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Satellite carrier structure analysis and aerodynamic properties for low altitude distribution system

Alçak irtifa dağıtım sistemi için uydu taşıyıcı yapısı analizi ve aerodinamik özellikleri

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Satellite Carrier Structure Analysis and Aerodynamic Properties for Low Altitude Distribution System

Highlights

- *Aerodynamics*
- *Rocket study*
- *CFD*
- *HAD*

Graphical Abstract

This study investigates analysis of low altitude satellite carrier system structure and aerodynamic characteristic properties to find the optimum parameters of low altitude delivery system. Computational Fluid Dynamics (CFD) tools are used to solve the governing equations of the system and to illustrate the airflow around the carrier system.

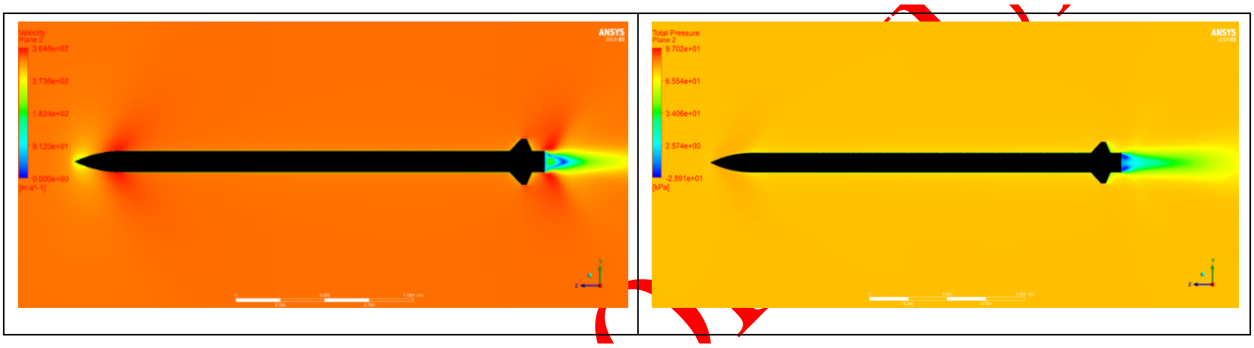

Figure. Difference for match 1 with optimum drag coefficient enhancement

Aim

Calculating the optimum parameters of low altitude delivery system

Design & Methodology

Computational Fluid Dynamics (CFD) tools are used to solve the governing equations of the system and to illustrate the airflow around the carrier system.

Originality

Obtaining the drag force and the drag coefficient in the velocity range of 0.6 and 4

Findings

The drag coefficient of the carrier system is 0.342 at M = 0.6 and 7.65 at M = 4 as maximum and minimum value

Conclusion

Satellite carrier system actual flight trajectory is widely and qualitatively agreement with the similar experimental and numerical studies in the literature.

Declaration of Ethical Standards

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

The Fuzzy Logic Modeling of Solar Air Heater Having Conical Springs Attached on the Absorber Plate

(Bu çalışma ECRES 2020 konferansında sunulmuştur. / This study was presented at ECRES 2020 conference.)

Araştırma Makalesi / Research Article

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ABSTRACT

This study investigates analysis of low altitude satellite carrier system structure and aerodynamic characteristic properties to find the optimum parameters of low altitude delivery system. Computational Fluid Dynamics (CFD) tools are used to solve the governing equations of the system and to illustrate the airflow around the carrier system. Computer Aided Design (CAD) structure of the satellite carrier system is generated using Space-Claim and exported to ANSYS solver. Commercial CFD software, ANSYS Fluent code is used to compute airflow velocities, pressure, the drag force and the drag coefficient and reported. In this study, the main goal is to obtain the drag force and the drag coefficient in the velocity range of 0.6 and 4 Mach number. The drag coefficient of the carrier system is 0.342 at M = 0.6 and 7.65 at M = 4 as maximum and minimum value. The satellite carrier system drag coefficient varies in the range of 0.342- 7.65 for different Mach numbers. Also aerodynamic analysis of the system velocity and pressure contours are investigated and reported in different conditions.

Keywords: Satellite carrier, aerodynamics, drag force, drag coefficient, rocket-target.

Yutucu Plaka Üzerine Konik Yayların Yerleştirildiği Güneş Enerjili Hava Kollektörünün Bulanık Mantık ile Modellenmesi

ÖZ

Bu çalışma, alçak irtifa dağıtım sisteminin optimum parametrelerini bulmak için alçak irtifa uydu taşıyıcı sistemi yapısının ve aerodinamik karakteristik özelliklerinin analizini araştırmaktadır. Hesaplamalı Akışkanlar Dinamiği (CFD) araçları, sistemin yönetim denklemlerini çözmek ve taşıyıcı sistem etrafındaki hava akışını göstermek için kullanılır. Uydu taşıyıcı sistemin Bilgisayar Destekli Tasarım (CAD) yapısı Space-Claim kullanılarak oluşturulur ve ANSYS çözücüsüne aktarılır. Ticari CFD yazılımı, ANSYS Fluent kodu hava akış hızlarını, basıncı, sürükleme kuvvetini ve sürükleme katsayısını hesaplamak için kullanılır ve raporlanır. Bu çalışmada temel amaç, 0.6 ve 4 Mach sayısının hız aralığında sürükleme kuvveti ve sürükleme katsayısını elde etmektir. Taşıyıcı sistemin sürükleme katsayısı maksimum ve minimum değer olarak M = 0.6'da 0.342 ve M = 4'te 7.65'tir. Uydu taşıyıcı sistem sürükleme katsayısı, farklı Mach sayıları için 0.342-7.65 aralığında değişmektedir. Ayrıca sistem hızının ve basınç konturlarının aerodinamik analizi farklı koşullarda incelenmiş ve tartışılmıştır.

Anahtar Kelimeler: Uydu taşıyıcısı, aerodinamik, sürükleme kuvveti, sürükleme katsayısı, roket-hedef.

1. INTRODUCTION

The Satellite carrier model characteristics and design parameters as well as the exterior fluid structures are analyzed and investigated using CFD code. Generally these engineering designs are estimated at different carrier's velocities in literature. The current model was inspired by the demand to develop a carrier for the low altitude satellite system which is about 4 meters in length and 0.3 meters in diameter. The satellite carrier's maximum velocity is intended to be less than desired value. According to literature one of optimal nose cones for this carrier situation is parabolic one [1, 2]. As known, fluid structure around the satellite carrier system and aerodynamics design characteristics such as velocity, airflow, pressure, lift and drag force and others have a big impact on the exterior lunch design of the satellite carrier system. The lift-drag force and the lift-drag coefficient are the main important design parameters for the satellite carrier system. Because necessary thrust properties of the system are directly related to exterior design parameters. CFD tools are widely preferred to investigate the equipment structures as the conceptual and preliminary design steps to decrease the production time and the costs in aeronautical applications before the experimental studies and production [3-5]. This study is related with the aerodynamic analysis of the satellite carrier system to be produced and the first aim is to obtain the drag and lift forces and the drag and lift coefficients in different velocity range of 0.6-4 Mach number.

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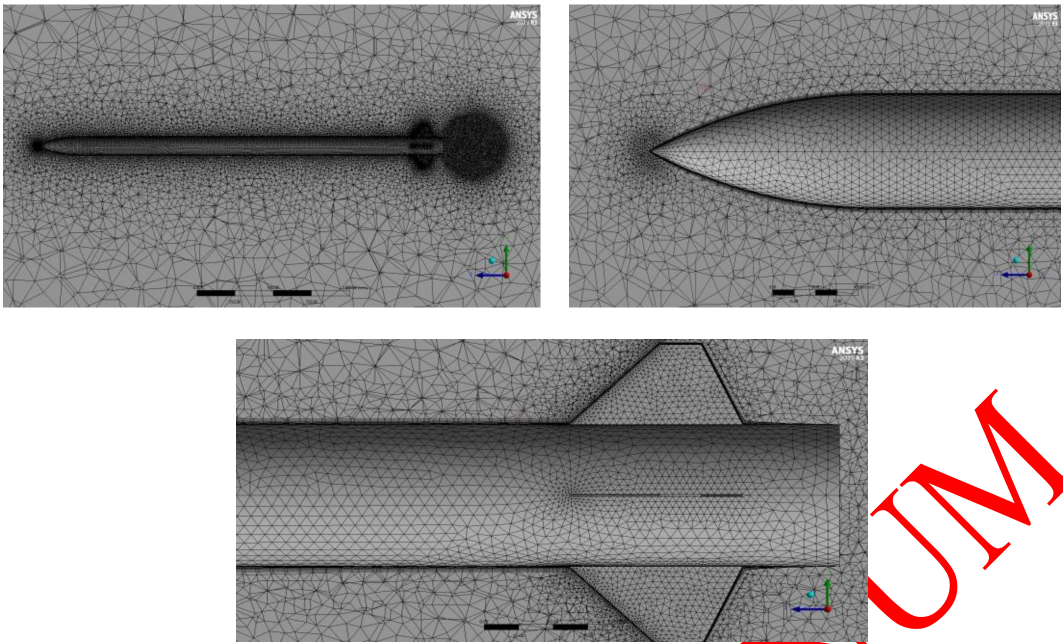

Figure 1. Mesh display of the satellite carrier

In different studies, Reynolds stresses and the shear stress transport (SST) turbulence model were modelled and studied around the wing of aircraft [6-9]. In this study, different conditions for the low altitude satellite carrier system were simulated and structure and aerodynamic characteristics of the system were analysed.

2. CFD CASES FOR THE SATELLITE CARRIER SYSTEM

In Figure 1 computational mesh structure is given around the system generated in ANSYS 2020 mesh module [10]. The velocity contours for different Mach numbers, around the carrier system with nose and cones and around a carrier frame without a nozzle cone were given in Figure 2. The carrier diameter is 0.3 m. and the length of this system without nose is 4 m. The satellite carrier system length with the nose totally is 4.2 m and the nose diameter in the medium is 0.15 m.

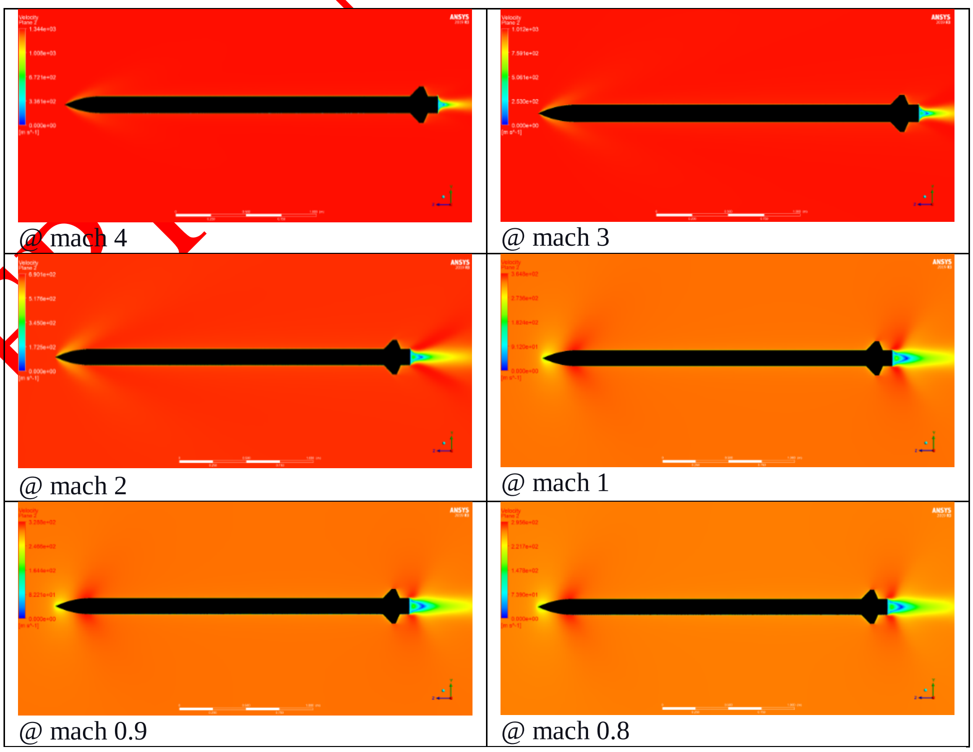

Figure 2. a Velocity contours in different mach numbers

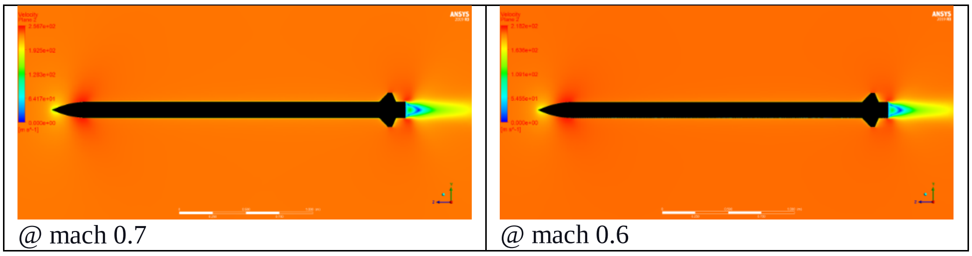

Figure 2. b Velocity contours in different mach numbers

Frontal area and drag coefficient calculations:

$$Frontal\ area\ (A) = 4 * 0.2 * 6.8 + \pi * \frac{6.8^2}{4}$$
$$= 120.44\ cm^2 = 0.01204\ m^2$$

$$Drag\ coefficient\ (Cd) = \frac{Drag\ force(Fd)}{0.5 * \rho * V^2 * A}$$

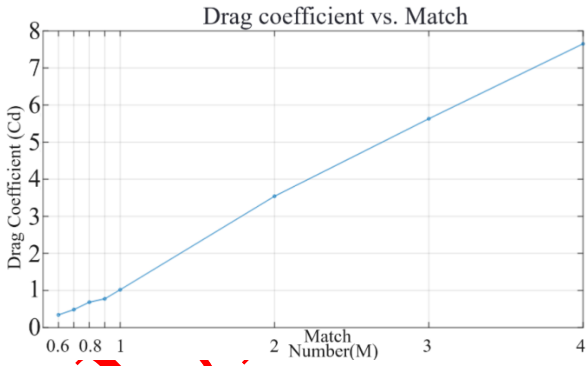

Figure 3. Drag coefficient versus Mach number

Table 1. Drag coefficients at different mach numbers.

Mach numbers	Drag coefficients
0.6 mach	0.342
0.7 mach	0.484
0.8 mach	0.685
0.9 mach	0.775
1 mach	1.02
2 mach	3.54
3 mach	5.63
4 mach	7.65

In Figure 3 and Table 1 drag coefficient calculations were given. According to literature drag and lift coefficients and also drag and lift forces are widely agreement with similar studies [6-7]. Also, in Figure 4 total pressure contours were given at different mach number. Different studies also used the same methodology to get the optimum design parameters [11-21].

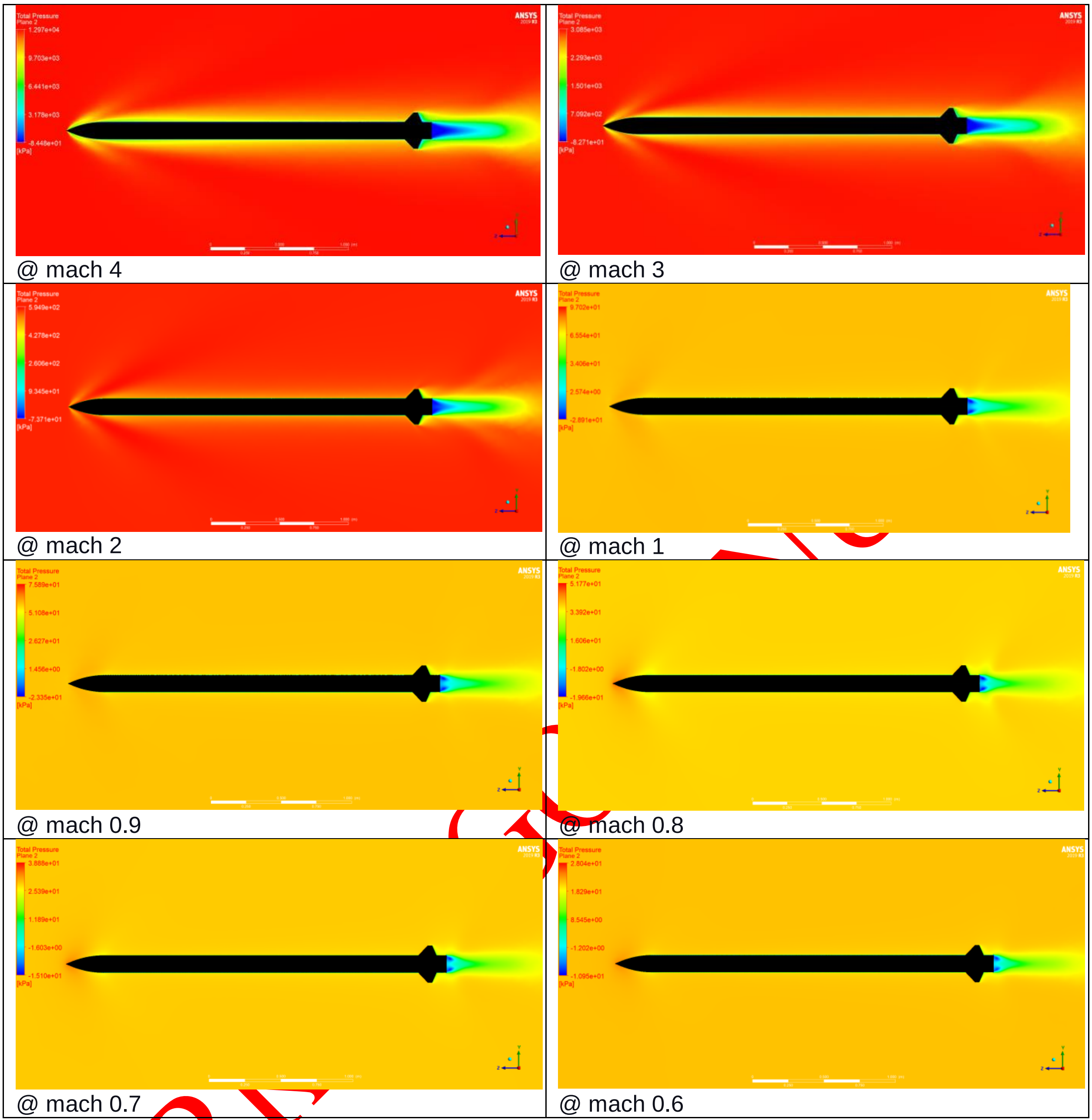

Figure 4. Total pressure contours at different mach number

3. CONCLUSIONS

In this study, CFD calculations and aerodynamic performance of the satellite carrier system with nose and flow for the different cases were investigated and the desired aerodynamics properties for simulations of exterior structure were obtained.

- As a result, satellite carrier system drag force is significantly lower compared to the drag force of the system in low Mach numbers. Again, the drag coefficient of the carrier system is 0.342 at M = 0.6 and 7.65 at M = 4 as maximum and minimum value.
- The satellite carrier system drag coefficient varies in the range of 0.342- 7.65 for different Mach numbers. This design was developed for the low altitude satellite carrier systems which will be used in national project.

Also this system successfully was tested by computational techniques. Accordingly, satellite carrier system actual flight trajectory is widely and qualitatively agreement with the similar experimental and numerical studies in the literature.

DECLARATION OF ETHICAL STANDARDS

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

AUTHOR CONTRIBUTIONS

All authors have same contribution in manuscript.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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