3 above shows that the DEGDN combustion temperature is lower when compared to NG. This will benefit the user (TNI/POLRI) by extending the weapon's life (barrel wear).
4. The study in terms of safety of propellant with NG content compared to DEGDN, namely NG has a lower limiting impact energy (LIE) value compared to DEGDN, this shows that propellant with NG content is more sensitive to impact than propellant with DEGDN content. This shows an increase in the safety of the propellant.
5. The ballistic performance test of the propellant with DEGDN content provides relatively higher Barrel Pressure and Initial Velocity values than the NG propellant. This shows that the ballistic performance of propellant with DEGDN content increases compared to propellant using NG.

From some of the points of analysis mentioned above, it can be concluded that DEGDN is a potentially energetic material that can be used as a substitute for NG in the propellant composition.

The Process of Making Nitrocellulose by Utilizing Paper Waste

In the chemical industry, Nitrocellulose has become a very important material and is widely used in various applications, including munitions, paints, inks, and explosives. However, the traditional process of making Nitrocellulose uses raw materials from wood or cotton, which has a significant environmental impact and sustainability of natural resources. To overcome this problem, innovations in making Nitrocellulose by utilizing paper waste have become the focus of research and development. Paper waste is an abundant resource and is usually considered waste. However, using the right technology, waste paper can be converted into valuable raw materials to produce Nitrocellulose. The process of making Nitrocellulose by utilizing paper waste involves several complex stages. First, paper waste must be processed and decomposed into fine fibers using a special processing method. Then, the fibers undergo a series of chemical reactions to replace some or all of the hydroxyl groups with nitrate groups, producing Nitrocellulose. The main benefit of making Nitrocellulose by utilizing paper waste is the reduction of dependence on limited natural resources, such as wood and cotton. By using paper waste as a raw material, efforts can be made to reduce pressure on forests and the natural environment. In addition, using paper waste can also reduce waste handling problems and help apply circular economy concepts.

Nitrocellulose or NC is a unique polymer material when viewed from its physical and chemical properties, so this material is widely used in various industrial fields, both civil and military. NC is in the low explosive category with a TNT equivalence value of 1.17, equivalent to a power index of 129.2%. The basic ingredient of NC is cellulose, which is widely found in plants and wood. Two cellulose sources often used for the NC manufacturing come from cotton fibers or wood pulp. The two materials have different cellulose characteristics, so the NC manufacturing process is also different. NC is obtained through the nitration process of cellulose compounds with nitric acid. This nitration process aims to add a nitro group (NO2) to the cellulose polymer chain to increase the nitrogen content (N%). This nitrogen content (N%) plays a role in the energy contained by NC, and for use in military applications, such as fuels, NC must have an N% value above 12.6%. Paper waste is one of the potential materials to be used in the NC manufacturing process. The paper has a main cellulose composition of up to 90%, sourced from wood pulp. In addition to cellulose, paper waste contains several other materials, such as ink, wax, and additives. Materials other than cellulose contained in this paper waste can block the nitration process on cellulose so that it affects the NC produced. Therefore, optimizing the paper waste nitration process to obtain NC with N% above 12.6% is necessary.

Manufacturing Process Making DEDGN as a Substitute for NG

In the munitions industry, Nitroglycerin (NG) has long been a commonly used explosive in the production of fuels. However, despite its high strength, NG also has highly sensitive and explosive properties, which causes challenges in terms of its safety and handling. Therefore, the development of safe and stable alternative explosives is important. One promising solution is Diethylene Glycol Dinitrate (DEDGN). DEDGN is an explosive that has more stable and safe properties than NG. The process of manufacturing DEDGN involves several complex steps, including the synthesis and purification of raw materials. These steps involve using specific chemicals and proper condition control to produce high-quality DEGGN. Creating DEDGN as a replacement for NG involves intensive research and development to ensure the desired quality, safety, and performance. In the process, high-quality raw materials must be selected and processed through a series of precise chemical reactions to produce a stable DEDGN and suitable thrust force. In addition, DEDGN purification is also an important stage in the manufacturing process. Purification aims to remove contaminants and impurities that can affect the quality and safety of DEDGN. Purification can be done through various methods, such as distillation and filtration, to ensure that the resulting DEDGN meets the established quality standards.[16]–[19].

Making DEDGN a replacement for NG is not only about producing safer explosives but also about optimizing the performance of munitions. The DEDGN can be tailored to specific needs, including desired thrust strength, stability, and performance consistency. This allows munition manufacturers to create more precise and effective propellants in weapon systems. In the research and development of DEDGN as a replacement for NG, PT Pindad is a leading defense company in Indonesia that actively participates. With its experience and technical capabilities, PT Pindad is committed to creating innovative and safe explosives to support the development of munitions independence in Indonesia. Advantages of DEGDN compared to NG as an energetic plasticizer propellant. DEGDN and NG are liquid ester nitrate compounds whose synthesis involves a nitration process to bind a nitro group (NO2) to an oxygen atom (O)[20]–[25]. The synthesis process of DEGDN and NG is very similar in principle. The difference lies in the basic materials used. If NG uses glycerin as a precursor compound, DEGDN uses diethylene glycol. In general, the process of DEGDN synthesis can be described as follows:

1. **Acid mixing process**
   At this stage, concentrated nitric acid is added to sulfuric acid with a ratio of 1:1. During the addition process, an exothermic reaction will occur so that the temperature must be controlled below 15°C. Then, stirring is carried out for 30 minutes.
2. **The diethylene glycol nitrification process**
   Diethylene glycol is dissolved in a dichloromethane solvent (DCM) at this stage. Then, it is slowly added to the nitric acid and sulfuric acid mixture. This process also takes place exothermically, where the reaction produces heat. To keep the product from being initiated to explode, the reactor must be conditioned at a temperature below 15°C. Once the addition process is complete, the reaction is left to stir for 1 hour.
3. **DEGDN purification process**
   After the nitration process, two solution layers will be obtained: the organic and water phases. The separation of DEGDN from the mixture is carried out through an extraction process that aims to separate the organic phase and the water phase. Furthermore, washing is carried out in the organic phase to remove the remaining acids by successfully adding distilled water, sodium carbonate solution, urea solution, and NaCl solution. This process is carried out 2-3 times and then continued with the evaporation process.

Pure synthetic DEGDN has a better level of safety than NG. But that doesn't mean the handling process is not dangerous. Trained personnel certified by PT Pindad must carry out the method of synthesis and storage of DEGDN. DEGDN storage is carried out in a special room that is maintained with humidity values.

Strategic Impact

Making Nitrocellulose using paper waste has a significant strategic impact in various aspects. First of all, from an environmental point of view, using waste paper as a raw material reduces the pressure on limited natural resources, such as wood and cotton. This contributes to forest conservation and reduces deforestation, which harms ecosystem sustainability. Paper waste can be converted into a valuable resource, reducing the amount of waste that goes into landfills and supporting the concept of a circular economy. Using waste paper as a raw material for producing Nitrocellulose opens new opportunities for creating sustainable and environmentally friendly business models. The chemical industry can be key in waste utilization and promote more environmentally responsible business practices. This can inspire other companies to adopt similar renewable resources and waste recycling approaches. An important strategic impact is in the context of national security. The production of Nitrocellulose using paper waste

strengthens the country's self-reliance in munitions stockpiles. By reducing dependence on raw material imports, the government can secure a critical supply of Nitrocellulose to meet national defense needs. This increases operational reliability and flexibility in emergencies or international trade policy changes.

Overall, making Nitrocellulose by utilizing paper waste has a significant strategic impact. From environmental aspects, chemical industry sustainability, and national security to economic impact, using paper waste as a raw material for Nitrocellulose production brings long-term benefits to the country. In the context of sustainable development, these innovations play an important role in creating a more environmentally friendly chemical industry and contributing to the country's independence and sustainability. The realization of this innovation program will improve and accelerate the development process and independence of propellant technology as part of defense technology in Indonesia. The development of defense technology independence has a strategic domino effect on the country's defense system and sovereignty. Mastery and autonomy in the field of defense technology will reduce dependence on meeting the needs of Defense and Security Equipment (Alpahankam). With reduced dependence, the sovereignty of the defense system will be more absolute.

One step closer to "environmentally friendly ammunition."

When we talk about innovation in the munitions industry, one of the aspects that is increasingly concerned is environmental sustainability. Amid global concern over climate change and environmental protection, the defense industry also seeks to adopt a more environmentally friendly approach to munitions production. In this context, "environmentally friendly ammunition" has emerged as a pursued goal. Environmental-friendly ammunition, or ecologically friendly munitions, refers to developing and producing munitions with a lower environmental impact. It covers various aspects, such as using renewable raw materials, reducing greenhouse gas emissions, better waste management, and reducing impacts on ecosystems and natural resources. PT Pindad has made significant progress in facing sustainability challenges at this stage. Innovations continue to emerge in using alternative raw materials, such as waste paper, and the development of more efficient and environmentally friendly fuels. In addition, efforts are also made to reduce environmental pollution produced during the production and use of munitions. In this case, the steps towards environmentally friendly ammunition have far-reaching strategic impacts. First, it strengthens the defense industry's commitment to contributing to global sustainability goals and maintaining harmony with the natural environment. Second, it improves the image and reputation of the munitions industry, strengthening public and stakeholder trust in environmentally responsible practices. Third, it creates new opportunities for developing technologies and research to meet sustainability needs. With the growing awareness of the importance of protecting the environment, steps towards environmentally friendly ammunition are increasingly relevant and important. With the adoption of this approach, the munitions industry is moving towards a more sustainable future, maintaining a balance between national defense needs and environmental protection and making a positive contribution to future generations.

Based on data from the International Trade Center (ITC), 2018, Indonesia is the 4th largest cotton importer in the world and imports 99% of its total cotton needs.24 Therefore, this propellant pilot plant innovation provides an alternative solution to this issue by utilizing paper waste as a source of cellulose for propellant base materials. This innovation will increase the value of the Domestic Content Level (TKDN) and as a concrete step in realizing environmentally friendly ammunition. Using paper waste as a raw material for making propellant is a breakthrough and innovation that will be applied in this pilot plant. This is done as an effort to realize the great ideals of PT. Pindad produces "environmentally friendly" products based on reduction, reuse, and recycling principles. In addition to the use of paper waste, the propellant pilot plant also carries out a process of recycling good raw and semi-finished materials such as ethyl acetate, dichloromethane, and nitrocellulose so that the use of chemicals is more efficient to minimize the impact on the environment. The pilot plant process line is also integrated with the waste treatment system to ensure no B3 material is wasted in the environment.

Conclusion

The manufacture of New Nitrocellulose-Diethylene Glycol Dinitrate (NC-DEGDN) propellant at PT Pindad is a significant strategic step in supporting the development of munitions independence in Indonesia. Through the development of this propellant, PT Pindad plays a role in strengthening the ability to produce munitions independently, which has an important impact in several aspects. First, developing propellant NC-DEGDN helps reduce dependence on propellant imports from other countries. By producing these propellants domestically, PT Pindad can ensure the availability of a stable supply and reduce the risk of changes in international trade policies. This contributes to the national security and

resilience of the defense industry in Indonesia. Second, developing this propellant improves the quality and performance of munitions produced in Indonesia. NC-DEGDN propellant offers high stability, adjustable explosive power, and consistent performance. Using this propellant, PT Pindad can produce more efficient, accurate, and reliable munitions, positively impacting national defense capabilities. Third, developing NC-DEGDN propellant strengthens technological capabilities and expertise in the national defense industry. The process of developing and producing propellants involves in-depth technical knowledge and expertise. PT Pindad, by involving research and development, has created innovations in the munitions industry and increased expertise in propellant synthesis, quality testing, and performance evaluation. Fourth, developing this propellant opens up opportunities for utilizing domestic resources and economic potential. By producing NC-DEGDN PROPELLANT, PT Pindad can reduce dependence on raw material imports, improve production efficiency, and generate new jobs. In addition, with superior quality and performance, this propellant also has the potential to be exported, increase the country's foreign exchange, and increase the contribution of the defense industry to the national economy.

Overall, manufacturing New Nitrocellulose-Diethylene Glycol Dinitrate (NC-DEGDN) propellant at PT Pindad is an important step in supporting the development of munitions independence in Indonesia. In terms of national security, munitions quality, performance, increased technical expertise, and economic potential, the development of this propellant provides significant benefits. Thus, PT Pindad has played an active role in strengthening the domestic munitions industry, improving the sustainability of national defense, and helping Indonesia move towards independence in the global defense industry. Development of the Propellant Pilot Plant with a new composition to improve propellant performance and safety during handling and manufacturing processes. Another creative idea applied to this innovation is using waste paper as a source of cellulose to manufacture nitrocellulose (NC) so that the production process is more environmentally friendly. Innovation in using fuel made from paper waste is the first step for Indonesia to master propellant technology. Propellant is one of seven strategic programs in the defense sector launched by the President and the Ministry of Defense of the Republic of Indonesia. Some of the long-term plans in the development of this innovation in the future are the need to develop propellants with various compositions for munitions of multiple calibers ranging from small-caliber munitions (MKK), large-caliber munitions (MKB), pyrotechnic munitions, and even for rocket applications. Further studies and optimization are needed to make single-base, double-base, triple-base and multi-base propellants. Further development of the propellant mixing process for the development of various grain shape propellants such as flake, tubular, single-perforated, and multi-perforated so that the application of this propellant pilot plant will be wider in multiple types of weapons and munitions. With the strategic program for the development of the Indonesian National Rocket Rhan-122B, in the future, there will also be an exploration of the manufacture of Double Base Propellant for Rockets. For a sustainable propellant production process, it is necessary to carry out collaborative innovations such as, it is necessary to explore cooperation with raw material suppliers for NC (cotton industry or paper industry) and, it is necessary to improve communication with PT Dahana for the application of making propellant ball powder in large-scale/manufacturing so that it can increase synergy between SOEs.

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