Modeling And Simulating The Design of Air Defense Missile Aerodynamic Systems

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Abstract. This paper is an academic study that discusses how to design air defense missile modeling and simulation, as a missile development strategy for the Indonesian National Army. Aerodynamic is the most important part of missile development, which regulates lift, drag, thrust and other parts that interact directly with air. The success of developing a rocket that has reached level 7 technology mastery readiness (Prototype Tested), can be a starting point to seriously initiate the development of Indonesian Missiles. The initial design process was based on the specifications of the 122 mm caliber defense rocket, the length of 2810 mm, the weight of the 60.8 kg rocket and the 15 kg warhead with an overall range of 30.5 km that would be adjusted to the initial configuration of the air defense missile. Aerodynamic testing will be carried out on Solid Work, Ansys and Missile Datcom software which will be compared with the results of each other. This development strategy can optimize the rocket products that have been successfully developed by Indonesia, because the sustainability of the rocket mastery will be very useful to be used as a basis for missile development, specifically in terminal air defense missiles, which is the weak point of Indonesia’s air defense today.

1. Introduction

As a large country, Indonesia also has the potential to be attacked by other countries. This is due to the vast area that must be protected by Indonesia with a total of 18,940 square kilometers and directly borders with 10 countries, namely Malaysia, India, Thailand, Singapore, Vietnam, the Philippines, the Republic of Palau, PNG, Australia and Timor [13].

Therefore, Indonesia must start from the beginning of all the preparations and efforts to protect the country's sovereignty. One way that, of course, must be prepared is about the independence of technology, in this case, Missile technology. Rocket is a vehicle that gets energy from the combustion process so that it gets thrust or thrust. In the last 10 years, Indonesia, which was pioneered by the National Rocket Consortium, has developed defense rockets. RX-1220 (Rhan 122B) is a rocket developed to replace the TNI GRAD RM 70 rocket that is no longer suitable to use.

In the development of rockets, of course, it cannot ignore the guidance problem, so that later defense rockets can be transformed into missile defense. Especially considering that we already have a lot of knowledge about rockets from the development of RHan-122B which has reached Technology Readiness Level 7 which has reached the stage Prototype Tested System (TRL). Whereas in Missile technology, it only arrived at TRL 2 where the concept formulation stage was taking place. Missile is a weapon delivered to the target through the flight process, but in its implementation, the Missile has a guide to reach its target. Missiles are very useful for destroying long-range targets according to the type of missile itself. To meet the requirements for flying on a guided missile, the Missile must have several requirements, including having an automatic guidance system.
Nevertheless, the aerodynamic system also has a very important role in optimizing the function of the missile itself. Therefore, it is important to do aerodynamics conceptual design in missile defense systems. The conceptual design itself is a process that discusses the stages required to design a system. In the study, the author will discuss the initial stages in the design of Missile aerodynamic systems which include fins, wings and other aerodynamic components, and conduct trials on relevant applications.

1.1 Identification of Problems
The missile system is a very complex system, where all systems integrate with each other to form a synergy to carry out the missile function as expected. One of the systems that play a very important role for the Missile is the aerodynamic system, this system is directly related in determining the maneuverability of the Missile such as the angle of attack, lift, drag, thrust, gravity weight due to interactions between the Missile and the air, both after launching from the system launcher, when in the trajectory, and when you want to cruise to the target.

If a missile does not have a mature aerodynamic design system, then, of course, the missile will not work optimally and will interfere with other systems, where other systems also depend on the aerodynamic system which is channeled through the components (wings) wing, tail, boattile, fins (canard) and other components that interact directly with air to maneuver. On the other hand, terminal air defense is one sector that needs attention. Therefore, the RHan-122B Rocket-based terminal air defense missile will be able to protect the sector. It also complies with the specifications and range of the 122B rocket defense.

2. Change the Rocket into A Missile
Rockets have developed rapidly at this time, rockets themselves are the result of research (search), research and development (research and development) that have been conducted by researchers for a long time. The development of the control rocket carried out by Indonesia, little by little has found a bright spot and gave quite encouraging results. Of course, this is supported by the development of science in applying technology that has been digested by Indonesia such as telemetry systems, navigation sensors, dynamic sensory sensors and actuator systems [2].

Rocket is a vehicle that has an energy conversion engine that can move according to the thrust generated by changing the chemical energy of fuel into heat energy [1]. The RX-1220 rocket is a missile developed by LAPAN which was acquired by the ministry of defense to become R-HAN 122, after being acquired, R-Han 122 became part of a national strategic program for the independence of the Indonesian Armed Forces in particular for Yon Rocket 2 / Mar which has the main task fostering capabilities and providing elements of terrain defense (Armed). The geographical display of the RHan-122B Rocket can be seen in Figure 1.

![Rocket Geometry](image.png)

**Figure 1.** Display of RHan-122 Rocket Geometry

2.1 Missile
A missile or missile is a vehicle that can be controlled or has an automatic control system to reach the target. There are 2 types of missiles, namely ballistic missiles, which are missiles that use trajectory trajectories and rely on gravity when approaching a target. In other words, this type of missile is
controlled only during the launch period or can be called a fire and forget missile. While other missiles are cruise missiles that use wings as propulsion that rely on aerodynamic systems and use jets as propulsion. Indonesia as the largest archipelago in the world should naturally have a superior air defense system.

Deploying air defense missiles in border areas and strategic locations will ultimately increase the country's defense capability from threats. On the other hand, the readiness of technology (Technology Readiness Level - TRL) in the Missile field in Indonesia is still very low. This is indicated by the fact that key technologies in the development of the Missile have not yet been touched. Key technologies in missile development include propulsion technology, guidance and control, and an integrated design process. But the success of the National Rocket Consortium consisting of Pindad, Lapan, Dahana, and PTDI in developing the RHan-122 rocket brought new optimism in missile development.

In the development of missiles, many countries have modified rockets into missiles, or modified missiles into different functions. This means that the same platform can use different functions, of course, with the addition of functions needed to modify the rocket into a Missile. Therefore, researchers are trying to realize the vision and mission of Indonesia in making Indonesia as one of the independent countries in the field of defense equipment specifically on rockets, this is also based on Indonesia's limited knowledge of missiles while on the other hand has successfully developed the RHan-122B rocket. This success must play a role in Indonesia's subsequent success in the development of 122 mm caliber defense missiles.

If you think further, it is not impossible to follow in the footsteps of other countries to develop rocket-based missile defense. The Rhan-122B rocket is a 122 mm caliber rocket aimed at destroying enemies in the 30km radius area, of course, this caliber can also be used as a missile with the same diameter to destroy enemy objects in the air with a 30km radius. This is also in line with some 122mm diameter missiles that have been developed in advance by other countries. Types of 122mm air defense missiles can be seen in Table 1. Of course in the figure, it can be seen that the use of 122mm missiles has been widely developed by other countries.

| No. | Name | Country | Specification                     |
|-----|------|---------|-----------------------------------|
| 1   | FZ275 LGR | Thales | Diameter: 70 mm                   |
| 2   | Hezbollah | Iran   | Weight: 10,3 kg Diameter: 72 mm  |
| 3   | Rafael | Israel | Weight: 90 kg Length: 3 m         |
| 4   | APKWS (Advance Precision Weapon System) - hydra | US | Diameter: 70mm Length: 1,3 meter Velocity: 793/detik Effective distance: 8 km |

2.2 Thinking Framework

The development of the defense rocket or R-han 122 which is affiliated with the RX1220 rocket has reached the point of success in the last test, this is a sign that the defense industry aided by the national rocket consortium is starting to have a bright spot in the completion of the rocket defense. Based on this the author's idea emerged to develop a rocket defense into a missile defense which is also one of the main priorities in the focus of the defense equipment defense besides the rocket itself. Surely it would be better if the defense rocket could be transformed into missile defense, so the authors would conduct a specific study on a guided missile aerodynamic system based on the 122B defense rocket. In making changes in a design concept it is necessary to pay attention to all the effects that will be received by the structure from the initial design so that the initial structure will be safe to use during its operation (Edlwan, 2017).
Therefore, of course, the change of RHan-122B Rocket into Missile needs to be done configuration and aerodynamic testing to make a missile structure that is reliable. The aerodynamic system itself is a complex system in the whole missile system, where the control of the missile will always interact with the air which is implicitly also part of the aerodynamic system. Therefore according to the author, it is necessary to hold a study of the transformation of 122 caliber defense rockets into 122 caliber defense missiles especially in the conceptual sector of defense missile aerodynamic design. Surely this will be an excellent work if a missile defense can be realized.

3. Research Methodology

In this study using the literature study method in which the data obtained is processed and then the problem formulation is carried out and linked to the needs of Indonesia for missiles and solving problems in the form of suggestions to become design literature that can be applied in the future.

A literature study is a research that is only based on written works, including research results that have been or have not been published [3]. Although it is research, research with a literature study does not have to go to the field and meet with respondents. The data needed in research can be obtained from library sources or documents. In library research, library research is not only for the initial steps of preparing a research framework but also utilizing library resources to obtain research data [15].

4. Determination of Aerodynamics

In determining the correct aerodynamics, the most important thing is to determine the desired configuration. In this case where the configuration of the missile defense will be by the 122 caliber defense rocket, which is the rocket that has been mastered by Indonesia technology. It aims to determine the places where components will be added to the rocket, to produce the functions of the Missile such as fins, canards, places for seekers, and appropriate for guidance and control.

After doing the configuration, the next thing is to produce an aerodynamic system that is right for the missile defense. After all, processes have been going well, the next missile will be tested. Testing itself has different types, namely testing tools using the wind tunnel and testing using simulations using the software. In this study, the authors recommend testing through software to save costs and efficiency.

The purpose of aerodynamics on rockets is to obtain a maximum configuration in an efficient external way. Of course, this cannot be separated from the phenomenon of the movement of airflow through the vehicle when sliding in the air. The forms of the airflow itself are influenced by several factors including the outer shape of the vehicle, the vehicle's flying speed, the density of the air mass. Surely the aerodynamic system on the rocket must be designed in such a way that it can stream the air efficiently, it will affect the rocket maneuvering motion. The rocket itself has a supersonic speed whose speed is above 1 mach speed, of course, this is different from the aerodynamic system on airplanes that only fly at speeds below 1 mach [1].

5. Software Instruments

A research instrument is a tool used to collect data or information that is useful to answer research problems. This tool must be selected according to the type of data desired in the study. The instrument functions as a tool at the time of research using a method. The instrument can also be defined as a tool that meets academic requirements so that it can be used as a tool to measure a measuring object or collect data about a variable. Research instruments are tools that are chosen & used by researchers in conducting their activities to collect data so that these activities become systematic and made easier by them [9].

5.1 Missile Datcom Software

Namely, Calculations using the Missile Datcom software are used to calculate the parameters of the RHAn-122B Rocket Aerodynamics where in the calculations, the Missile Datcom will calculate lift, drag, and aerodynamic moments, the Missile Datcom software will require geometric data from the RHAn-rocket Rockets 122B is used. The geometry variable needed as input to the Missile Datcom is the
definition of the RHan-122B Rocket coordinate geometry points on the horizontal, vertical axis along with the size of the circumference and radius of each of the defined coordinate points. Examples of test results can be seen in Figure 2.

| X (m) | Zupper (m) | Zlower (m) | S (m³) | R (m) | P (m) |
|-------|------------|------------|--------|-------|-------|
| 0     | 0          | 0          | 0      | 0     | 0     |
| 7.134146 | 1.5      | -1.5       | 7.068583 | 1.5   | 9.424778 |
| 12.52439 | 1.5      | -1.5       | 7.068583 | 1.5   | 9.424778 |
| 13.47591 | 1.3      | -1.3       | 5.309292 | 1.3   | 8.168141 |
| 19.65854 | 1.3      | -1.3       | 5.309292 | 1.3   | 8.168141 |
| 20.09706 | 1.6      | -1.6       | 8.042477 | 1.6   | 10.0531 |
| 32.5   | 1.6      | -1.6       | 8.042477 | 1.6   | 10.0531 |

**Figure 2.** Example of Test Results

5.2 ANSYS Software
ANSYS provides a comprehensive set of computational fluid dynamics software to model fluid flow and other related physical phenomena. It offers unmatched fluid flow analysis capabilities, providing all the tools needed to design and optimize new fluid equipment and to solve existing installation problems. The main ANSYS products in the liquid area are ANSYS Fluent and ANSYS CFX. With this solution, you can simulate various phenomena: aerodynamics, combustion, hydrodynamics, liquid / solid / gas mixture, particle dispersion, reaction flow, heat transfer, and more. Steady-State and Transient Flow phenomena are easily and quickly resolved. Graphical results from ANSYS CFX or ANSYS FLUENT CFD software simulations will show how fluid flow, particle flow, heat transfer, chemical reactions, combustion, and other parameters develop over time. Example results from ANSYS simulation can be seen in Figure 3.

**Figure 3.** Example of ANSYS Simulation Results

5.3 Solid Work Software
Solidworks is one of the CAD (Computer Aided Design) software published by Dassault Systemes. In 1995 Software Solid Work was officially introduced to the public following other software manufacturers that were first released to the market (Pro-ENGINEER, NX Siemens, I-Deas, Unigraphics, Autodesk Inventor, Autodesk AutoCAD and CATIA). Solid Work software is also widely used to design a tool such as bolts, frames and other tools. Of course, this can be used to create a configuration design of the RHan-122B Rocket as a form of implementation of the dimensional data that has been obtained.
The advantages of Solid Work can also be exported to other software such as ANSYS. This will certainly facilitate researchers in calculating the aerodynamic coefficient on RHan-122B-based air defense missiles later.

6. Conclusions

Literature study on how to determine the air defense missile aerodynamic system that refers to the defense rockets have been carried out with the strategy of achieving the chosen plan is to use software that is divided into 2 main parts, namely the initial configuration design using solid work software and the determination of aerodynamic systems using software missile datcom and ansys fluent which in the process will be compared in terms of results.

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