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Composite Materials Used In Helicopter Fuselage And Ansys Analysis

Hasan Hüseyin Köse[1], Okan Gül*[2]

[1]Mechanical Engineering Department, Kocaeli University, Türkiye
[2]Mechanical Engineering Department, Kocaeli University, Türkiye

*(okan.gul@kocaeli.edu.tr)

Abstract **–** Composites are materials that obtained by bringing together two or more different materials in a certain ratio and appropriate circumstances to gain the desired purpose. Due to the high strength/density ratio, composites are widely used. Their low density contributes fuel economy savings in vehicles and advantageously to increase speed. Also because of their low density, military equipments such as armours, weapons can be carried with less effort. The applications of composites in defence industry are increasing. The composite materials which are used in military aircrafts such as planes, helicopters; armoured vehicles such as tanks and panzers; heavy trucks for using military transportation, bullet proof vest, weapon bodies are used more and more in different applications. In recent years, with developing technology, the role and application areas of composite materials in defence industry are increasing rapidly. The use of composite materials in helicopter fuselage, unmanned aerial vehicle, tank and aircraft armour, aircraft tail and wing components and landing field makes significant contributions to the development of the defence industry. In this study, we examined the composite materials used in the helicopter fuselage and made ANSYS analysis.

Keywords – Helicopter, Fuselage, Composite, Analysis, ANSYS

I. INTRODUCTION

Composite materials were developed by the Wright brothers in 1903. It has become an indispensable part of the aviation industry after their first successful flying experiment (Soutis, 2005). Starke and Staley (1996) stated that the strength/weight ratio (specific strength) was the most important criterion in material selection in the first aircraft, and therefore composite materials were used. However, changing needs over time have revealed that composite materials should have some additional properties. For example, in the 1990s, considering the aging aircraft fleets that had been in inventory for a long time, designers began to consider improved damage tolerance and corrosion resistance in composite materials (Starke and Staley, 1996). Some of the aircraft containing composite material worldwide are: F–14, F–15, F-16, F/A–18, AV–8B, Eurofighter (EFA), Advanced Jet Fighter (AJF), Joint Strike Fighter (JSF–F35).), F–117 Black Hawk, Beech Aircraft Starhip, Pacific Theater B29, APACHE, B–2 Bomber [1]. Materials used in aircraft fuselage is seen in Fig. 1.

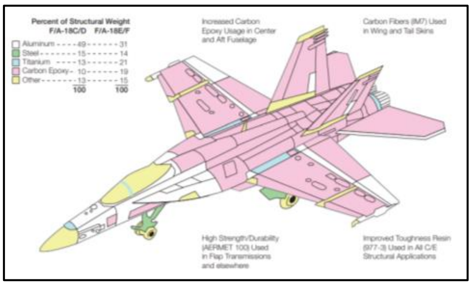

Fig. 1 Materials used in aircraft fuselage

In today's modern aircraft designs, as material fatigue has become a part of the design together with static and dynamic strength calculations, the life cycle planning of the aircraft has been extended up to 70 years. Today, multifunctional, nanocomponent composite materials are being developed to meet new design criteria. Composite materials forming, strength, corrosion strength etc.

design, improvement, renovation, maintenance/repair operation, maintenance etc. It makes it possible to use fewer parts at every stage. When the number of parts used is low or can be reduced, it provides a decrease in the amount and variety of spare parts required for maintenance/repair, operation and maintenance activities, and a significant decrease in the life cycle costs of the system or product. Today, aircraft manufacturers and maintenance/repair companies use composite materials not only to reduce the number of parts, but also to reduce costs. Although some metal alloys such as titanium have excellent corrosion resistance and a high specific strength ratio, they are more expensive than composite materials [1].

Composite applications in military helicopters started in the 1970s. It is aimed to reduce the weight of helicopters without sacrificing strength with composites, which are thought to be used as an alternative to aluminum alloys. In the process until today, we see that both material groups are used effectively, since the cost factor is at least as important as the performance. In the construction of the V22 Osprey army helicopter, 57% by weight of reinforced plastic material, primarily carbon, was used. Reinforced plastics will play an even bigger role in the next generation of tilt-rotor aircraft [1].

EH 101 Merlin is one of the first helicopters to use composite in its fuselage. Glass and carbon fiber reinforced plastic are used in the body of this model. This structure can withstand the stresses during normal flight and descent during attacks. Producing the same body from metal requires many additional and connecting elements. In addition, an equivalent composite structure is more robust and durable. Carbon-epoxy composite is used in the front of the fuselage of the NH 90 military transport helicopter. In this region, which can be described as complex in general, the joining and additions that would be necessary in the use of metal were no longer needed with the use of composites. Europe's latest military cargo plane, A400M, is manufactured using 30% plastic material [2].

It seems as though advanced composite materials are found on more and more aircraft each year. Helicopters in particular have seen remarkable growth in the number of components now manufactured using fiberglass, carbon, or aramid (Kevlar) fibers. But then, rotary-wing aircraft have always had a closer relationship to composite materials than their fixed-wing counterparts. In aerospace, we rarely consider a material's strength without regard for its weight. The primary advantage to composite structures is not that they are any stronger than similar metallic structures, but that they are lighter. Helicopter manufacturers have exploited this concept almost from the beginning out of necessity. While weight is an important consideration in fixed-wing design, it has always been paramount in the design of a helicopter largely due to the fact that early helicopter engines were notoriously underpowered [3].

Carbon fiber is an extremely versatile material. While it is generally higher modulus, or stiffer than fiberglass, it comes in a wide variety of strength and stiffness combinations making it suitable for many different applications. Because it is stiffer and lighter than fiberglass it is more likely to be used in the fuselage or tail boom of a helicopter, although its stiffness makes it an ideal candidate for the spar in a main rotor blade. In the latter case a helicopter manufacturer may elect to use graphite fiber. A graphite fiber starts its life as a carbon fiber, but goes on to be processed at considerably higher temperatures graphitizing the carbon. This additional processing allows structures to achieve higher strength-to-weight or stiffness-to-weight ratios than with carbon fiber. Lightness, strength, flight range and payload increase, long service life, corrosion resistance, maintenance possibility of repair and technical innovations to be implemented composite materials in terms of military and civil aircraft increasingly wing, fuselage, horizontal/vertical stabilizers, helicopter propellers and shafts and other have been widely used in departments. Optimum weight and bending in tail cone design features are requested. For this reason, the structure may be exposed to maximum loads are taken into account [4].

Kevlar is a fiber introduced by the DuPont company in 1972 and is known for its slogan five times stronger than steel of the same weight. Although Kevlar is resistant to burning, it does not melt or flow. This fiber also has advantages such as high modulus of elasticity, high tensile stress, resistance to chemicals, high thermal properties and dimensional stability. It is widely used in many applications today. Kevlar is a carbon-based polymer structurally similar to nylon. When nylons are in high concentration in solution, the flexible chain structure tangles too much. Due to this entanglement, medium-length fibers are formed when the solution is twisted, which adversely affects the fiber structure. In order for Kevlar fibers to be used in fabric applications such as body armor, they must first be spun into yarn and coated with plastic resin to increase the stiffness of the fibers. These coated fibers are then tightly knitted to obtain an effective fabric, and additional rigidity and strength are added by layering with plastic film. The layers are the source of impact strength because each layer absorbs some energy and spreads the impact force throughout the material. Thanks to all these features, Kevlar can be used in many daily applications such as shipbuilding, pressure vessels, sports products, work clothes requiring thermal resistance, fire blankets, high speed tires for vehicles such as motorcycles and airplanes, conveyor belts and hydraulic hoses, as well as bulletproof vests and helmets. It is also widely used in applications requiring vital protection such as vehicle protection and strategic equipment shielding [6].

Fibers are usually in the form of a woven cloth or fabric. A laminate is composed of multiple plies of a fabric and each ply can be oriented in any direction we choose. Since engineers are usually able to predict the type and magnitude of loads a part will be expected to handle, we can engineer strength only in the directions it is needed and eliminate it where it is unnecessary. The end result is a structure no heavier than it needs to be to perform a particular task. Fiberglass has a fairly high strength-to-weight ratio, good environmental resistance, and is quite flexible (low modulus). This particular set of properties makes it an excellent candidate for making main and tail rotor blades [3].

Epoxy is a type of two-part plastic resin. Fibreglass is glass fibres arranged in a mat, or woven into cloth. “Fibreglass” or “glass fibre” is often used as a shorthand for GRP (glass reinforced plastic), meaning a composite material made from plastic reinforced with glass fibres. With the use of both, carbon epoxy material is formed. This material lighter and stronger than fiberglass but more expensive. This material mostly used in rotor blades [5].

II. Materials and Method

ANSYS package program was used to examine the effect of composite materials used in the helicopter fuselage on durability. In this scenario, the helicopter crashes into the wall at 150 m/s. This wall is made of structural steel. And the helicopter body is made of aluminum alloy. Total deformation and stress analysis of the nose and cabinet, which is the first part that meets the force, was determined. In order to make comparisons, material selections were made as aluminum alloy and carbon fiber. The helicopter cabin and nose used in the analysis was designed in the solidworks program. For the static structural analysis, ANSYS workbench was used.

III. Results and Discussion

A. Helicopter Frame Ansys Analysis

ANSYS package program was used to examine the effect of composite materials used in the helicopter fuselage on durability. In this scenario, the helicopter crashes into the wall at 150 m/s. Helicopter fuselage and wall used in the crash scenario is seen in Fig. 2. This wall is made of structural steel. And the helicopter body is made of aluminum alloy.

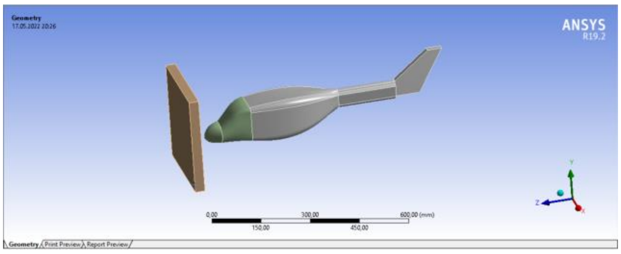

Fig. 2 Helicopter fuselage and wall used in the scenario

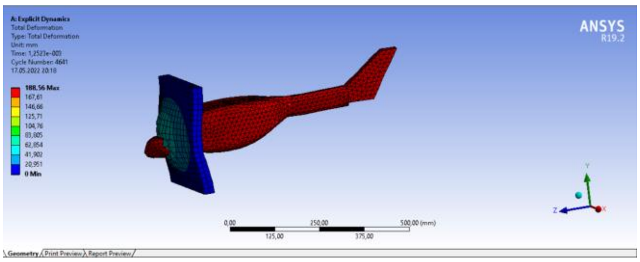

Fig. 3 Crash scenario

The crash scenario with explicit dynamic is shown in Fig 3. According to the results of explicit dynamic analysis, the maximum total deformation was determined as 188.56 mm. In this scenario, the cabin and nose of the helicopter are exposed to high stresses. For this reason, we can examine these parts more closely and see the effect of composite materials on durability more closely.

B. Nose Analysis

Total deformation and stress analysis of the nose, which is the first part that meets the force, was determined. In order to make comparisons, material selections were made as aluminum alloy and carbon fiber.

The total deformation after the load applied to the nose made of aluminum alloy is seen in the Fig. 4. The maximum total deformation was obtained as 0.0059689 mm.

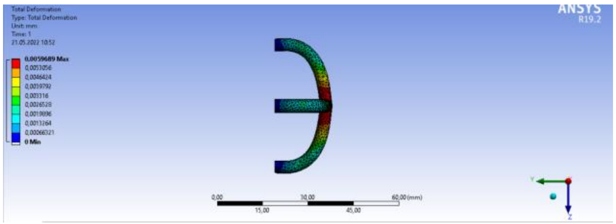

Fig. 4 Total deformation for aluminum alloy

The total equivalent stress after the load applied to the nose made of aluminum alloy is seen in the Fig. 5. The maximum total equivalent stress was obtained as 26.107 MPa.

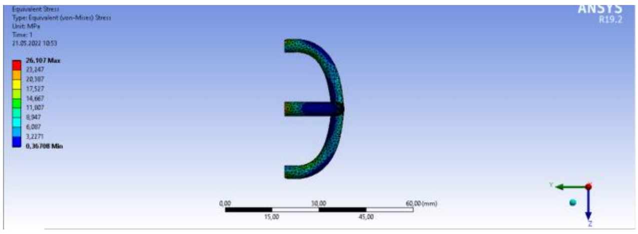

Fig. 5 Total equilavent stress for aluminum alloy

The total deformation after the load applied to the nose made of carbon fiber is seen in the Fig. 6. The maximum total deformation was obtained as 0.014986 mm.

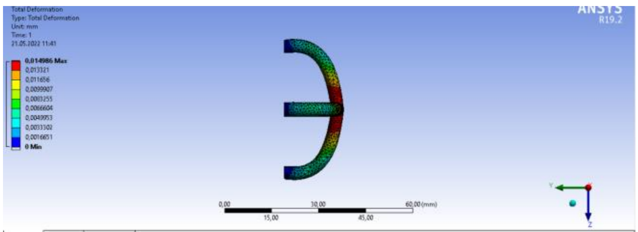

Fig. 6 Total deformation for carbon fiber

The total equivalent stress after the load applied to the nose made of carbon fiber is seen in the Fig. 7. The maximum total equivalent stress was obtained as 39.936 MPa.

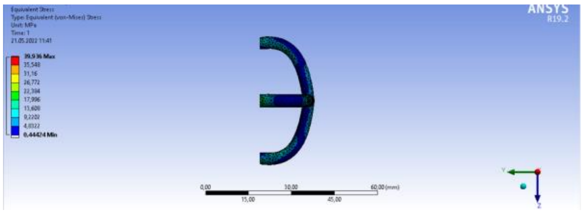

Fig. 7 Total equilavent stress for carbon fiber

C. Cabinet Analysis

The cabin is one of the most important parts of the helicopter. It protects the pilot with its cage structure around it and provides a healthy control of the helicopter. Reducing weight and increasing durability in this part will take the helicopter to an advanced level. For this reason, the use of composite materials in the cage structure is constantly increasing. The helicopter cabin used in the scenario was designed in the solidworks program is seen in Fig. 8.

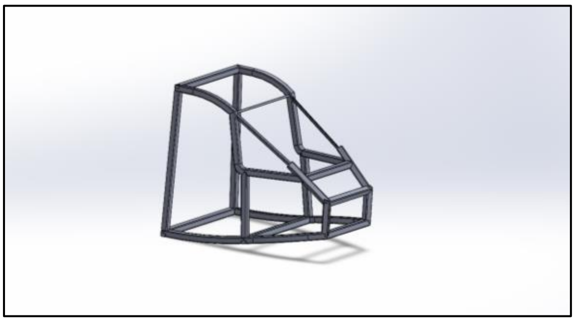

Fig. 8 The helicopter cabin used in the scenario

The cabinet after mesh is shown in the Fig. 9. This mesh consists of 88488 nodes and 45830 elements.

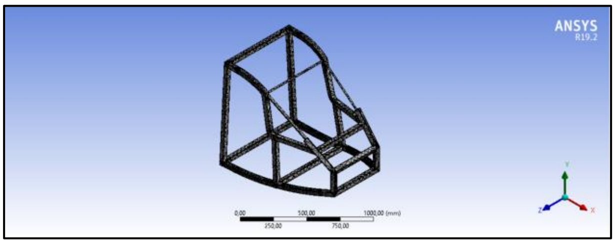

Fig. 9 Cabinet after mesh

Force applied surfaces for static structural analysis is seen in Fig. 10. The applied force was used as 500 N.

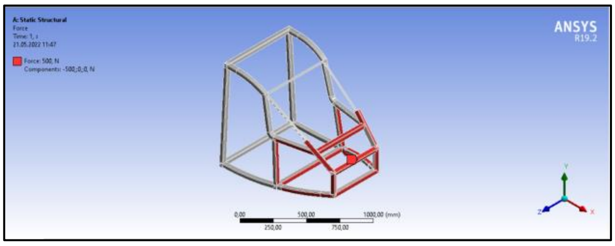

Fig. 10 Force applied surfaces

It is compared the results by working with the carbon fiber and aluminum alloy values given above. The total deformation after the load applied to the cabinet made of aluminum alloy is seen in the Fig. 11. The maximum total deformation was obtained as 0.048299 mm.

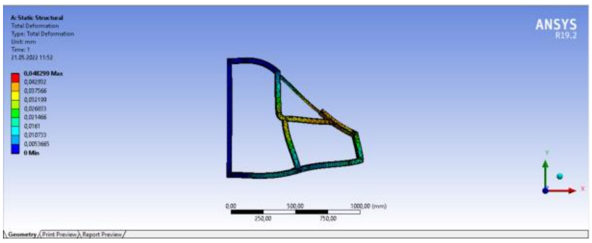

Fig. 11 Total deformation for aluminum alloy

The total equivalent stress after the load applied to the cabinet made of aluminum alloy is seen in the Fig. 12. The maximum total equivalent stress was obtained as 4.5109 MPa.

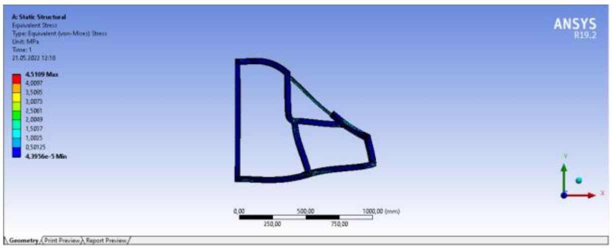

Fig. 12 Total equilavent stress for aluminum alloy

The total deformation after the load applied to the cabinet made of carbon fiber is seen in the Fig. 13. The maximum total deformation was obtained as 0.086394 mm.

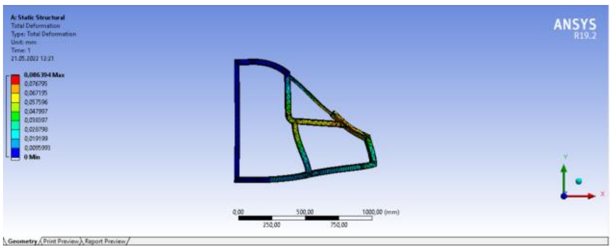

Fig. 13 Total deformation for carbon fiber

The total equivalent stress after the load applied to the cabinet made of carbon fiber is seen in the Fig. 14. The maximum total equivalent stress was obtained as 12.184 MPa.

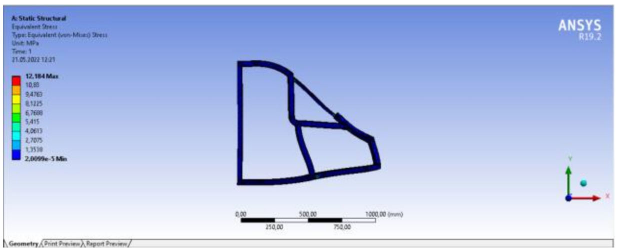

Fig. 14 Total equilavent stress for carbon fiber

IV. CONCLUSION

Composite materials are very important in aviation. As seen in the examinations, composite materials provide the same amount and more durability, although they are lighter. As composite technology develops, it is inevitable that its use in helicopters will increase. In the future, it can be said that most of the helicopter fuselages will be composed of composite materials. It is obvious that composite materials reduce weight, but the increase in durability needs to be supported by experiments by examining in more detail, and it would be correct to add it to helicopters by calculating the cost.

If the results are summarized;

- The maximum total deformation was obtained as 0.0059689 mm for aluminum alloy nose.
- The maximum total equivalent stress was obtained as 26.107 MPa for aluminum alloy nose.
- The maximum total deformation was obtained as 0.014986 mm for carbon fiber nose.
- The maximum total equivalent stress was obtained as 39.936 MPa for carbon fiber nose.
- The maximum total deformation was obtained as 0.048299 mm for aluminum alloy cabinet.
- The maximum total equivalent stress was obtained as 4.5109 MPa for aluminum alloy cabinet.
- The maximum total deformation was obtained as 0.086394 mm for carbon fiber cabinet.
- The maximum total equivalent stress was obtained as 12.184 MPa for carbon fiber cabinet.

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