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Static Analysis and Design of Fixed-Wing Tactical Unmanned Aerial Vehicle (TUAV) Retractable Main Landing Gear

Abdullah KOCAMER[1] Metin UZUN[1] Sezer ÇOBAN[1,*]

[1] Iskenderun Technical University, Faculty of Aeronautics and Astronautics, Hatay, Türkiye
*sezer.coban@iste.edu.tr (Corresponding Author/Sorumlu Yazar)

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ABSTRACT

In this study, it was aimed to design a composite landing gear that is resistant to landing loads and has maximum lightness in unmanned aerial vehicles. In this context, a landing gear design was carried out based on the loads that the aircraft's landing gear will be exposed to during landing and take-off, and a three-dimensional modeling was created. Numerical analyzes were made using the designed solid model finite element method. It has been observed that the obtained data can meet the loads on the aircraft landing gear in the specified configuration without any breakage. The findings at the end of the study were supported by graphics.

Sabit Kanatlı Taktik İnsansız Hava Aracı (TUAV) Katlanabilir Ana İniş Takımının Tasarımı ve Statik Analizi

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ÖZ

Bu çalışmada, insansız hava araçlarında iniş yüklerine dayanıklı ve maksimum hafifliğe sahip kompozit iniş takımı tasarlamak amaçlanmıştır. Bu kapsamda, iniş ve kalkış sırasında uçağın iniş takımlarının maruz kalacağı yüklerden yola çıkılarak iniş takımı tasarımı yapılmış ve üç boyutlu modelleme oluşturulmuştur. Tasarlanan katı model sonlu elemanlar yöntemi kullanılarak sayısal analizler yapılmıştır. Elde edilen verilerin belirtilen konfigürasyonda uçak iniş takımları üzerindeki yükleri herhangi bir kırılma olmaksızın karşılayabildiği gözlemlenmiştir. Çalışma sonunda elde edilen bulgular grafiklerle desteklenmiştir.

INTRODUCTION

In this study, information about the issues related to the design of the landing gear and the main landing gear attached to the fuselage, wing closing kinematics equations are given. Passive, active and semi-active control strategies are defined. Magnetorheological (MR) dampers are introduced. Working principles of MR dampers and various MR damper models are presented. An MR damper descent illustrated by the current-dependent Bouc–Wen model team model and a detailed study has been made about the scenarios related to it. All this A nose landing gear model with torsional degrees of freedom (shimmy) analyzes were made. Wong et.al in their study, presents an efficient methodology that applies high-fidelity multi-disciplinary design optimization techniques to commercial landing gear assemblies, for weight, cost, and structural performance by considering both structural and dynamic behaviours (de la Puente Cerezo et al., 2017, Wong et al., 2018 and Tugay, 2009).

In this thesis, the history of the landing gear and their development in the historical process are briefly mentioned. Afterwards, the requirements that will be needed to design the landing gear are specified and how the design process is carried out. Necessary information about its operation is given. General information about landing gear configurations later and a suitable two-seater high performance trainer aircraft from within these configurations determined. Sample roll-up compartments and roll-up mechanisms for retractable landing gear exemplified and appropriate ones determined. Dampers, one of the basic components of the landing gear In this study, in which information about the dampers is given, the necessary formulas for the dampers are also given. More Afterwards, the loading conditions that the landing gear will be exposed to are shown, and the front of the landing gear is determined according to these conditions sizing has been done. In line with EASA CS-23 requirements, the landing gear must be adjusted according to the landing type of the aircraft. The foundation loads to which it is subjected and the strength requirements for these different loading scenarios calculated and tabulated. Finally, according to the calculation results with the CATIA V5 package program, the descent A three-dimensional drawing of the gears has been made, this drawing is one of the EASA CS-23 landing gear loading scenarios. By determining the most critical one for the team and creating a structural static analysis model in Hyperworks software, Altair Critical loading situation was analyzed with Hyperworks Optistruct solver. Munjulury et.al in their study, landing gear weight is computed using analytical methods based on parametric 3D models. The procedure established by Kraus and Wille is applied as a baseline so as to create a procedure capable of dealing with landing gear weight calculations (Elmas, 2012, Yin et al., 2017, Zhou et al., 2017 and Munjulry, 2017).

CONSTRUCTION OF LANDING GEAR STRUTS

In modern airplanes used today, the landing gear has a retractable structure. In addition to carrying the aircraft during taxiing, the landing gear must also bear the impact loads on the aircraft during landing. Some landing gears distribute impact loads to the fuselage. Others absorb the shock and convert it into heat energy. Shock absorbers consist of polymeric metallic springs or piston cylindrical shock absorbers. The energy required to be absorbed by the landing gear on landing will be borne by both the strut and the tire. Both elements will compress under load and absorb their share of energy. Landing gear has many systems for performing missions (Kocamer & Oktay 2022).

STRUTS

The struts protect the main structure of the aircraft by absorbing the shocks and impacts that occur when the aircraft lands. The struts on the nose of the aircraft are called the nose struts, and the struts on the rear part are called the main struts. The side post and the drag post are parts of the main post. These keep the main strut in balance. The side post consists of two parts and is mounted to the main post with fasteners. The side strut is folded from the hinge as the landing gear is taken in. The drag strut keeps the main strut in balance. One point is connected to the main post, while the other point is connected to the connecting piece.

TACTICAL UNMANNED AERIAL VEHICLES (TUAVS)

Tactical Unmanned Aerial Vehicles (TUAV) mainly undertake surveillance duties as well as reconnaissance missions. Although all vehicles covering reconnaissance and surveillance missions and moving for tactical purposes at a certain range and for a certain period of time are considered as “Tactical UAVs (TIHA)”, in fact, these two essences there are some differences in the concepts of the designs made for the mission, but the aircraft with a ceiling altitude of 8,000 meters with a maximum take-off weight of 50 to 1500 kg, cruising between 4 and 12 hours for reconnaissance and surveillance, is the most accepted definition of TIHA at the moment. it is more suitable. The main reason why there is no definite definition at the moment is that there is no universally agreed classification for unmanned aerial vehicles, and a vehicle can carry the characteristics of more than one class according to today's classifications. If we open the subject a little more; a UAV originally designed for surveillance or The surveillance TIHA can transmit the data it obtains on the battlefield to the ground control station in real time. Generally, vehicles of this type have larger wingspan and rather a simple two-stroke or Wankel type piston engine (Coban & Oktay, 2017, Oktay & Coban, 2019 and Oktay & Coban, 2017).

FINITE ANALYSIS METHOD

The finite element method is an analysis method in which unit models are created by dividing the parts into a finite number of elements in order to analyze the behavior of the parts in long and complex problems, and the result is obtained by determining the boundary conditions under certain effects and analyzing from specific to general. In the structural static calculations made with the finite element method, as shown in Equation (1), {f} is the force vector acting on the body, [k] is the stiffness matrix of the body, {δ} is the displacement matrix of the unknown joints. When it is desired to find the total displacement of the whole system without point displacement, it is passed from the stiffness matrix of the body to the general stiffness matrix (Stenstrand, 2018).

$$\{f\}=[k]\cdot\{\delta\} \qquad \text{Equation (1)}$$

First, all the parts for which the solution is to be calculated are divided into simple geometric shapes known as finite elements. As input parameters in finite element analysis, the structure of the created mesh, the element type used in the mesh, the element size, the boundary conditions to be determined in the system and the technical properties of the material are entered. In order to reach the most accurate analysis, it is very important for the results to be entered by making precise selection of all parameters. In order to solve the problem, the geometric model was used to divide it into unit parts using the finite element method, and the "Mesh" application was used. When the results of the solution meshes are compared, the best result for the mesh was obtained with the "Automatic Method". Using the Sizing command in the mesh section, the size of the elements allocated to the unit element on the model is determined as 2 mm. On the other hand, "Face Sizing" is applied to all gear surfaces and element sizes are selected as 1 mm. In solution networks, the quality is determined in the range of “0-1” for each element. The overall average quality of the solution network is read with "Avarage Mesh Metrics". In this direction, while 1 represents the highest quality, the quality of the element decreases as it approaches 0. In addition, the average Skewness and Orthagonal values are also important parameters for the mesh quality. For these values, the average skewness value of is between 0 and 0.50, and the average orthagonal value is between 1 and 0.70, which indicates a quality mesh structure. The orthogonal quality is 0.78. When the average skewness value is examined, it is 0.27 (Caires, 2006, Jambor, 2016, DIN EN, 2007, Konez, 2019 and Strzelecki & Sempruch, 2016). The total number of mesh elements in the landing gear design is 2550000.

DESIGN OF RETRACTABLE MAIN LANDING GEAR AND SOLID MODEL DRAWING

The technical drawing of the main landing gear strut is shown in Figure 1.

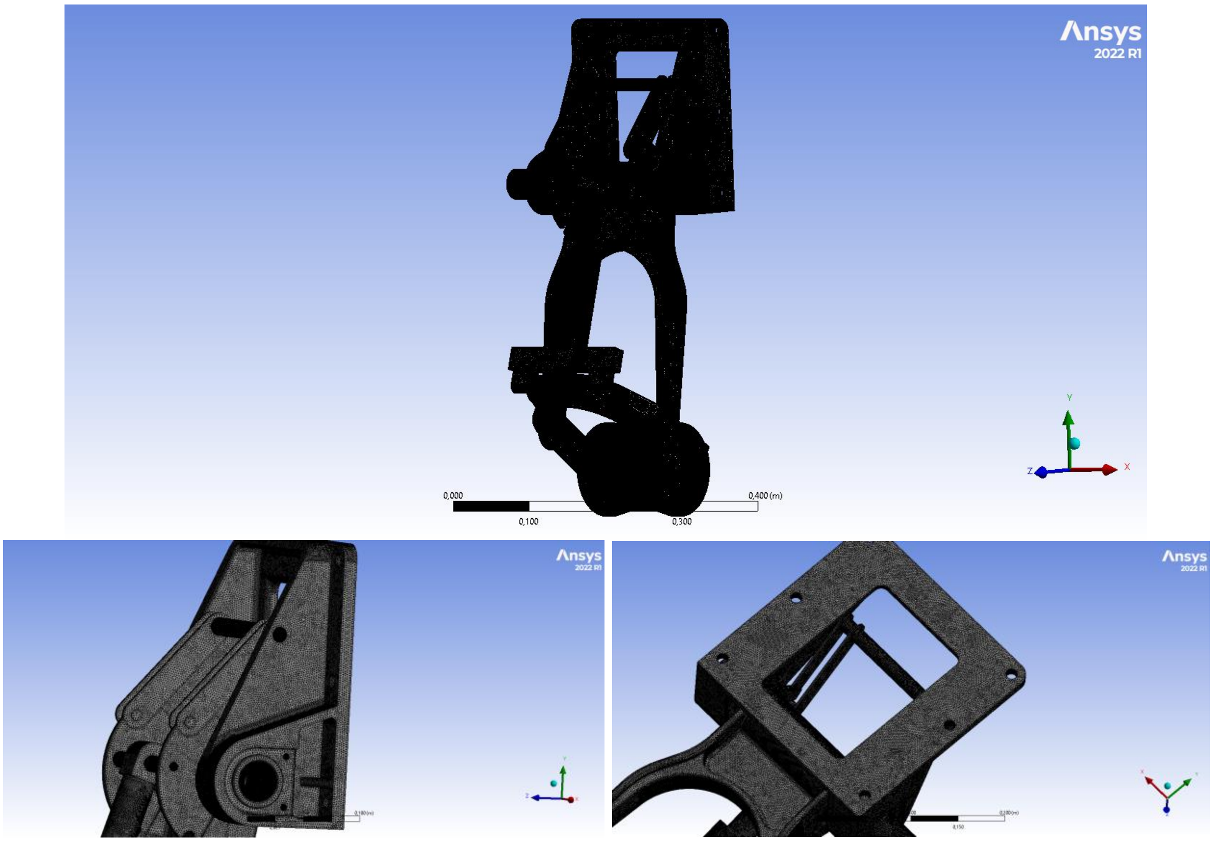

Figure 1. Technical drawing of main landing gear

STATIC ANALYSIS RESULTS

Stress can be defined as the amount of load per unit surface. If the stress vector acts perpendicular to the cross-sectional surface, this stress is called normal stress, and if the stress is in the cross-section plane, the resulting stress is called shear stress. Figure 2 shows the total stresses resulting from a load of 2000 Newtons applied to the landing gear from the y-axis of the wheel shaft.

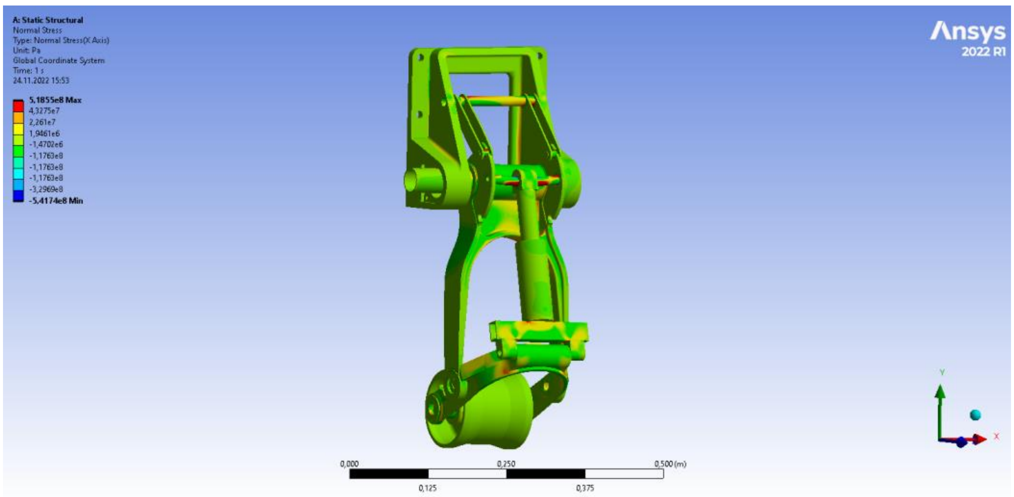

Figure 2. Total Stress Analysis

It is called the theoretically calculated stress that is assumed to have the effect of stresses occurring in many different directions on a member by itself. It is found by breaking hypotheses. Equivalent stress must always be less than or equal to the safety stress. Equivalent (von-Mises) stress stress analysis results are given in Figure 3.

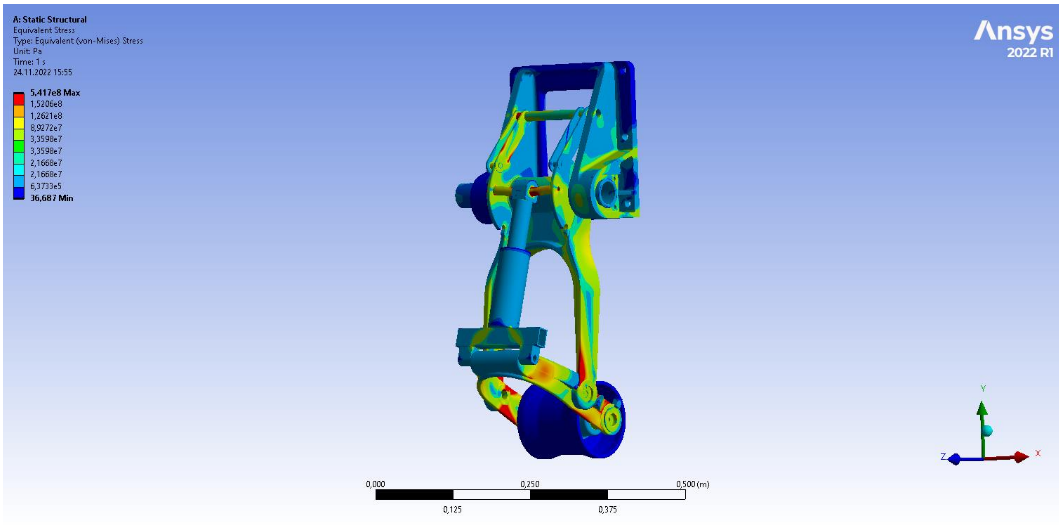

Figure 3. Equivalent (Von-Mises) Stress Analysis

Normal elastic strain analysis results are shown in Figure 4.

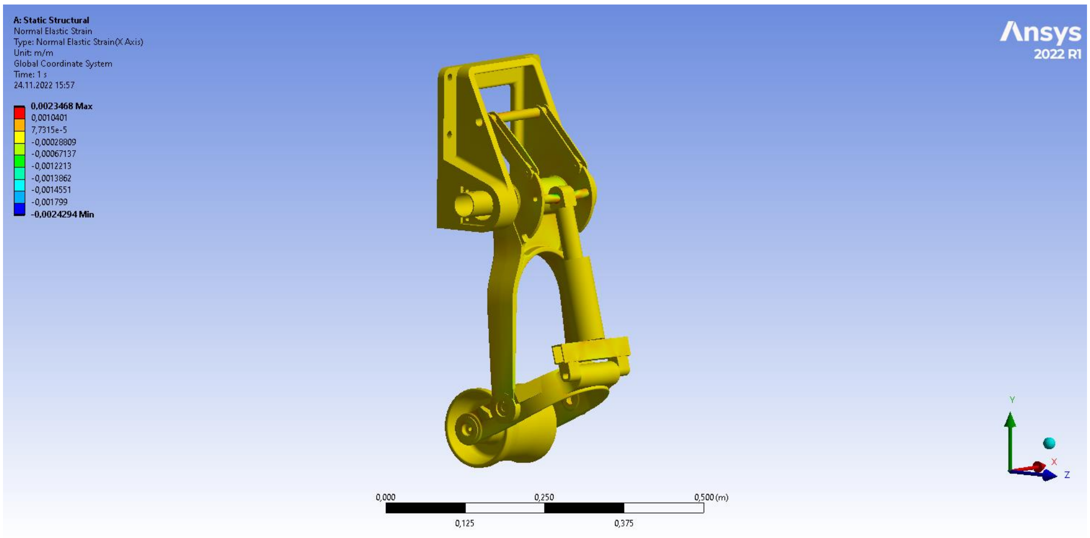

Figure 4. Normal elastic strain analysis

Shear stress is a stress that occurs due to the forces or force vectors applied to the surface of the object, as well as due to the torsion (torque) process. If you apply a force to a cylindrical material from both ends and in opposite directions, that is, if you turn it in opposite directions from both ends, shear stress will occur as a result of torsion and torsion. Shear force, shear force or tangential force; shear stress, on the other hand, can be encountered in the form of various expressions such as shear stress or tangential stress. When a shear force is applied to an element, it causes the two opposite surfaces of the object to slide parallel and opposite to each other; An angular deformation is observed in the element. Shear stress analysis results are shown in figure 5.

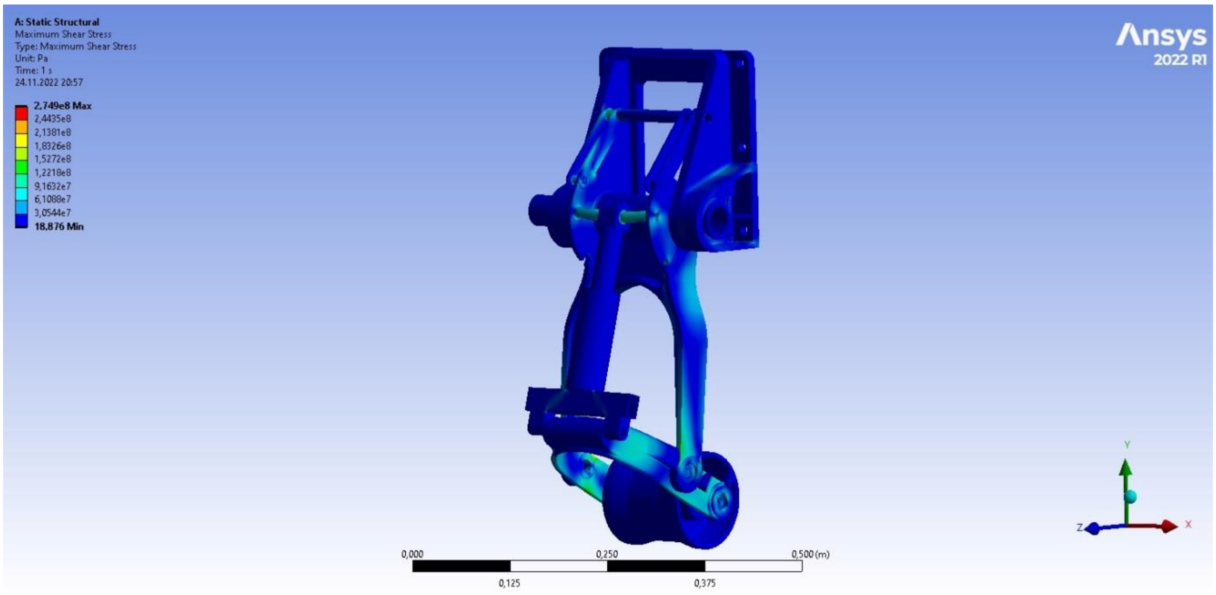

Figure 5. Maximum shear stress

Maximum principle stress analysis results are shown in Figure 5.

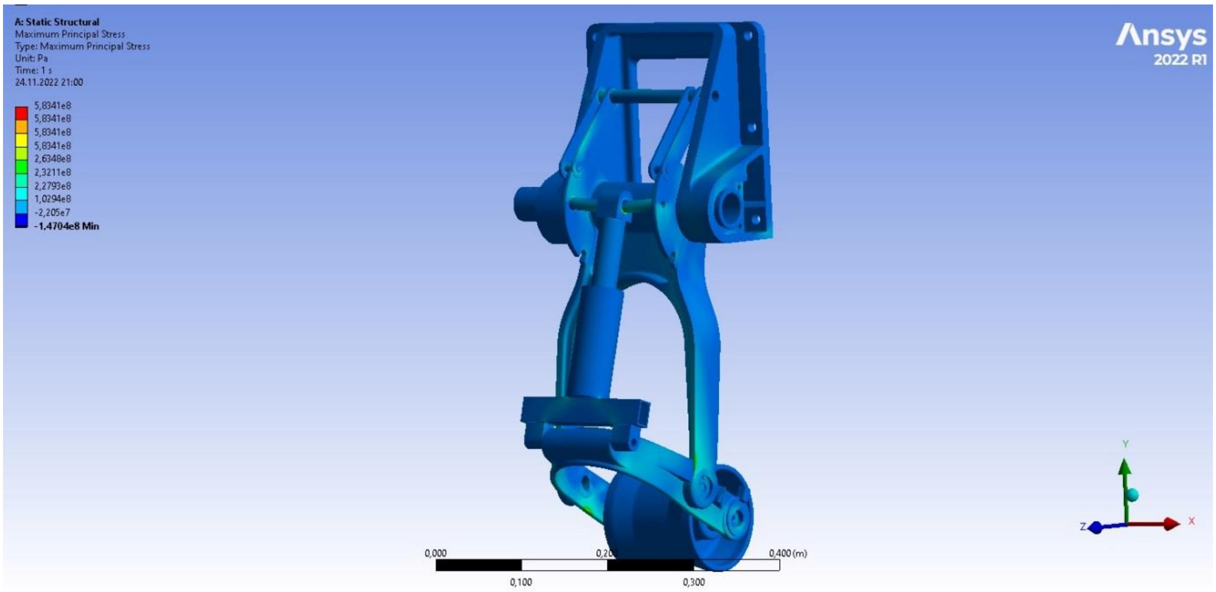

Figure 6. Maximum principle stress analysis

CONCLUSION

In this study, collapsible main landing gear design and static analyzes were made for tactical unmanned aerial vehicle. The designed landing gear belongs to a 200 kg tactical unmanned aerial vehicle. Therefore, a force of 2000 N was applied to the foldable main landing gear we designed in the y-axis direction. As seen in the numerical analysis results, it is seen that the stress on the landing gear is high at some points. However, these values seem to be of reasonable size when compared to other landing gear.

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