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Design of Bell 429 Helicopter for Range Performance

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Abstract— ***This paper is all about improving the range performance of Bell 429 Helicopters, which is really important for mission versatility and efficiency. We're looking for ways to make the Bell 429 more versatile and multi-role, so it can meet the needs of different missions. We'll be using a multi-disciplinary approach with materials science and structural analysis. We'll be looking at how to reduce weight without sacrificing safety or structural integrity, and how to use advanced materials to balance strength, weight and durability. We'll also be looking at how design changes affect the helicopter's fuel consumption, endurance and range. The goal is to get the Bell 429 to have a much better range performance. The results of this research will help shape the design of rotorcraft, giving manufacturers, operators and aviation stake holder's better capabilities in their planes.***

Keywords: bell 429 helicopter, range performance, mission versatility, efficiency, multi-role capability, Multi-disciplinary Approach, Materials Science, Structural Analysis, and Weight Reduction.

I. INTRODUCTION

A helicopter is an aircraft that utilizes rotating wings to generate lift, propulsion and control. Helicopters are characterized by their use of rotating wings or blades known as rotors for the generation of lift and thrust. Helicopters differ from fixed-wing aircraft in that they are able to take-off and land vertically, as well as remain stationary. Helicopters' ability to hover and maneuver in tight spaces makes them highly versatile and suitable for a wide range of applications [1].

By reducing the weight of Bell 429 helicopters, to increase their range performance. With a view to reducing the overall weight of the aircraft seat, in so far as it does not compromise security or structural integrity, determine and implement lighter materials and structural modifications.

Bell Helicopter and Korea Aerospace Industries have produced the Global Ranger 429[15], a light twin engine helicopter. On February 27, 2007 the prototype flight was carried out, and on 1 July 2009 it had been certified as a type. The Bell 429 is capable of single-pilot IFR and Runway Category A operations[2].

The Bell 429 helicopter has been modified to improve range performance. These modifications are based on the helicopter's take off gross weight, so they can be adjusted based on different take off gross weights. They can also be adjusted based on empty weight, Useful Load, Minimum Empty Weight, Max Useful Load, and Max Gross Weight. (Inc., 2020).

II. LITRETURE REVIEW

1. This paper provides an analytical framework for evaluating the cruise performance of conventional rotorcraft. It covers power requirements, endurance, and range for both turbine and battery-powered rotorcraft. The study introduces improved models for engine-specific fuel consumption and power contributions, resulting in more accurate and efficient methods for evaluating endurance and range in constant-speed cruise. This framework enhances our understanding of optimal cruise performance in rotorcraft design, providing valuable insights for future progress in rotorcraft technology [3]. (Giulio Avanzini, June 11, 2021).
2. The conceptual design of the Heimdall, a coaxial rotor helicopter designed for 24-hour hover missions, has demonstrated remarkable success in meeting the rigorous requirements of the American Helicopter Society's Student Design Competition. Not only does the design meet the stringent endurance and payload criteria, but it also emphasizes safety and reliability. By incorporating mature and feasible technology, this cost-effective design has a strong potential for mission success, demonstrating innovative thinking and problem-solving in helicopter design[4]. (Sourav Sinha, May 2017).
3. This thesis aims to create a methodology that can help helicopter developers make better decisions for their technology development activities based on both performance and economics. The methodology uses the following performance parameters to evaluate the basic price of the helicopter: gross weight deliverable module (DL) minimum viable product (FM) total basic price number of helicopters research and development investment cost addition to base price addition to investment cost number of helicopter It is possible to use these variables together to get the best cost efficient

technology development model [5]. (Kara, september 2014).

4. This study looks at how to design and size a helicopter using a Turkish civilian helicopter market case study. It uses QFD and an RF Sizing algorithm to figure out design parameters, evaluate configurations, and optimize helicopter sizing. This innovative approach shows promise for designing helicopters specifically for certain markets, like Turkey, using multidisciplinary and probabilistic design methods[6]. (Selvi, SEPTEMBER 2010).
5. This paper is designed to provide a conceptual approach to helicopter design for the purpose of an AE4306-Helicopter Design course. It is based on a closed-form formula and approximate data from historical sources. The purpose of this paper is to provide a straightforward design process for the capstone of a helicopter design course, as well as to demonstrate the ability to optimize and make decisions, both in engineering and managerial roles. Additionally, it serves as a framework for further research[7]. (Kee, 1983-06-01)

III. METHODOLOGY

A. Research
B. Bell 429 study
C. material selection
D. Calculation
E. Conclusion

There are Different ways to increase rang of bell 429 helicopter.

(1) Upgraded Engines
(2) Increased Fuel Capacity
(3) Weight Reduction strategy
(4) Efficient Avionics
(5) Enhanced Propellers or Rotors
(6) High-Altitude Operation

So, we have selected weight reduction strategy to decrease the inner structural seat weight of the bell 429 helicopter. To decrease the seat weight, we can reduce the to change the material of the weight and also decrease the weight of the material.

Material selection:

Seat material and its structural material selection based on some factors,

Weight: When it comes to aircraft seats, it's important to make sure they don't add too much weight to the helicopter. Too much weight can have a negative impact on fuel economy, performance, and the amount of cargo you can carry. That's why it's common to use lightweight materials like carbon fiber or high-tech lightweight alloys.

Fire Resistance: In order to comply with safety regulations, aircraft seats must possess fire-resistant properties. Materials such as Nomex are widely utilized in aviation due to their fire-repellent properties[8].

Durability: It is essential for helicopter seats to be able to withstand the effects of flight, such as vibrations and impacts. To ensure the seat remains in good condition, It is advised to utilize materials that are extremely robust, such as plastics, metals or composite materials.

Comfort: Helicopters are used for a variety of purposes, including transportation, medical evacuations, and other missions. When it comes to passenger comfort in a helicopter, there are a number of factors to consider, such as the type of padding, the material used for cushioning, and the ergonomic design of the helicopter.

Maintenance and Cleanliness: In order to maintain and maintain the cleanliness of helicopter seats, it is important to select materials and fabrics that are easy to clean. This will ensure that the seat remains in good condition and meets hygiene standards [9].

Regulations and Certification: Aviation safety and certification requirements for seat materials must be met by the relevant regulatory bodies, including the FAA in the US and EASA in Europe.

Cost: The selection of seat materials can also be affected by cost, as more sophisticated materials or bespoke designs can be costly. Operators must weigh safety and performance against financial considerations when making decisions[10].

Aesthetics: In certain circumstances, the appearance of the interior of a helicopter may be of interest, particularly for the purpose of VIP transport or corporate use. The selection of interior materials and finishes may be influenced by the desired aesthetic.

IV. CALCULATION

We take the assumption that weight of 1 person is 91 kg[11].

1 Passenger weight =91 kg.

- Bell 429 is 7 seater and 1 pilot capacity helicopter.
- No. of Passenger + pilot = 7+1 =91*8
  =728 kg
- Total weight of passengers and pilot is 728 kg.
- Assume luggage weight 16 kg per person
- Baggage weight = 16 kg

Total 8 person so total luggage weight will be
No. of Baggage = 8
=16*8
=128 kg

Total weight of passenger with pilot and their luggage
Total weight = passage wight + luggage weight
Total weight = 728+128
= 856 kg / 1887 lbs

Payload weight: The quantity of cargo, passengers, and baggage that can be stored on board and transported safely is referred to as the "payload". The term "payload" originates from the cargo that is paid to be transported [12].

Empty weight: The empty weight refers to the mass of airframe, engine, propeller, rotor, and stationary equipment.

- By changing seat material and its seat structure material we reduce the 56 kg of empty weight of helicopter.
- So, we reduce the minus the 56 kg from empty weight find the range for new empty weight after changing seat material.

Empty weight =2025 kg = 2025 – 56 =1969 kg

Payload = 1150 kg

Gross weight: The total weight of an aircraft is the sum of its payload and empty weight. It's also known as the "all-up weight" or "AUW". It's the total weight of the aircraft at any given time, whether it's flying or just on the ground. During a flight, the gross weight of the aircraft will go down because of the fuel and oil used [13].

- Gross weight = Payload weight + Empty weight
  =1150 + 1969
  =3119 kg
- Fuel tank capacity = 215 Us gallon + 40 Us gallon
  = 255 gallons
  = 814 lit + 151 lit
  = 965 lit

Fuel tank capacity: the ability of tank to store amount of fuel.

Fuel consumption: Engine designers strive to achieve a higher level of performance, reduced fuel consumption, reduced weight, and improved dependability by optimizing the engine's fuel consumption rate, which can be measured in terms of miles per gallon or liters per kilometers.

Specific fuel consumption (SFC): SFC (System Fuel Consumption) is the amount of fuel burned per unit time needed to generate a given engine power. It is a technical measurement that shows how effectively the engine uses fuel to generate power [16-22].

SFC

SFC = W fuel/ p*t

(There is typically 0.5 to 0.8 lbs./hp/hr. specific fuel consumption index for

For small helicopter turbines, an average of 0.5 is suitable.)

SFC = fuel/p*t
= 965/544* 3.27
= 0.542

T = W fuel / SFC *P
= 965 LIT/ 0.542* 544
= 3 .27 HOUR

Endurance: The endurance of an aircraft is the maximum amount of time it can remain in the air while flying with a single fuel load. Endurance is distinct from the distance flown, which is known as the range [14].

Endurance = Wfuel/S * 1/p
= 965/0.542 * 1/544
= 3.30 hour

Range = Time * forward speed
= V/P * Wfuel/S
= 241/544 * 965/0.542
= 712.177 km

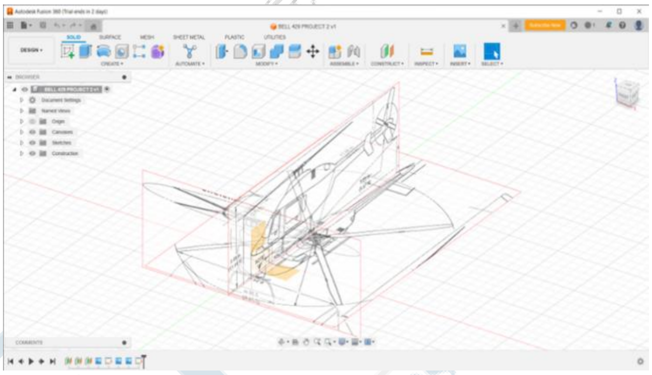
Fuel Consumption = 114.33 lit/km
= 1.1433 lit /km

V. DESIGN

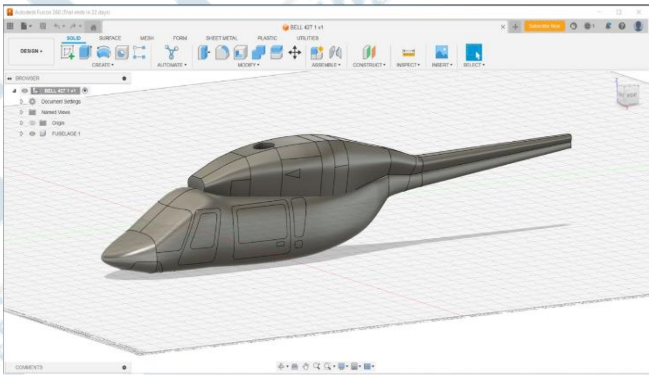
[1] First of all take a blue print with dimensions of three views and crop different view.

[2] INITIAL MODEL SETUP

Import different view with dimension in fusion 360 in desire axis.



- Design 2d model and then extrude to create 2d to 3d model.

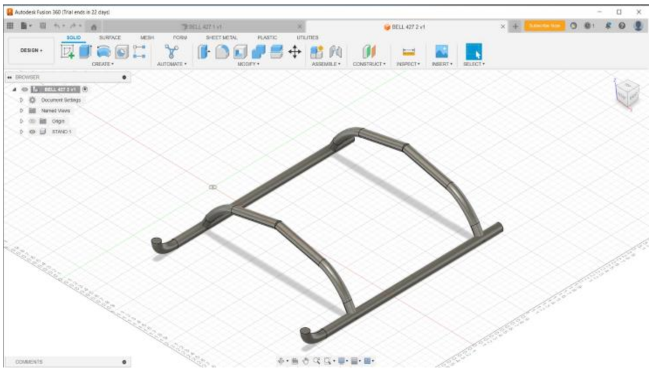


Helicopter Fuslage

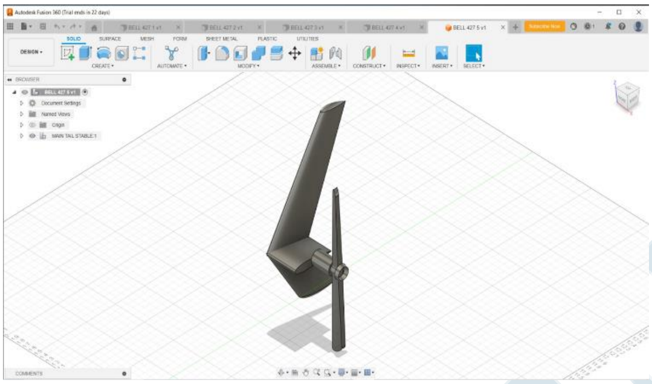
Design steps:

1. Choosing blueprint
2. Cropping the blueprint
3. Importing view
4. Sketching the top vie
5. Scatter the blueprint
6. Fuselage surfers 3d convert
7. Engine exhaust design
8. Edit form
9. Offset plane
10. Main rotor design and rotor blade design
11. Sketching airfoil
12. Drowning the boomerang
13. Blades 3d content
14. Back tail design
15. Creating a tail loft
16. Design skide

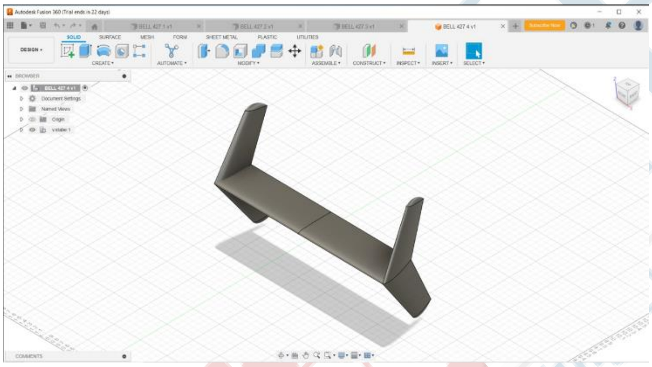
Engine exhuast



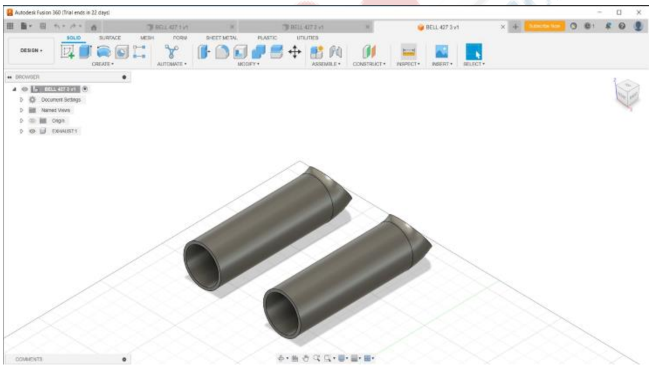
Helicopter landing skid design



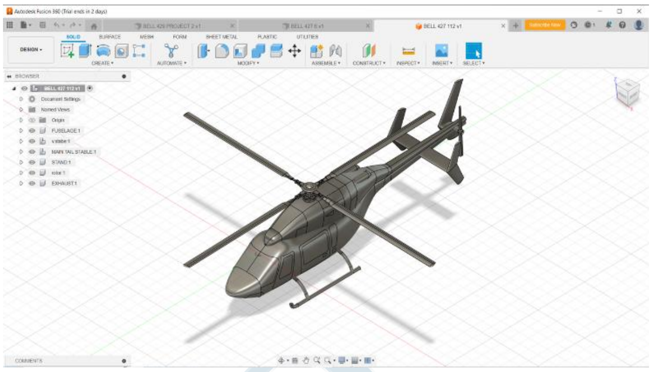
Helicopter tail rotor



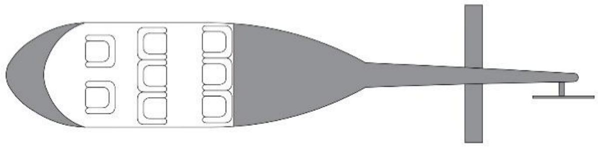
Horizontal stabilizer



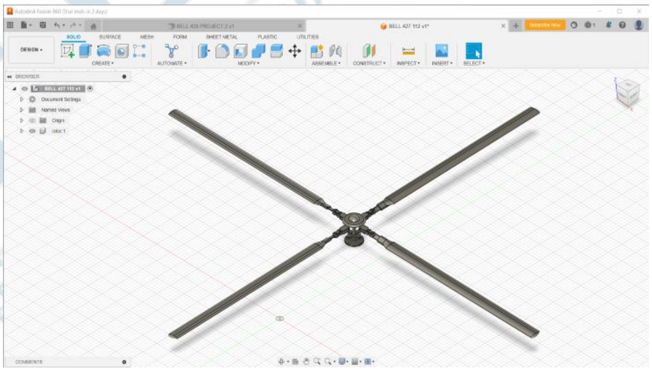
Helicopter main rotor



Complete helicopter



BELL 429 SEAT LAYOUT



VI. CONCLUSION

In conclusion, our team has successfully implemented the weight reduction technique to enhance the range performance of the Bell 429 helicopter. To achieve this, a comprehensive approach is necessary that includes progress in range performance. The integration of lightweight materials is a promising development for range improvement, however, safety considerations must be taken into account and materials and designs must be rigorously tested to guarantee that weight reduction efforts do not jeopardize structural integrity or safety. The use of lightweight materials for seats is a key factor in the overall reduction of the helicopter's weight, which is essential for improving fuel efficiency as the aircraft requires fewer forces to lift off and remain in flight. This lower weight translates into lower fuel consumption, resulting in an extended range. The utilization of lightweight materials increases the payload capacity of a helicopter, as seats account for a significant proportion of the interior weight. This increase in capacity can be used to transport additional passengers or cargo, thus increasing the operational range of the helicopter without compromising safety and performance. Additionally, the reduction of weight in the helicopter seat, which is turned, leads to an increase in fuel efficiency as the helicopter requires less energy to lift and maintain flight. The lighter the helicopter, the more agile it is and the better it navigates through different flight conditions, resulting in improved fuel efficiency. Material science and technology advancements are often associated with the adoption of lightweight materials, which often result in more aerodynamic and streamlined designs. These innovations, such as stronger and more resilient composite materials, not only help to reduce weight, but also improve the helicopter's structural integrity and overall safety. The use of lightweight seats helps to maintain a balanced and balanced weight distribution throughout the helicopter, which is essential for maintaining stability during flight and allowing the aircraft to remain responsive and manoeuvrable. This balance also has a positive effect on fuel efficiency and flight performance. Additionally, lightweight materials often offer ergonomic design benefits, which not only enhances the passenger experience, but also optimizes the use of space in the helicopter, allowing for more passengers to be accommodated without compromising comfort. The utilization of lightweight materials encourages innovative design options, such as the incorporation of high-tech materials and technologies which improve both weight reduction as well as structural integrity, thus contributing to a more aerodynamic and streamlined helicopter design.

VII. ACKNOWLEDGMENTS

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