BILKENT UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

INDUSTRIAL DESIGN PROJECTS

2022 – 2023

Editors: Gülce Bayram, Müjdat Tohumcu, Yıldıray Yıldız
May 2023

Printed in Meteksan Matbaacılık, June 2023

Publisher Certificate Number: 51344

Printing House Certificate Number: 46519

ISBN: 978-605-9788-50-2

Content

PREFACE

University-industry collaborations provide future engineers with a broad understanding of industry and business practices. Such collaborations also provide a platform for students to demonstrate creative design solutions to important problems encountered by industry. We provide this learning opportunity with a two-semester sequence of design courses for the senior-level students. This year, 14 groups, each consisting of five to six students, were provided with design projects from leading industrial organizations. Projects were selected such that students could leverage their undergraduate studies to design a product needed in today's world. Projects were also selected to bring out the students' creativity in both the design phase, which is completed in the first semester, and the embodiment phase normally completed in the second semester. At their final presentation sessions, the students are provided with a unique opportunity to present detailed design specifications of their products and the finished prototypes to the industrial sponsors.

We as a department are grateful to the academic and industrial mentors, instructors, and teaching assistants for the continuous guidance and advice they provided.

On behalf of the Mechanical Engineering Department, I would like to thank all those who have generously contributed their time and resources that enabled tomorrow's engineers to gain invaluable experience during this process and demonstrate their capabilities in these trying times.

İlker Temizer
Professor and Chair
Mechanical Engineering Department
Bilkent University

LIST OF CONTRIBUTORS

Supporting companies and organizations:

Instructors:
Assoc. Prof. Dr. Yıldıray Yıldız and Doç. Dr. Müjdat Tohumcu

Bilkent University Industry Cooperation - Graduation Projects Coordinator:
Yeşim Gülseren

Industrial mentors:
Barbaros Çetin (BİLKENT)
Serter Yılmaz (ROKETSAN)
Şükrü Emre Aydemir (ROKETSAN)
Onurcan Kurt (VESTEL)
Petek Ellialtıoğlu (ASELSAN)
Oğuz Doğan (ASELSAN)
Emre Öztürk (ASELSAN)
İlhami Gümüş (VESTEL)
Alaz Can Ertekin (NUROL)
Fatma İdil Aldı (ARÇELİK)
Gürkan Keçeci (BRİSA)
Deniz Tür (FNSS)
Ahmet Gürsoy (ROKETSAN)
Murat Alp (ROKETSAN)
Furkan Kılavuz (ARÇELİK)
Ali Gündoğdu (PLAN S)
Eren Özgün (PLAN S)
Olgun Altay (VESTEL)

Academic mentors:
Asst. Prof. Dr. Onur Özcan
Assoc. Prof. Dr. Yıldıray Yıldız
Assoc. Prof. Dr. Barbaros Çetin
Asst. Prof. Dr. Melih Çakmakcı
Asst. Prof. Dr. Yegan Erdem
Dr. Şakir Baytaroğlu

Teaching Assistants:
Ayten Gülce Bayram
Mustafa Uğur
Yunus Altıntop
Özgür Can Gümüş
Muhammed Yusuf Uzun
Emirhan İnanç
Mehmet Hakan Sarı

Department Staff:
Ela Baycan
Şakir Duman

Lecturers on Seminars:
Design: Burcu Dönmez
Numesys- Ansys: Şule Ağtaş
Teamwork: Serdar Bilecen
Patents: Sevda Kalyoncu
Design 2: Kutay Edis
Manufacturing: Nejat Ulusal
Project Management: Önder Balioğlu

PROJECTS

2022-2023

Design of a Multi-Purpose Remote-Controlled Underwater Vehicle

BilMarine (1)

Academic Advisors : Assoc. Prof. Barbaros Çetin
Asst. Prof. Onur Özcan

Teaching Assistant : Özgür Can Gümüş

ABSTRACT

The goal of this project is to design a versatile underwater vehicle that can be controlled remotely while meeting the project's requirements and constraints. The primary objective is to create a vehicle with 4 degrees of freedom (DOF) capable of maintaining its position underwater. Specifically, the vehicle should be capable of linear movement in the Z-axis (horizontal movement), Y-axis (depth control), as well as rotation in the Y-axis (yaw) and X-axis (pitch). The vehicle must gather data from its environment in real-time to enable feedback control and research purposes. Sensors onboard the vehicle will collect this data, which will be transmitted to the control center for analysis. To enable remote control, the ballast mechanism has been proposed to change the vehicle's overall density, thereby allowing control of its depth and angle of attack. The side motors facilitate forward movement and right-left turning. We used Matlab, Unity, and ROS environments to create relevant simulations to model the system dynamics for simulation and design purposes. During the design process, ANSYS analysis aided in the design of the vehicle's outer shell, and simulations were used to replicate real-time conditions. Impermeability was taken into account, and the vehicle was designed accordingly to ensure it would withstand underwater conditions.

Problem Definition

Diving is an essential yet dangerous work field for maintaining current industrial infrastructure. Working underwater poses significant dangers due to a lack of light, oxygen, high pressure, health problems, and corrosive seawater. For instance, despite the first manned mission to the moon being completed in 1969, the first manned mission to the Mariana Trench, which is 11 km below the surface, was not accomplished until 2012 [1]. This comparison highlights the challenges of manned deep-sea missions and underscores the importance of unmanned underwater vehicles. Unmanned underwater vehicles (UUVs) offer a safer and more efficient solution for conducting deep-sea missions.

Figure 1: Underwater drone - Fifish-v6 [2].

Underwater work poses significant risks to human workers, who must adhere to strict rules and prohibitions. However, advances in marine technology have made it possible to automate many of the manual tasks involved in underwater missions, thereby enhancing human control and reducing risks. By using automated or remote-controlled vehicles, the human factor can be eliminated as much as possible, making underwater work safer and more efficient. These developments offer significant promise for improving the safety and effectiveness of underwater work while minimizing risks associated with manual labor.

Figure 2: Underwater mission with human presence [3].

Underwater operations were essential for the continuity of various industry applications. Especially underwater cable and pipeline connections, offshore oil platforms, and underwater power systems require commercial offshore divers to locate and assemble these systems. Unfortunately, commercial offshore diving is costly and poses a significant risk to the human body. By deploying remotely operated underwater vehicles, the cost of a deep sea survey can be reduced by 40% to 60% while removing the human factor and reducing the operational risk for the divers [4].

A complication in the life-supply systems, any unintentional impact or decompression sickness below 100 meters, can be lethal for the divers. The proposed underwater vehicle focuses on diminishing or reducing the presence of the human factor in the missions by partially solving the problem without human assistance. The vehicle will be able to do maintenance checks, surveillance, collect data. Thus, a remote operation will reduce the time spent in the water by the offshore divers, minimizing the operations' risk [5].

[1] R. A. Lutz and P. G. Falkowski, “A dive to challenger deep,” Science, vol. 336, no. 6079, pp. 301–302, 2012.
[2] “FIFISH V6 underwater robot,” QYSEA Official. [Online]. Available: https://www.qysea.com/products/fifish-v6/. [Accessed: 10-Oct-2022].
[3] E. Hunt, “'people want blood and Gore': What we got wrong about filming sharks,” The Guardian, 10-Jul-2020. [Online]. Available: https://www.theguardian.com/environment/2020/jul/10/people-want-blood-and-gore-what-we-got-wrong-about-filming-sharks. [Accessed: 16-Dec-2022]
[4] S. K. Jain, “A Review Paper on: Autonomous Underwater Vehicle ,” International Journal of Scientific & Engineering Research, vol. 6, no. 2, Feb. 2015.
[5] T. G. Shields, “Clinical presentations and significance of decompression sickness: An analysis of incidents from commercial diving operations 1977–87,” Advances in Underwater Technology, Ocean Science and Offshore Engineering, pp. 175–194, 1988.

Design

Corner

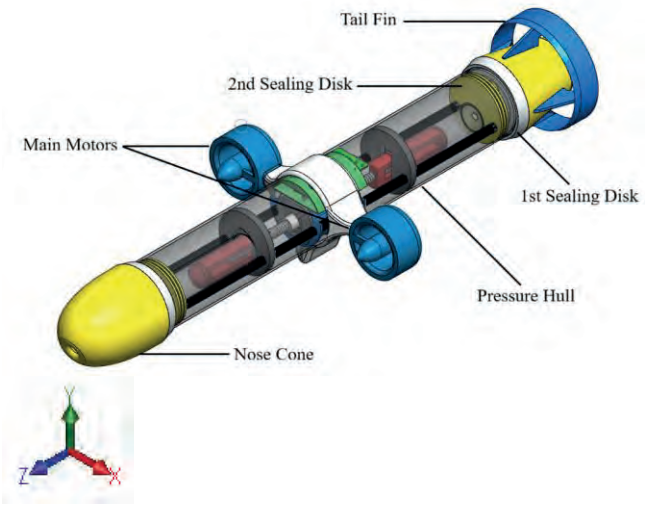


Figure 3 : Overall design.

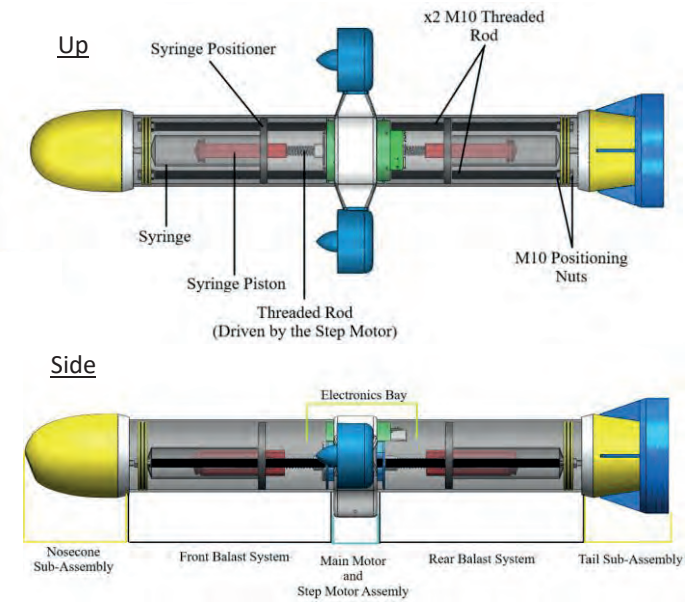


Figure 4 : Subsystems of the vehicle.

The design of the system is based on the fundamental requirements of the mission. To achieve four degrees of freedom, coupled brushless motors and ballast tanks are placed symmetrically. The motors provide axial rotation in the Y-axis and linear thrust in the Z-axis, while the ballast tanks provide axial rotation in the X-axis and linear motion in the Y-axis. This configuration enables the vehicle to execute sharp and accurate maneuvers, allowing it to operate in unstable conditions and providing operational flexibility in confined spaces.

The vehicle hosts five sensors for collecting data from its surroundings: pH, temperature, depth, flow rate sensors, and an IMU. Further, a camera is mounted under the body for surveillance and observation. The vehicle can be controlled using an Android application with touchscreen joysticks and sliders for depth, angle, and position control. Further, all sensors can be monitored through the app. A robust and stable communication infrastructure is built using the Robot Operating System (ROS) for such complicated network traffic between underwater and the user.

Outcomes

This system is a mechanical design project that integrates the knowledge gained in courses such as dynamics, control systems and mechatronics. The project is divided into several stages, which were completed during 2022-2023 academic year.

- Literature research
- Determination of needs and requirements considering standards
- Engineering analysis including:
  - -Control system design and analysis
  - -Mathematical modeling and simulation
  - -Network performance analysis
  - -CFD analysis
- CAD drawings
- Safety Analysis
- Manufacturing processes, assembly, design verification
- Testing the system

*This project is supported by Tübitak 2209-A Programme.

Mechatronic Design of an Optical Zoom Mechanism

Focus Point (2)

(From the left) Osman Örnek, Y. Ensar Unutmaz, H. Alperen Sivrikaya, Emirhan Pekşen, M.Taha Yıldız, F. Emre Öcal

Academic Supervisors: Assoc. Prof. Dr. Yıldıray Yıldız, Dr. Müjdat Tohumcu
Industrial Supervisors: Serter Yılmaz, Şükrü Emre Aydemir
Technical Assistant: Mehmet Hakan Sarı

ABSTRACT

This project aims to design and manufacture an optical zoom mechanism for seeker missiles. The mechanism will enable the missiles to adaptively change their Field of View (FOV) by utilizing an intermediate lens, which can be positioned to achieve the desired zoom ratio. A smaller zoom ratio will provide a wider FOV, increasing the chances of detecting a target, while a higher zoom ratio is more suitable for target identification. The adjustable zoom ratio is achieved by using a mobile lens that is driven by a DC motor combined with a ball screw. This mechanism ensures precise and smooth lens movement while maintaining a compact design. Given the nature of its application, the zoom mechanism must be able to withstand harsh physical conditions, maintain extreme precision in lens positioning, and remain unaffected by external vibrations. These factors have been taken into account during the design process to ensure that the final product will meet the demanding requirements of seeker missiles.

Keywords: optical zoom mechanism, lens, actuator, encoder, transmission, controller, motor, focal length, control unite

Problem Definition

Effective focal length (EFL), an optical measure, is key to infrared homing missiles as it relates to Field of View and magnification. In ROKETSAN missiles, fixed lenses result in constant EFL, limiting adaptiveness and hit probability. Our task is to design a mechatronic zoom mechanism with 3 lenses, a motor, transmission interface, and a microcontroller-filled card box. The middle lens will move quickly and precisely to change EFL, meeting strict performance,

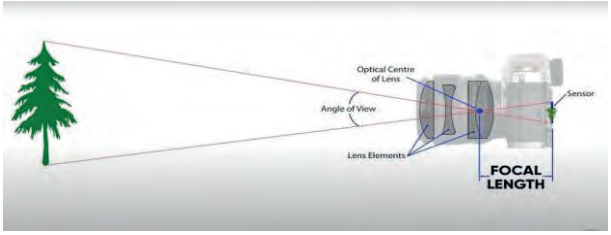


Figure 1: Focal Length Description from Camera [1].

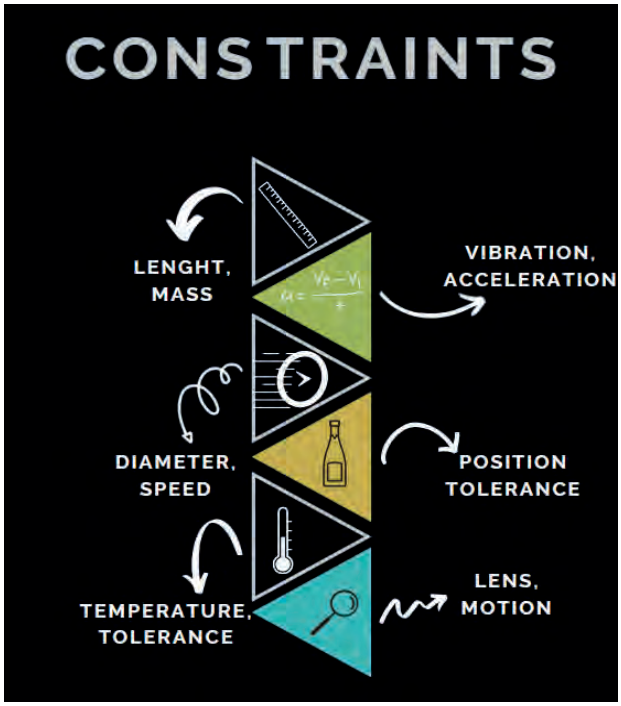


Figure 3: Categories of the Constranints

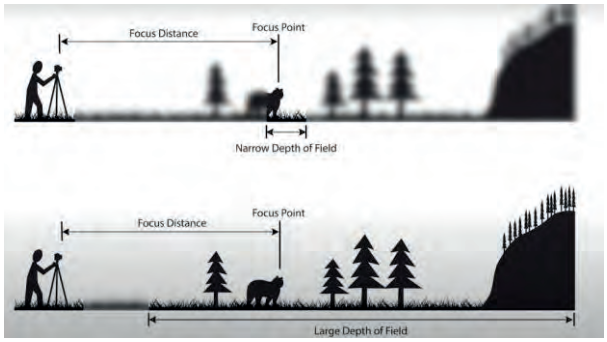


Figure 2: Clarification of the importance of Focal Length [2]

In infrared-homing missiles, camera modules are used to gather information from the target. In ROKETSAN products, the lenses in these cameras are fixed to their positions. This results in a constant EFL. As explained in the figures 1 and 2, this causes the camera to be inadaptive and enable it to zoom in or out, hence decreasing the hit possibility. To eliminate this problem, we are given the task of designing a mechatronic zoom mechanism. This mechanism will consist of a camera design with 3 lenses, a motor, a transmission interface and a cardbox containing the mechatronics elements such as microcontroller and motor driver. The lens in the middle will be designed to have the ability to move a desired point that is inputted into the system with high precision and speed to change the EFL. The project is inherently subjected to strict performance, mass and dimensional requirements due to the reason that it would be installed in a missile.

[1] D. Berkenfield, D. Black, M. Corrado and L. Silverman, “Understanding Focal Length,” Nikon USA. [Online]. Available: https://www.nikonusa.com/en/learn-and-explore/a/tips-and-techniques/understanding-focal-length.html#:~:text=Lens%20focal%20length%20tells%20us,and%20the%20higher%20the%20magnification. [Accessed: Oct. 8, 2022].

[2] C. (2021, June 04). How lens work in camera | lens mechanism | how lenses function. Retrieved November 12, 2022, from https://www.youtube.com/watch?v=fRKsKR9wvqE&ab_channel=CameraZone

Design

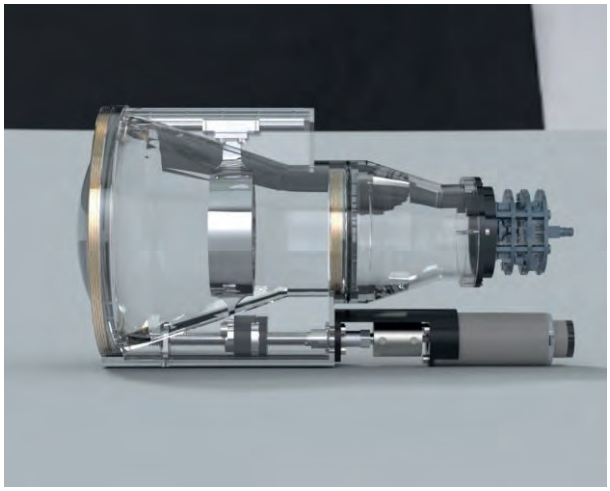
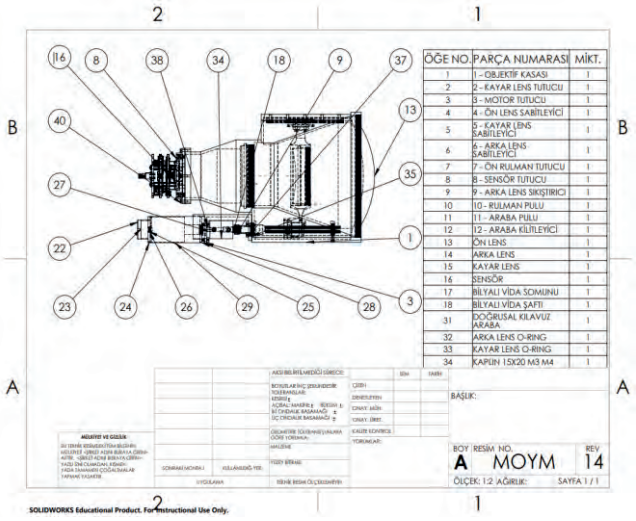


Figure 4 : 3D Model of the System



ÖĞE NO.	PARÇA NUMARASI	MİKT.
1	1 - OBJEKTİF KASASI	1
2	2 - KAYAR LENS TUTUCU	1
3	3 - MOTOR TUTUCU	1
4	4 - ÖN LENS SABİTLEYİCİ	1
5	5 - KAYAR LENS SABİTLEYİCİ	1
6	6 - ARKA LENS SABİTLEYİCİ	1
7	7 - ÖN RULMAN TUTUCU	1
8	8 - SENSÖR TUTUCU	1
9	9 - ARKA LENS SIKIŞTIRICI	1
10	10 - RULMAN PULU	1
11	11 - ARABA PULU	1
12	12 - ARABA KİLİTLEYİCİ	1
13	ÖN LENS	1
14	ARKA LENS	1
15	KAYAR LENS	1
16	SENSÖR	1
17	BİLYALI VİDA SOMUNU	1
18	BİLYALI VİDA ŞAFTI	1
31	DOĞRUSAL KILAVUZ ARABA	1
32	ARKA LENS O-RING	1
33	KAYAR LENS O-RING	1
34	KAPLIN 15X20 M3 M4	1

BAŞLIK:
BOY RESİM NO. A MOYM REV 14
ÖLÇEK: 1:2 AĞIRLIK: SAYFA 1 / 1
SOLIDWORKS Educational Product. For Instructional Use Only.

Figure 5: Bill of Materials in Turkish

The mechanism can be explained as:

- A brushed DC motor for actuation.
- A ball screw mechanism to transmit the motion to the lens.
- A linear guide to ensure ball screw works with no wobbling.
- A sliding lens holder to create the motion-lens interface.
- A sensor to collect infrared radiation on its FPA.
- An objective case to mount all the elements properly.

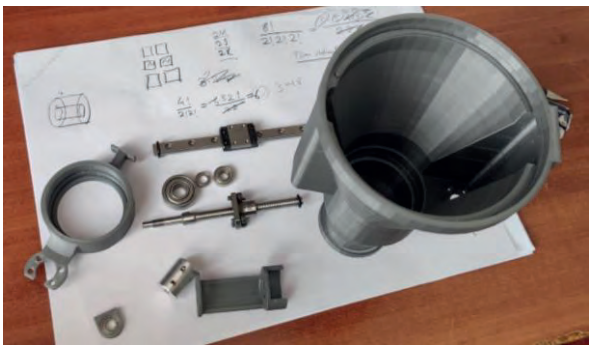


Figure 6: 3D Printed Version of The System

Outcomes

This system is a mechatronic design project that combines the mechanical engineering knowledge acquired at mechanics of materials, control systems and mechatronics courses. It is done in several steps through the 2022-2023 academic year given as below:

- Literature research
- Creating a preliminary design according to requirements provided by ROKETSAN
- Engineering analysis including:
  - Torque and Speed Calculation
  - Thermal Strain
  - Structural Stress
  - Modal Analysis
- CAD Drawings
- Finalizing the Design and Safety Analysis
- Mathematical Modelling and Control
- Planning of manufacturing processes, assembly, design verification and testing of the system

Improvement of The Vibration Transfer Characteristics of a Compressor Base Plate Bracket

B&E (3)

Ersu Çoruh ALTUNEL | H.Bahadır BİLİR | T.Batuhan ERTEK | Ege ERTAŞ | Ege SABUNCU | Berke UĞUR

Academic Advisor : Assoc. Prof. Dr. Yıldıray Yıldız
Industrial Advisor : İlhami Gümüş
Teaching Assistant : Mustafa Uğur

ABSTRACT

One of the major issues in white goods technology is vibration and noise. The objective is to minimize the noise pollution caused by white goods between 40 to 60 decibels. The essential cause of this vibration is the compressor. Improving the response of the baseplate to the vibration is crucial, since the uncontrolled vibrational behavior of electronics poses dangers and may harm to products, consumers, and businesses. In this project, we will analyze several base plate designs and alternatives to see how they affect the vibration transfer characteristics from the compressor side to the body/chassis. During development phase several designs have created and improved with respect to the simulation results. Thus, the latest design has the most promising results among previous concepts. All tests will be conducted with respect to the ISO standards after manufacturing phase is completed. If all of the procedures are completed without a problem, physical tests will be done in Vestel City. There are some safety rules and practices in our production areas to prevent or reduce accidents and injuries. After testing process, the design may be modified slightly if there seems to be a possible improvement opportunity regarding the achievement of this project.

Problem Definition

The vibration and noise issue is one of the critical concerns of white goods industry. Anti-vibration plates are placed beneath the compressors in the white goods to handle this problem. The sound pollution produced by white goods, which ranges in volume from 40 to 60 dB, is intended to be kept to a minimum. Developing the base plate and, if necessary, using a different material are the most efficient ways to prevent vibration and noise pollution because base plate is behaving like a spring beneath the compressor. Different materials become an option if they make manufacturing process easier or more affordable. Since the profit is the main purpose in mass manufacturing, the amount of money spent for production phase has a significant importance.

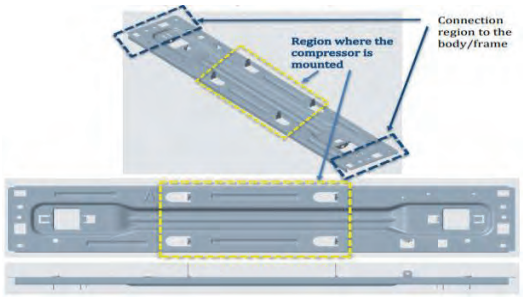


Figure 1: CAD Model of a Base Plate

The compressor is the most significant noise source in both household and commercial refrigerators. Improvement of the vibration characteristics of the base plate is an important issue because uncontrolled vibration behavior in electronic appliances poses several risks, disturbance and disadvantages for the users and products. The significance of the problem caused by vibration depends on the working field of the refrigerator however even a minor undesired outcome needs to be solved in order to prevent any possible malfunctioning. Since electronic parts and cables have a risk of electricity leakage, a small deformation may cause a shortcut or may even start a fire.

Figure 2: Refrigerator Base Plate Maintenance [1].

In addition to the mechanical concerns, customer satisfaction is also needed to be considered. Noise pollution is the most common issue area for customers. The sound created by the compressor should be reduced or made acoustically undisturbing. Acoustic theories will be used in order to achieve that.

In the designing process, profit-based and ease of production are also needed to be considered. In Vestel facilities, MC, MCP & MCL series are used as semi-h-frame presses, and the final design should be suitable for these machines. The geometry, thickness and settling technique of the made-used base plate could all have an impact on the fabricated portion's vibration-damping capacity, which could make it inadequate. So, this project additionally aims to improve currently used base plate designs, provide easier production and decrease the response to the vibration while considering production cost and production time.

Figure 3: Refrigerator Compressor [2].

[1] LovetoKNow, "How to Clean Refrigerator Coils", cleaning.lovetoknow.com [Online].
[Available]:https://cleaning.lovetoknow.com/house-cleaning-tips/how-clean-refrigerator-coils. Accessed on: Apr 27, 2023.
[2] Aisen, "AISEN Direct Cool Single Door Refrigerator,". [Online].
Available: https://aisenindia.com/product/aisen-direct-cool-single-door-refrigerator-100-l-hairline-greyar-d1052sg-hg/.
[Accessed: Apr 27, 2023].

Design

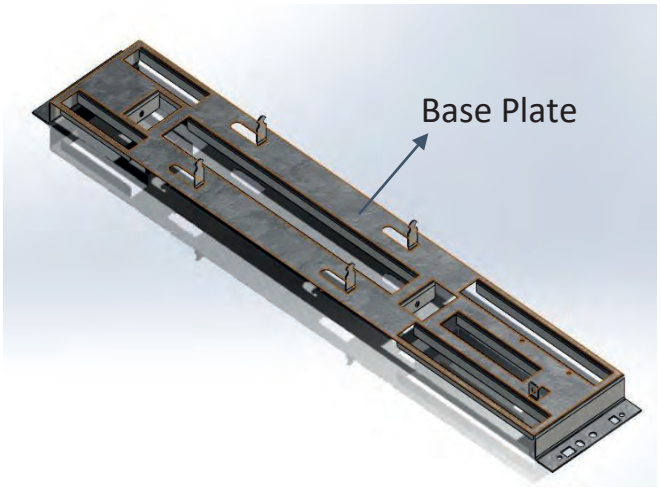


Figure 4 : 3D Model of the Base Plate Body

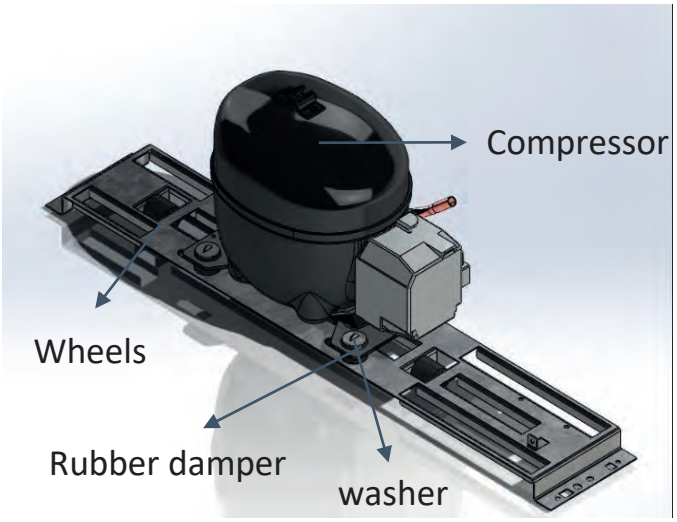


Figure 5 : 3D Model of the Assembly

The working principle of the selected detailed design is achieving the optimal vibrational characteristics for the Compressor Base Plate Bracket through appropriate material selection and manipulation of geometry such as holes and grooves in specific stress points as well as the additional support equipments such as wheels and rubber dampers.
This design is suitable for laser cutting and bending operations for manufacturing process. This is also beneficial for mass production and Vestel can make for the ease of production of the groove type elements used in the previous drawings.

To improve the design, the stiffness needed to be increased therefore, the related inertia is increased. Additionally, the flaps were made aligned vertically which were tilted before in order to increase horizontal stiffness and damping. The vibration source in the system which is compressor will be seated directly on 4 rubber supports which will behave like dampers. Using the design according to these requirements will increase the damping capacity. Moreover, the rubber dampers will be fixed to the compressor and the base plate with the help of flaps. Rubber absorbers will be located to the critical locations in order to minimize the noise created.

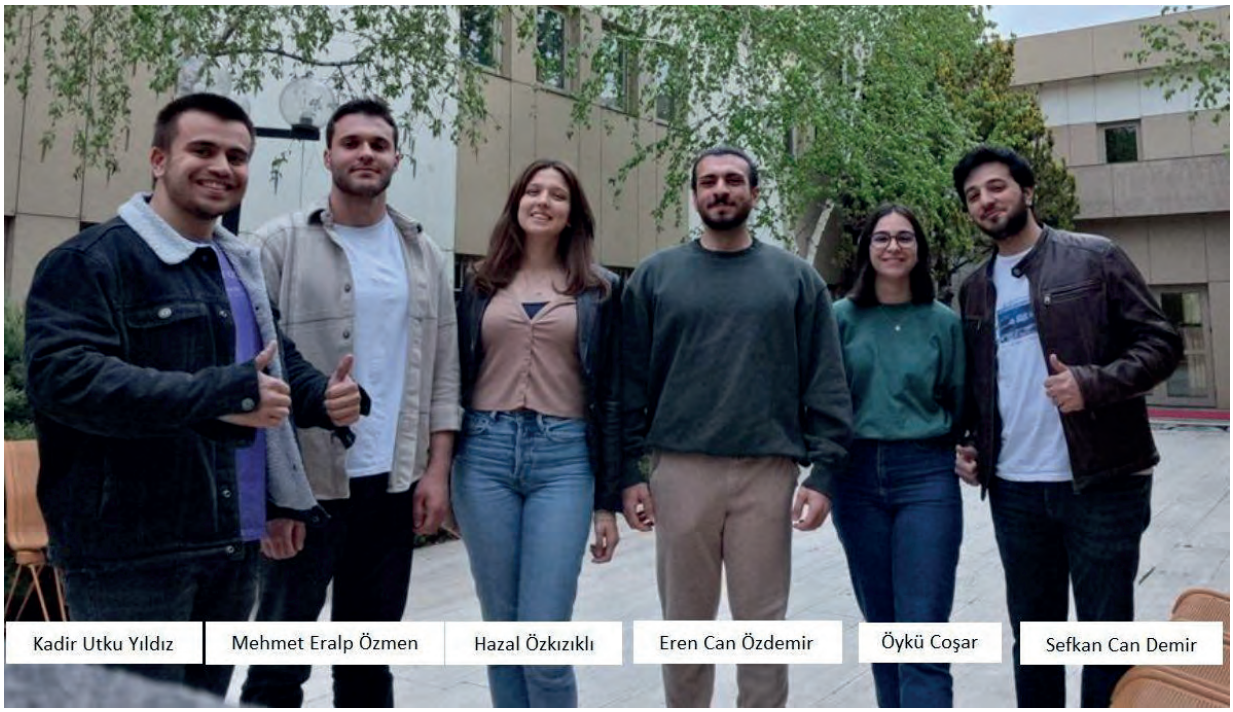
Outcomes

This system is a mechanical design project that combines the mechanical engineering knowledge acquired at dynamics, control systems and vibration courses. It is done in several steps through the 2022-2023 academic year given as below:

- Advanced knowledge about vibration
- Optimization of a design
- Engineering analysis including:
  - Single degree of freedom system modeling
  - Control system construction and analysis
  - Mathematical modeling
  - Inverse kinematics analysis
  - Frequency response analysis
- CAD drawings
- Vibration Analysis
- Planning of manufacturing processes, assembly, design verification and testing of the system

Design and Analysis of a Multi-Point Locking Mechanism for an Airtight Access Door

Clavis (4)



Academic Advisor : Asst . Prof. Dr Melih Çakmakcı
Industrial Advisor : Emre Öztürk
Petek Ellialtıoğlu
Oğuz Doğan
Teaching Assistant : Mehmet Hakan Sarı

ABSTRACT

This project presents the design and analysis of a multi-point locking mechanism with a central actuating point for an airtight access door on a radar chassis. The objective of the project is divided into 3 concepts, structural design of the main frame, actuation mechanism and latch design. The actuation mechanism, which has 3 arms attached to the latches via its sliding locking areas, is chosen for the design to accomplish time efficiency and ergonomy of the structure without compromising airtightness. The finalized design is analyzed for safety, durability, and robustness using the finite element method on ANSYS. The materials of the design are finalized according to a reconsidered design matrix and the FEA results, with the door being made of aluminum, and some of the locking mechanisms manufactured from stainless steel. The cost analysis is made, and it is specified which parts are manufactured and which parts are bought according to the budget constraints. The project concludes with a discussion of safety concerns regarding the usage of the mechanical component, alongside other codes and standards.

Problem Definition

In the defense industry, quick accessibility of the valuable electronics inside the radar chassis is an essential feature from a maintenance perspective and in case of emergency. Since radars must resist challenging environmental conditions and electronics inside the chassis need to be protected from environmental factors such as humidity and dust, access doors are designed airtight. Currently, Aselsan uses a sideway opening access door with multiple independent locks in their radar chassis.

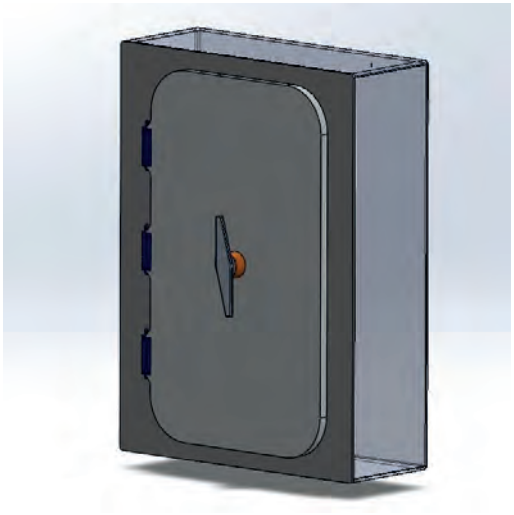


Figure 1: General Structure of the Airtight Door

The current design's individual locking mechanisms cause time loss and hinder quick access in emergency situations. To resolve this issue, a multi-point locking mechanism will be designed, analyzed, and manufactured to ensure time efficiency. The locks will be connected to a central actuation point, simplifying the locking and unlocking process for all locks on the door. The mechanism will operate under pressurized conditions of up to 35 mbar to provide a dry and stable environment for the electronic components.

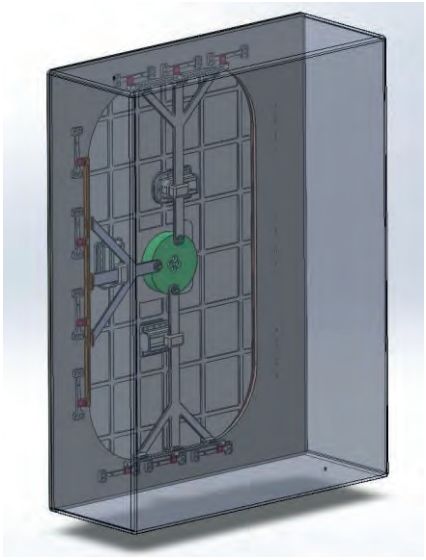


Figure 2: Internal Structure of the Airtight Door

The proposed solution must meet several requirements and constraints, including an airtight seal with 35 mbar internal pressure, dimensions between 600 mm to 1000 mm, and a weight of under 15 kg. Additionally, a maximum pressure drop of 0.2 mbar is allowed during a 30-minute waiting period, and the main component must be made of aluminum. The manufacturing budget for the prototype is 90,000 TL. The door also will be operational for 15 years to ensure the durability concerns. Finally, the door must be able to operate in temperatures ranging from -33°C to +63°C.

The solution product will be subjected to MIL-STD-810 G standard. This standard is the Department of Defense Test Method Standard which is used for Environmental Engineering Considerations and Laboratory.

Design

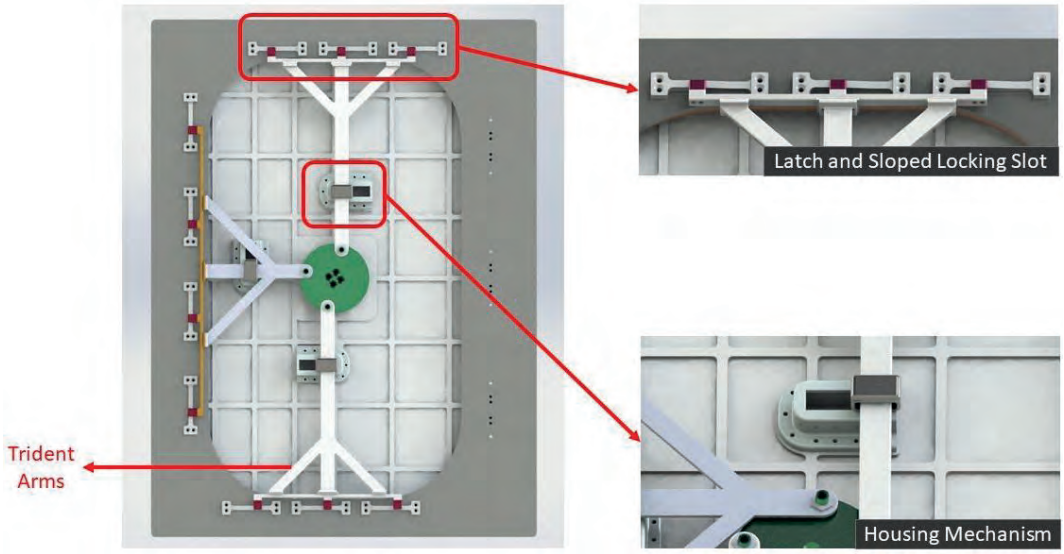


Figure 3 : 3D Model of the System

The unlocking and locking process of the mechanism is intuitively designed to facilitate user convenience. When the handle is rotated counterclockwise and the outside surface of the system is facing the user, the mechanism opens, corresponding to unlocking. Conversely, when the handle is turned clockwise, the system closes, resulting in locking. The actuation mechanism can rotate within a restricted angle of 100 degrees, with its end fastened to an o-ring, ensuring optimal airtightness.

The locking mechanism cap is connected to the actuation mechanism, and three trident profiles, fastened to latches, enable access door locking and unlocking. The trident profiles move through the bedding mechanism to the lock housing, guided by its inclined geometry, which exerts a pulling force on the door and compresses the sealing material between the door and backing structure. This innovative design ensures optimal airtightness and improves the system's efficiency.

Outcomes

This project is a mechanical engineering endeavor that applies knowledge from courses in structural mechanics design and material science. The project will be completed in stages during the 2022-2023 academic year:

- Literature research
- Determining subsystems based on requirements provided by ASELSAN
- Engineering analysis including:
  - -Mathematical modeling
  - -Stress analysis
  - -Deformation analysis
- CAD drawings
- Safety Analysis
- Planning of manufacturing processes, assembly of the parts, design verification and leakage testing of the system.

Ensuring Easy Cleaning of the Bottom Part of the Washing Machine with Easy Movement

MYTE (5)

From left to right: Hasan Yiğit Tekin, Burak Yeşilyurt, Yunus Emre Yüzyıl, Ahmet Can Özkan, Göktuğ Alp Çebi, Umut Tazıcı

Academic Advisor : Asst. Prof. Dr. Melih Çakmakcı
Industrial Advisor : İlhami Gümüş
Teaching Assistant : Mustafa Uğur

ABSTRACT

The objective of this report is to show analysis for the proposed concepts for the design problem of “Ensuring Easy Cleaning of the Bottom Part of the Washing Machine with Easy Movement” provided by Vestel. The main design problem is to develop, analyze and manufacture an external system that will lift and move a washing machine to clean under it. This system will operate with a motor in the mechanism and it will be powered by the washing machine’s electricity. In this booklet a detailed design report of the project will be presented. The project will include a thorough and complete depiction of the finished design, including any technical drawings or schematics and required analyses. These findings will be used in the manufacturing process.

Problem Definition

Cleaning under the washing machine can be troublesome for users. Generally, empty washing machines weigh around 30-40 kilograms average. Thus, lifting the washing machine without using any helping lifting mechanism could be difficult for users. Since there is limited space under the washing machine, cleaning materials cannot reach under the machine so there is a need for a system that can lift the machine upwards to clean under it. This lifting system should not require any human power and should operate fully automatically.

Figure 1: Lifting System With Washing Machine [1].

In order to clean the area around and underneath the washing machine, it must be lifted at least 8 cm from the ground and there must be a space under the machine so that the cleaning tools can reach beneath the washing machine. In the system, the space under the machine does not take up much space after lifting the machine, which means easier cleaning for the user. It is important that the parts and sizes to be used are designed and selected considering these situations.

The scissor lift system is designed to lift at least 70 kilograms in order to work properly and in all conditions. Due to the heavy load to be lifted, the parts in the system are selected from durable materials such as hard polymers and metal. At the same time, since this lifting system is a part to be added to the washing machine from the outside, there are limits to the space and height that the system will occupy under the machine. The system will have a minimum height of 5 centimeters in addition to the original height of the machine. The main purpose of the lifting system is to improve and ensure hygiene of the located area of the washing machine. By lifting the washing machine and create an extra gap underneath the machine, the system enables easy cleaning. Furthermore, the integrated wheels under the lifting system enables easy movement to the washing machine to carry.

The lifting system is designed for a specific washing machine with fixed dimensions and standards belonging to Vestel. The lifting system is also designed in accordance with the global white goods standards in terms of user safety, work safety and maintenance.

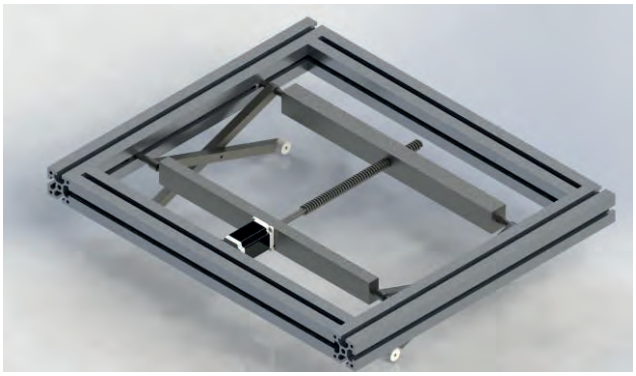


Figure 2: Detailed Design of the System

[1] İ. Gümüş, *Ensuring Easy Cleaning of the Bottom Part of the Washing Machine with Easy Movement*. Vestel, 2022.

Design

Figure 3 : 3D Model of the System

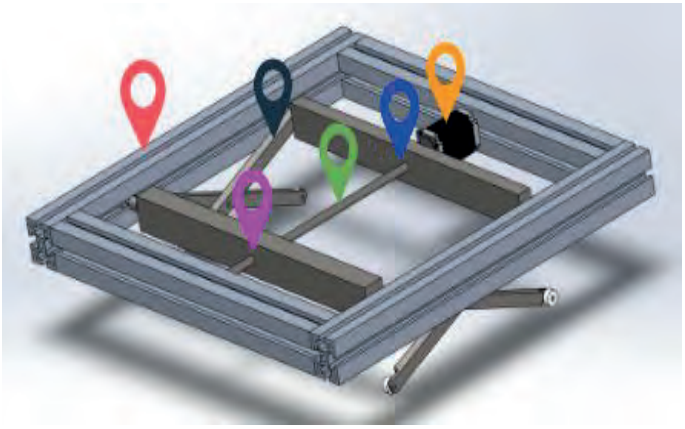


Figure 4 : Components of the System

Working Principle

Electric scissors lifting systems use hinges and an electric motor to lift the platform. This system works by applying force to the scissors arms by lead screw, which results in extending and lifting the platform. Therefore, the washing machine will be lifted by the movement of the scissors. The platform is composed of a sigma profile to further increase the strength. As the electric motor starts working, the lead screw starts to rotate. Therefore, the rotation of the leadscrew moves the connection beam horizontally. As a result, the connection beam either closed or opened the scissors, which will result in the lifting or lowering of the platform.

Components

- Steel Case
- Scissors
- Lead Screw
- Nut for Lead Screw
- Step Motor
- Roller Bearing

Outcomes

This system is a mechanical design project that combines the mechanical engineering knowledge acquired at dynamics, control systems and mechatronics courses. It is done in several steps through the 2022-2023 academic year given as below:

- Literature research
- Determination of sub-systems according to requirements provided by Vestel
- Engineering analysis including:
  - System analysis
  - Static analysis
  - Power analysis
  - Dynamic analysis
  - Safety analysis
- CAD drawings
- Planning of manufacturing processes, assembly, design verification and testing of the system

Integrated Starter and Generator Design for Armored Vehicles

Jetstream (6)

Academic Advisor: Dr. Şakir Baytaroğlu
Industrial Advisor : Alaz Can Ertekin
Teaching Assistant : Yunus Altıntop

ABSTRACT

The purpose of this project is to design an integrated starter and generator (ISG) which will be integrated into the powertrain system of the Nurol Makina's Ejder Yalçın vehicle. ISG is an electric motor with the combined purpose of a starter and generator. In the starter mode, ISG supplies required initial power to start the internal combustion engine (ICE), in this vehicle Cummins ISL 9 engine is used. Then electric motor produces additional torque while the ICE is under heavy load, therefore, torque curve of the ICE becomes more stable. In addition, ISG uses the existing torque from the engine during break and idle speed to recharge the battery. The ISG designed in this project is a permanent magnet synchronous motor (PMSM) that works with 48VDC. The electric machine will be positioned between the ICE and the transmission to eliminate changing torque ratio. A cooling jacket that encapsulates the electric motor is designed to ensure the system does not overheat. Antifreeze is used for the liquid cooling and the cooling system is connected to the vehicle's heat exchanger system.

Problem Definition

To start a vehicle, the internal combustion engine must turn the crankshaft at a cranking speed. To help the ICE in this condition, a starter motor which is an electric motor is used. An electric motor is able to generate high torques starting from 0 rpm while a petrol or diesel motor needs to get to a certain rotational speed depending on the motor. The Torque-RPM graph of the ICE is given in Figure 1. Furthermore, the kinetic energy generated while the engine is at idle speed or while braking are used to recharge the battery of the vehicle with an alternator. The ISG combines these two separate machines. There are two main parameters that was prioritized while deciding the torque supplied: incline of the vehicle and whether it would have load or not. With combination of these two parameters, calculations were done for 4 cases:

- Zero incline, zero load
- Zero incline, load
- 60% incline, zero load
- 60% incline, load

By looking at the maximum velocity achieved in each gear under these cases, power supplied by the electric motor was iterated. Calculations showed that the maximum power required is 40kW.

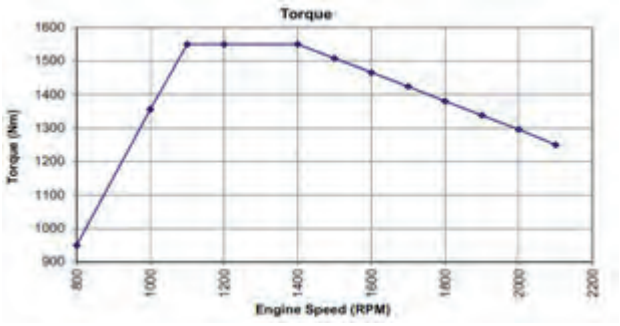


Figure 1: Torque-RPM Graph of Cummins ISL 9

Figure 2: ISG Configuration

The electric motor will be connected to the internal combustion engine with J1939 protocols, and the rpm of the ICE will be read by sensors. According to the rpm and the gear of the vehicle, the ISG will provide the necessary torque to move the vehicle at the desired speed. This process starts with a current supply for the stator which creates a rotating magnetic field (RMF). RMF has rotational motion around the stator and by cutting the air gap it goes through the stationary rotor conductors. Electromagnetic force (EMF) is created in the rotor magnets because of that relative motion. A magnetic field is then created. Therefore, a mechanical force is presented on the rotor. The sum of forces on each magnet creates torque to make the rotor rotate.

The cooling jacket encapsulates the electric motor to ensure the cooling of the motor and to minimize the heat transfer to the surrounding systems. The jacket is connected to both the ICE and transmission by SAE3 standards. Antifreeze is used as the coolant and the cooling system is connected to the heat exchanger system of the vehicle.

Design

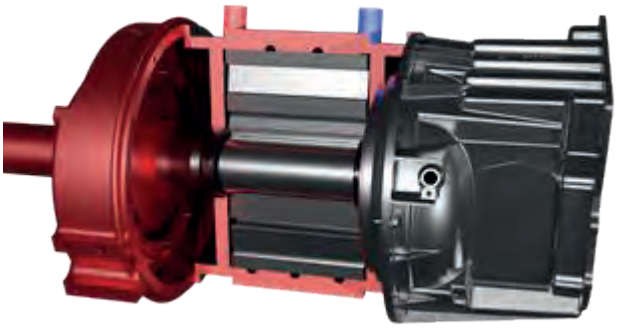


Figure 3 : 3D Model of the System

Figure 4 : Stator and Rotor of PMSM

Designed ISG is a bidirectional component of the powertrain system that includes PMSM and a cooling jacket which also functions as casing. Cooling jacket is connected to the ICE and the transmission according to the SAE 3. Also, it supports the shaft of the rotor in both ends with two identical bearings. Stationary part of the PMSM, which is stator, shrunk-on into the cooling jacket. The stator has 36 trapezoidal slots that creates useful area for the wirings. The inner and the outer diameter of the stator set as 259 mm and 410 mm respectively. The total length of the PMSM is 380 mm. Stator and the rotor has the same length which is 250 mm. The rotor is encircled by the stator. It has 12 poles and 12 magnet pairs integrated into it. When the ISG is on the starter or torque supplier mode, rotor transforms the electrical energy comes from the battery into mechanical energy. The opposite is valid during the charging mode of the ISG. Since the power transmission conducted through the shaft, shaft of the rotor connected the crankshaft and the transmission by couplings. Therefore, torque chain becomes complete and more stable.

Outcomes

This project consists of a mechanical system that blends knowledge from statics, mechanics of materials, mechatronics and thermodynamics courses with engineering expertise. During the 2022-2023 academic year, followed steps through the project are as follows:

- Literature review
- Selection of materials and suitable manufacturing method for each component
- Determination of design parameters and creating the geometry according the requirements and constraints provided by Nurol Makina
- CAD drawings
- Planning each phase of the production
- Engineering analysis that includes:
    - Static structural analysis
    - Heat transfer analysis
    - CFD analysis
- Prototype and 3D printing of the scaled PMSM

*This project is supported by Tübitak 2209-B Programme.

Optimization of a Dishwasher Hinge According to Friction, Load and Ergonomic Parameters

ImParaDoors (7)

Academic Advisor : Asst. Prof. Dr. Melih Çakmakçı
Industrial Advisor : Sultan Ahmet Koç
Teaching Assistant : Emirhan İnanç

ABSTRACT

Dishwashers are composed of various minor components that are required for their functionality . One of these components, the door hinge mechanism, is fastened to the chassis and opens and closes the door. Being one of the primary contact points for the customer, the dishwasher's ergonomics and safety are directly correlated with the quality of the hinge mechanism. While it takes care of its current functionality with no problem, Arçelik wanted to, allow the door to stay open at any angle, supported via the hinge mechanism. The goal of this project is to deliver on that innovation while still meeting the specifications, restrictions, codes, and standards established by Arçelik and agreed upon by the project team.

Problem Definition

Dishwashers contain a lot of moving parts and structural features in order to function properly. The door of the dishwasher makes sure that the washing cycle is carried out securely. The door must be able to open, close, and remain open at various angles in order to allow for ease in loading and unloading of the dishes before and after the cycle.

The angular stability is sustained using the hinge mechanism. It links the dishwasher's door to the chassis. The hinge mechanism involves four main components: The spring, pulley, rope, and hinge arm. The mechanical movement of the hinge mechanism is actualized when the components are aligned in a specific manner. The spring, pulley, and hinge arm are all fastened to the back wall of the chassis in that order, starting from the chassis. The spring and the hinge arm are connected to the rope on two ends, and it passes through the pulleys.

The ability to maintain stability at intermediate angles between 0 and 90 degrees is one of the essential characteristics of a functional hinge mechanism in contemporary dishwashers. The major objective of this project is to improve Arçelik's hinge mechanism so that it can retain stability between 0 and 90 degrees while abiding by the safety specifications and design limitations that Arçelik offered.

The improvements were planned to be executed with the minimum number of changes to the current design. The following were aimed to be conserved: the orientation of the hinge mechanism, the nature of the original components, and the dimension of the components. The improvements were also planned considering the originality, durability, cost, and efficiency of the mechanism.

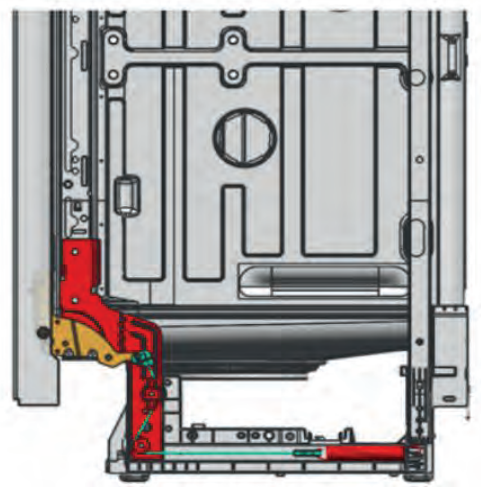


Figure 1: Arçelik's Original Hinge Mechanism Design to be Optimized [1].

The design criteria were derived from overall concerns regarding the mechanism and its components so that a more numeric and analytical design process could be conducted. To accomplish this, five main criteria were derived: cost, simplicity, flexibility, material choice, and cost. Further, the limitations regarding storage, logistics, and safety that were provided by Arçelik were thoroughly considered in each component's design.

The main concern about safety issues is to build a mechanism that could support a dishwasher door with a maximum mass of 15.2 kg. To prevent failure of the hinge mechanism while opening and closing, the collapse of the door, and noise, the hinge mechanism must provide enough support for stability at any angle.

[1] O. U. Selvi, "Arçelik Bilkent Bitirme Projesi: Optimization of a dishwasher hinge according to friction, load and ergonomic parameters." Arçelik, Ankara.

Design

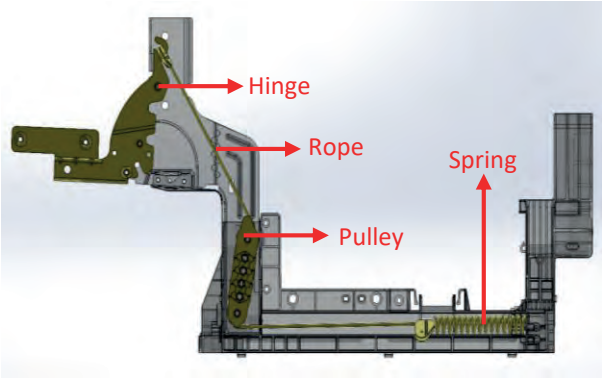


Figure 2 : 3D Model of the System Assembly

The overall system consists of four subsystems: the hinge, the rope, the spring, and the pulley. The hinge is used to connect the dishwasher lid and the rope. It allows the dishwasher lid to move at a limited angle of rotation. Also, it provides the rope to carry the door load along, via tension. The rope connects the hinge arm to the spring by going through the pulley. The friction between the rope and the surfaces it contacts is one of the important aspects of the mechanism that helps with the adjustment of the dishwasher lid and its stability at different angles. The spring adds the system a spring force for further stability.

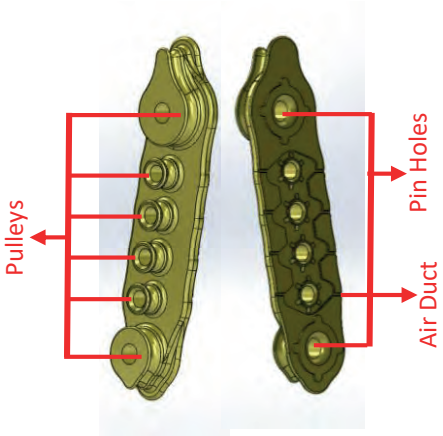


Figure 3 : 3D Model of the Pulley Subsystem Front and Rear View

The purpose of the pulley is to change the angle of the force. The force applied by the spring is transferred to the pulley with the help of the rope, and the pulley transfers the force to the hinge. The pulley mechanism consists of six pulleys of different sizes which create a considerable amount of friction to stabilize the dishwasher lid at any desired angle. There are eight air ducts in the pulley mechanism to release the heat caused from the rope friction. Two pin holes are used to connect the pulley to the chassis.

Outcomes

This mechanical design project utilizes the theories that are in the scope of mechanics, dynamics, and manufacturing courses. As a part of ME 481 and ME 482, several steps were followed to create the final design:

- Literature review
- Analysis of the current system by Arçelik to determine the improvement points
- Engineering analysis and design, including:
  - Mathematical modeling
  - Force, moment, and friction analysis
  - CAD and technical drawings
  - Total deformation, equivalent stress and strain, and thermal strain analysis
  - Assembly and physical test
- Risk analysis according to safety, dimensional, and functional concerns
- Manufacturing analysis and 3D printing
- Prototyping and physical tests

*This project is supported by Tübitak 2209-B Programme.

Dual Axis Solar Tracking Power Generator Design

Helios (8)

Altar Sertpoyraz | Can Ünen | Burak Arslan | Emre Bulut | Aykut Fatih Koçer

Academic Advisor : Asst. Prof. Dr. Onur Özcan
Industrial Advisor : Gürhan Keçeci
Teaching Assistant : Muhammed Yusuf Uzun

ABSTRACT

The aim of this project is to design and produce a power generator that utilizes sun as the main power source, and positions its focus according to the location of the sun to maximize the power output. In line with European union's goals to minimize carbon emissions by 2050, BRISA is seeking ways to minimize their carbon footprint. Analyzing the renewable energy resources in Aksaray, where the factory is located, the energy source that is dominant yielded to be solar power. Thus, the project contains a solar power generator design. To increase the efficiency of the system, dual-axis solar tracking is added and the power generator geometry is set as parabolic-trough collector for ease-of-assembly and geometric constraints. The net power output of the system is required to be 11 W/m^2 on average when the sun is up, approximately 300-400^oC on the absorber tube of the collector.

Problem Definition

Climate change is a recent topic around the world as it affects everyone on the planet. The European Union wants to become carbon neutral by 2050 in order to combat climate change. In order to achieve this goal, big factories are challenged to find renewable energy sources. BRISA is aiming to implement renewable energy based solutions to its factory in Aksaray, Turkey.

Solar power plants are among the most developed renewable energy technologies are offer relatively high efficiencies. One type of solar power plants are concentrating solar power (CSP) systems. These systems concentrate the sunlight in a specified area to a point or an area densely and use this dense solar energy to provide heat for power cycle. They have various geometries and applications areas from mega power plants to smaller power plants with limited output.

Figure 1: Parabolic-Trough CSP System [1].

The chosen layout for the scope of the project is parabolic-trough collector as it can be used for modular power plants and the system is easier to build. In this layout, the reflected sunlight is collected in the absorber tube.

Figure 2: Kimco 400W Braked Servo [2].

To increase efficiency, the system will have sun-tracking ability in two-axis. From the solar data provided by NASA, the system will align the reflector towards the sun to maximize the power output. The movement of the system will be provided by braked servo-motors, as they provide position control and low power consumption.

The system is required to have a size limitation on $1m^2$ area from bird eye view. In this area limitation, the system is expected to produce 11W/h. The system will be operational 24/7, so it should be durable to wet and windy environmental conditions. The prototype should be built for less than 50.000TL.

The end prototype will be subjected to performance tests, the produced power will be monitored and compared to the requirement set by BRISA. The tests will monitor the temperature change in the inner surface of the absorber tube.

[1] P. Pande, “Solar parabolic trough,” Green Clean Guide, 21-Jul-2020. [Online]. Available: https://greencleanguide.com/parabolic-trough/. [Accessed: 22-Oct-2022].
[2] ILX. (). Kinco 400w frenli servo motor - smh60s-0040-30abk-3lkh | ilx, [On-line]. Available: https://www.ilx.com.tr/tr/ilx- muhendislik- urun/kinco-400w-frenli-servo-motor---smh60s-0040-30abk-3lkh-ilx. [Accessed: 2023-03-10].

Design

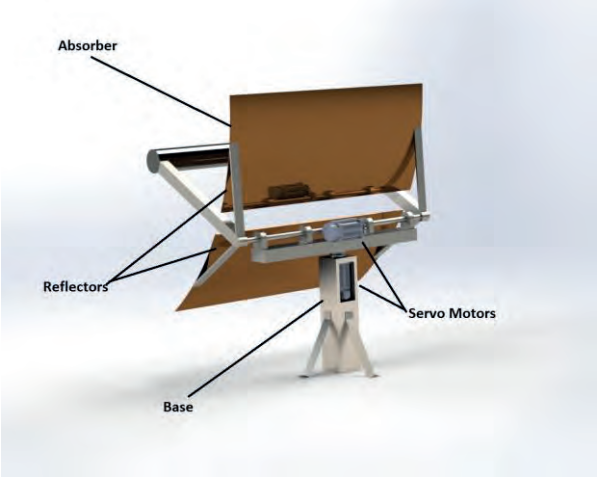


Figure 3 : 3D Model of the System

The final design consists of a parabolic reflector surface, cut in two for ease of assembly, and an absorber tube coated with dark chromatic coating. The system motion is provided by two 400kW braked servo-motors and bearings for minimizing friction in the system. System will be driven by microcontrollers and the sun location will be extracted from NASA's and CASIO's astronomical databases for specified location, date and time.

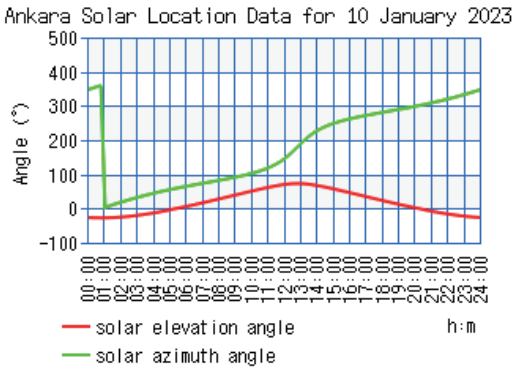
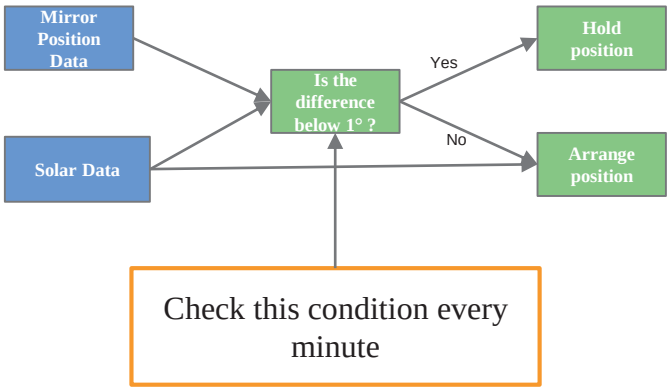


Figure 4 : Solar Data From CASIO KEISAN Database

A passive control method has been adopted to optimize energy consumption and enhance energy efficiency accordingly. The control algorithm is outlined below:



Outcomes

This system is a mechanical design project that combines the mechanical engineering knowledge acquired at dynamics, control systems and mechatronics courses. It is done in several steps through the 2022-2023 academic year given as below:

- Literature research
- Determination and design of sub-systems according to requirements provided by BRISA
- Engineering analysis including:
  - Optical Analysis
  - Thermal Analysis
  - Control System Design
  - Structural Analysis
- CAD drawings
- Safety and Budget Analysis
- Planning of manufacturing processes, assembly, design verification and testing of the system

Design and Production of A Pan & Tilt Mechanism

Mission:Possible (9)

Bora Öztaş | Ömer Tarık Banuş | Kerem Dülger | M. Zübeyir Atlıoğlu | Metehan Aydemir | M. Emre Erçelik

Academic Advisor : Asst. Prof. Dr. Onur Özcan
Industrial Advisor : Deniz Tür
Çağkan Güneri
Ozan Berkay Balyemez
Teaching Assistant : Yusuf Uzun

ABSTRACT

The aim of this project is to design and produce a pan & tilt mechanism system for military ground vehicles. Pan & Tilt Mechanism is an apparatus that is used to rotate an object with two different axes of rotation. Military land vehicles must be able to withstand the extreme conditions of combat. These vehicles may be exposed to harmful chemicals, intense sunlight, subzero temperatures, explosive shocks, and intense vibrations. It is therefore crucial to provide a clear view of the surrounding environment without compromising the safety of the vehicle's occupants. This can be achieved through the use of pan and tilt mechanisms, which offer a high degree of flexibility and can be used to track targets by using camera or laser guidance or monitor specific areas in the world coordinate system using azimuth and elevation angles. The project aims to carry a laser with maximum load of 1 kg and provide at most 10 milliradian angular resolution as well as stabilization performance higher than 15 milliradian. To achieve required accuracy and resolution, tools such as cascaded PID control algorithm which offers faster response, reduction in overall variability of the system alongside Kalman Filter are utilized in the project.

Problem Definition

In military operations, the ability to identify, track, and lock onto a target is of paramount importance. Using a sight unit such as camera or laser can provide advantages over relying solely on human vision, as it can capture a broader field of view and offer greater accuracy. However, a stationary, fixed ones offer little utility on the battlefield. In order to enable them to focus on specific locations, various technologies have been developed, including our project's Pan-Tilt mechanism. This system allows a laser, which is used instead of a camera, to be oriented towards any point in space using spherical coordinates, with users able to position the laser in the horizontal plane using the azimuth angle and in the vertical plane using the elevation angle. The design supports two operating modes: locking onto a fixed angle and following a moving target. These systems enhance the military capabilities of armored ground vehicles and can be easily affixed to th

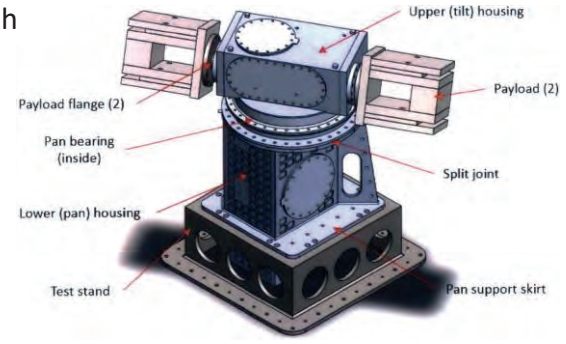


Figure 1: General Structure of the Pan-Tilt Mechanism [1].

The development of this project poses several challenges, as it involves the integration of mechanical, electrical, and software design. These three components are interconnected, and the selection of certain design elements in one area can have implications for the other areas.

Figure 2: AV210-75 Laser [2].

For example, the mechanical design, including the choice of gear structure, can impact the control variables of the system. Similarly, the properties of the electric motor, such as its center of gravity, inertia, and mass, are determined by the mechanical design. In order to ensure that these two physical systems function properly, a suitable controller program must be developed. In order to proceed with this project, firstly we focus on the mechanical design, taking into account the desired characteristics of the final physical system. This will inform the selection of appropriate electronic components. Finally, the necessary software will be developed to activate and control the system. At the end of the project, we aim to produce a local and national pan-tilt mechanism that is open to future developments.

The design requirements for this project include the integration of mechanical, electrical, and software design elements.

[1] 2022. [online] Available at: <https://www.semanticscholar.org/paper/Design-and-testing-of-a-pan-tilt-mechanism-for-Mills/149eec3332e1f1887c3861acfe0fc37d2c125d2c> [Accessed 14 November 2022].
[2] At ve anahtar at Silah Tabanca Lazeri-Trendyol Trendyol.com. Available at: https://www.trendyol.com/at-ve-anahtar/at-silah-tabanca-lazeri-p-153488124 (Accessed: April 27, 2023).

Design

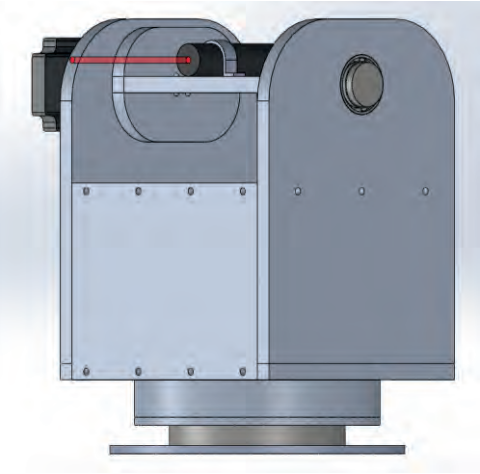


Figure 3 : 3D CAD Model of The System

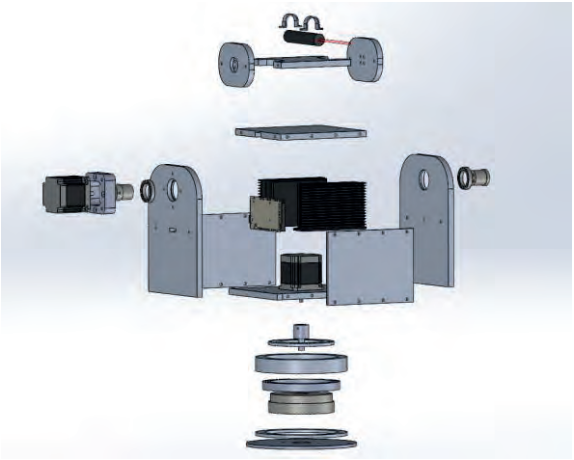


Figure 4 : Exploded View of The System

In order to deliver a high-quality and uniform product that adheres to military standards, we will prioritize adherence to US Military requirements. This project will encompass a wide range of engineering sectors, including testing and environmental concerns. The project can be broken down into three distinct sections: mechanical components, electrical components, and testing environmental concerns. We will ensure that all necessary measures are taken to address these concerns and deliver a product that meets all relevant military standards.

In the part of the mechanical design we consider for the pan & tilt mechanism, which is designed for elevation, there are 2 side abutments, 2 shafts to be connected to this abutment, 2 side load holders to which these shafts are attached, and 1 medium load holder.In the middle section, there is a protection section for the drivers and microprocessor required for motor control. This part is connected to the azimuth motor part by means of a shaft.At the bottom, there is the motor that will rotate the system in the azimuth axis.This motor will rotate the system by means of shaft and bearing. The part where the motor will be fixed is also designed to be attached to the vehicle.

Outcomes

This system is a mechanical design project that combines the mechanical engineering knowledge acquired at strength of materials, dynamics, control systems and mechatronics courses. It is done in several steps through the 2022-2023 academic year given as below:

- Literature research about existing pan-tilt technology
- Determination of subsystems with respect to requirements provided by FNSS
- Engineering analysis including:
  - Power transmission analysis
  - Control system construction and analysis
  - Mathematical modeling
  - Inverse kinematics analysis
- CAD drawings
- Safety Analysis
- Planning of manufacturing processes, assembly, design verification and testing of the system

Design and Production of a Fuel Transfer Pump

Group (10)

Academic Advisor : Assoc. Prof. Yıldıray Yıldız
Dr. Müjdat Tohumcu
Industrial Advisor : Murat Alp
Ahmet Gürsoy
Teaching Assistant : Özgür Can Gümüş

ABSTRACT

The objective of this project is to compare and determine concepts that can yield optimal results for manufacturing a "Fuel Transfer Pump" intended for use in various ammunition, including cruise missiles. The impeller and its housing are the most critical and challenging aspects of the design, as the impeller design must meet the requirements for flow rate and pressure difference. Specifically, a flow rate of 300-1000 L/h and a pressure difference of 40-75 kPa between the inlet and outlet are necessary. Moreover, the design should be capable of operating with the JP-10 fuel. Throughout the project, engineering analysis, planned manufacturing processes, and cost analysis were conducted. Using the boundary values of the required outlet pressure and flow rate intervals, various scenarios were created, and the final impeller design was produced. The designed impeller underwent several engineering tests, including modal, flow, and pressure analysis, and the results were evaluated to make the necessary modifications to the final design.

Problem Definition

A pump is a mechanical device that converts electrical energy into hydraulic energy to transfer fluids through mechanical action. Centrifugal pumps are commonly used in the defense industry for fuel transfer in missiles and rockets. Additionally, impellers that are the key components of a centrifugal pumps are used to transfer the mechanical energy in the shaft into a hydraulic energy in the fluid. Design of an impeller affects the properties of fluid at the outlet such as flow rate, pressure and velocity. The main aim during the design of an impeller is to specify the optimum properties of fluid to transfer maximum amount of fluid in a short time. Impellers have several curved blades or vanes that revolve around a central shaft to provide a fast fluid flow inside the pump housing.

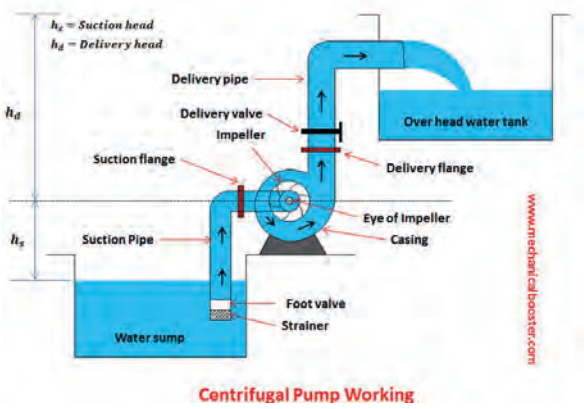


Figure 1: Demonstration of the Centrifugal Pump Working Principle [1]

The fluid is sucked into the pump as a result of a low-pressure zone that is created at the center of the impeller as it rotates. When the fluid is forced outward into the volute or diffuser, where the kinetic energy is transformed into pressure energy, the impeller blades transfer this kinetic energy to the fluid.

Figure 2: Impeller [2].

However, Pumps that are currently utilized in military ammunition are often operating with a predetermined constant flow rate. This feature of pumps creates a problem in terms of flexibility. Therefore, it is not possible for us to use these pumps in different environments, and thus in different ammunition. Purchasing external parts instead of self-production may also lead to integration and financial issues for the manufacturer firm. Thus, producing pumps in-house can partially address these problems.

Our project aims to develop a pump design that can operate in extreme conditions and be used in various ammunition parts. Furthermore, it will provide R&D opportunities to improve the design by documenting the development process. The exact dimensions and constraints of the solution product are defined by Roketsan.

[1] P. Mishra, "Centrifugal pump - working principle, main parts with application," *Mechanical Booster*, 21-Feb-2018. [Online]. Available: https://www.mechanicalbooster.com/2017/07/centrifugal-pump.html. [Accessed: 17-April-2022].
[2] Bortoro. (2021, January 30). *Types of impeller in pumps - selections and considerations*. ACCA Pumps. Retrieved April 28, 2023, from https://accapumps.com/types-of-impeller-in-pumps-selections-and-considerations/

Design

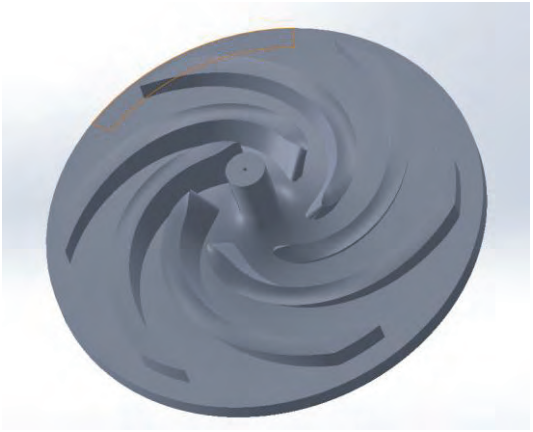


Figure 3 : Model of the Impeller

Figure 4 : 3D Model of the Casing

The design of our system has been finalized. An impeller design was created by taking the desired constraints into consideration and analyzing in ANSYS. The diameter of the impellers is 49mm and contains 6 blades. It has been observed that the maximum values of the fuel transfer pump requirements (175 kPa pressure and 1000 Liter / hour flow) for the guided missiles requested from us by ROKETSAN company has been achieved.

A casing design was made in accordance with the dimensions of the impeller design and to protect it. This casing will contain the impeller, motor, shaft and cables. It will enter through the casing end where the fluid impeller is close and will be ejected from the casing cavity with the engine speed rotated to reach the desired pressure and flow rate. Then the fuel will fill the fuel tank optimally. Pump does not exceed 45 watts of power, which is well below the theoretical limit we set.

Outcomes

This project is a comprehensive mechanical design endeavor that integrates the knowledge and principles acquired in dynamics, control systems, and thermodynamics courses. The project is conducted in several stages throughout the 2022-2023 academic year, as outlined below:

- Extensive literature review to identify relevant research and establish foundational knowledge.
- Identification and selection of subsystems based on requirements provided by ROKETSAN.
- Detailed engineering analysis, including modal, flow and pressure analysis conducted via ANSYS
- Creation of technical drawings for the design of the system.
- Conducting a comprehensive safety analysis.
- Development of plans for manufacturing processes, assembly, design verification, and testing of the system.

Design and Production of Automatic Tablet Detergent Dosing System In Dishwashers

Has Quintet (11)

Academic Advisor : Asst. Prof. Dr. Yegân Erdem
Industrial Advisor : Furkan Kılavuz
Teaching Assistant : Emirhan İnanç

ABSTRACT

The aim of this project is to build an automatic throwing mechanism that contains multiple detergent tablets in a dishwashing machine to automate the task for the customers. In a conventional dishwasher, user needs to load the tablet detergent each time before starting the program. This causes issues related to mainly ergonomics problems for the user. The project aims to change the design and working principle of a conventional dishwasher dosage mechanism that loads one tablet at each time, to a design that contains more than seven tablets at once. The solution product is an isolated rotating system embedded inside the door of a dishwasher that contain multiple detergents and load one tablet at each program by rotating at a specified angle. Since the volume inside the dishwasher is extremely crucial for maximum cleaning space inside the dishwasher, the rotating design is chosen as one that can handle this problem in an effective way. The proposed solution of the project also integrates a fan at an inside layer that can enhance the water and moisture retention for protecting the functionality of the tablets.

Problem Definition

The dishwasher is one of the main white goods that is frequently used in everyday life. Currently, a dishwasher is found practically at almost all houses. And those dishwashers generally only allow one fill of detergent, thus each washing cycle requires the addition of detergent by the user. This is ineffective due to the fact that the design is not ergonomic. People may have back discomfort or other comparable long-term health issues by bending over to the machine every time in order to fill the dispenser again and again. What's more, in the age of the internet of things, this conventional approach is ineffective and cannot be used for smart home applications. Hence, this design allows the remote control of a dishwasher. Furthermore, there will be extra room created by placing the tablets in the dishwasher. Therefore, the project's goals include automating the detergent insertion procedure, as well as storing the detergents and displaying them for the benefit of the consumer.

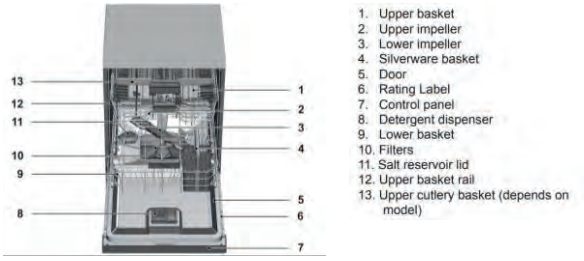


Figure 1: Overview of the Arçelik 9463 STA [1]

The tablet is deployed at a specific time during the starting period of the cleaning program, and this deployment time varies across different companies. One issue that is crucial in this problem is related to sustaining the moisture-free environment for the detergent tablets.

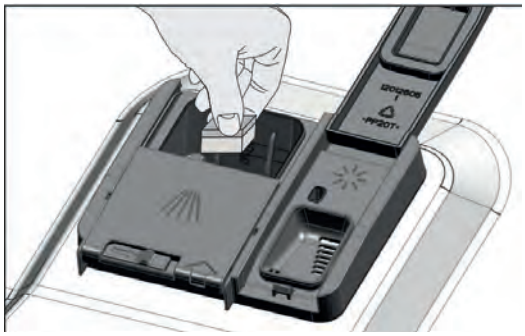


Figure 2: Arçelik Detergent Dispenser [1].

The moisture-free environment for the tablet is crucial since exposure to the moisture will dissolve the tablet before deployment, resulting in a failure of the cleaning program. This is important since customers are sensitive to the reliability of the dishwasher. Therefore, the design must have a moisture-free environment. And the size constraint is important as well since the tablets will fit into them and the optimization of the space inside the dishwasher is crucial for maximizing the cleaning volume for the customer.

There are specific standards that will be subjected to the design that are related to energy efficiency, sanitization, and dosing technology such as NSF Standard 184, EU 2019/2022, and DIN 2043.

Since the development of automation technologies increased rapidly over the last decade, it is essential to transform the everyday technologies to enhance their life quality, and the design of this project proposes a solution that is capable of achieving this in a practical manner.

[1] “User's manual - Arçelik.” [Online]. Available: https://download.arcelik.com.tr/download.usagemanuals/2782-kt-condensation-dryer-user-manual-en_US_20160905160261_User-20Manual-20-20Fileen_US.pdf. [Accessed: 27-Apr-2023].

Design

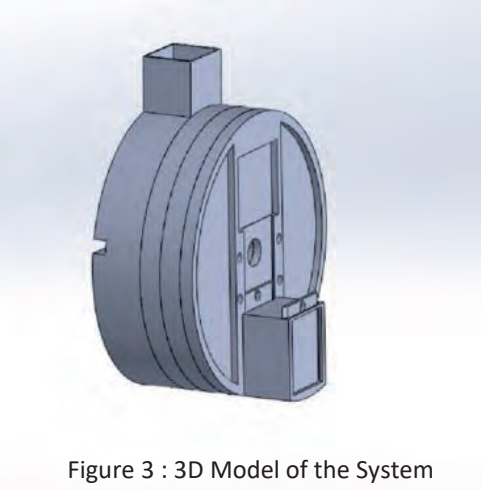


Figure 3 : 3D Model of the System

The design consists of various and different purpose parts. There are mechanical and electronic parts and these parts will work in an integrated manner with each other. The main purpose of the mechanical parts is to place the tablets into the system and then transfer the tablets from the system to the machine. We can say that this mechanical part consists of 4 main parts: the lower insertion which allows the tablets to be inserted into the system, the upper and lower tablet revolver which plays an important role in the insertion of the tablets into the slots and their subsequent transfer to the machine, the cover and the flap which allow the tablets to enter the machine one by one, and finally a sheath covering the whole system.

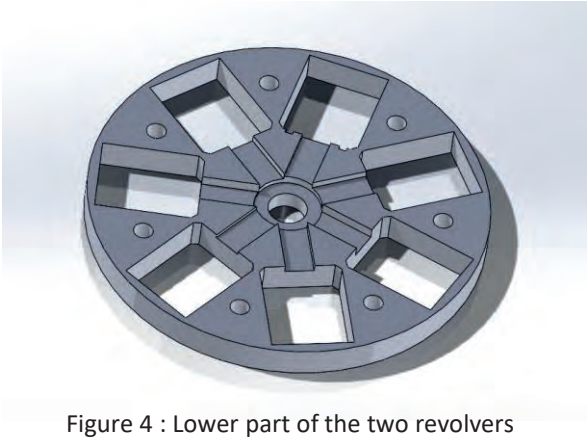


Figure 4 : Lower part of the two revolvers controlled with stepper motor

The function of the stepper motor in the electronic part is to provide a continuous revolving movement to the tablet revolvers and to drop the tablets between the 2 lids with the effect of gravity. At the same time, the IR sensors detect the presence of the tablets and lead to the motion of the servo motors to ensure the opening of the first and second lids. Also, these sensors will show how many tablets are left in the system. Thanks to the electronic parts, the operation of the system will be controlled.

Outcomes

This system is a mechanical design project that combines the mechanical engineering knowledge acquired at dynamics, mechanics and materials science, control systems and mechatronics courses. It is done in several steps through the 2022-2023 academic year given as below:

- Literature research
- Determination of constraints and requirements provided by Arçelik
- Engineering analysis including:
  - Thermal analysis of the body of the design
  - Control system construction and analysis
  - CFD analysis of the fans
  - Risk Analysis of the system including the FMEA
- CAD drawings
- Safety Analysis
- Planning of manufacturing processes, assembly, design verification and testing of the system

*This project is supported by Tübitak 2209-B Programme.

Development of Deployable Helical Antenna Mechanism for CubeSat Application

SkyPiercer (12)

Team members from left to right: Ali Burak Özel, Mert Aybar, Melike Nur Gürsoy, Mert Çakılcı, Dilara Özev, Cemal Kaan Köse.

Academic Advisor: Asst. Prof. Dr. Onur Özcan
Industrial Advisor: Ali Gündoğdu
Teaching Assistant: Ayten Gülce Bayram

ABSTRACT

The objective of this project is to create a deployable helical antenna mechanism specifically designed for CubeSat applications. Antennas used in space must meet stringent radio-frequency requirements for their designated applications while also exhibiting consistent performance, lightweight construction, compactness, and resilience to the harsh space environment. Our team has developed a Deployable Quadrifilar Helical Antenna Mechanism to fulfill these expectations, which comprises an antenna, housing, and deployment/lock sections.

This design incorporates the unique properties of nitinol, including its shape memory alloy feature, to enable rapid and stable deployment using the stored strain energy. The quadrifilar helical design further enhances the mechanism's stability in space. The team has worked tirelessly to create a highly efficient and effective solution that meets all of the required specifications for space applications.

Problem Definition

CubeSats are small, low-cost satellites that are designed with tightly controlled dimensions and masses. Unlike conventional satellites, they are a more budget-friendly option for space research and communication. Each CubeSat is composed of individual units that measure precisely 10x10x10 cm and weigh approximately 1.3 kg. As a result, CubeSat subsystems, such as the antenna mechanism, must achieve their objectives with the minimum possible volume and weight.

Figure 1: A CubeSat (with Monopole Antennas) [1]

Deployable helical antennas provide superior signal quality compared to conventional monopole antennas used in CubeSats. To minimize space requirements, the helical antenna and its deployment mechanism are mounted on the CubeSat and occupy only a tiny amount of space when stowed. When deployed, the antenna should be four times longer than its stowed length, and the deployment process must be reliable and occur away from human interaction, in Earth's orbit.

To reduce the overall weight and volume of the CubeSat, the antenna and deployment mechanism must be lightweight. The deployment mechanism should also ensure proper angle and planarity upon request, withstand temperature loads in space, and endure launch loads while in a stowed mode.

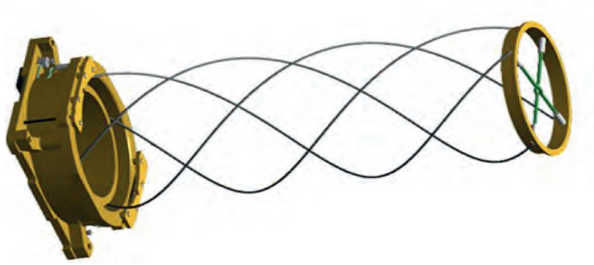


Figure 2: Deployable Helix Antenna [2].

The desired electromagnetic characteristics, such as gain, bandwidth, and coverage, should be present in the helical antenna. Market -available CubeSat- compatible helical antenna designs often feature poor strengths and limited bandwidths. The CubeSat's limited size prevents higher-strength antennas from being used. As a result, the limited space must be utilized effectively, and the antenna system's deployment mechanism must be designed such that it is short when stored and long when deployed. Finally, the developed antenna system must be strong, long enough to have the specified electromagnetic characteristics, and compact and light enough to satisfy the requirements.

The environment in space, material properties, launching process, and cost limitations lead to numerous design constraints and requirements during the development of deployable helical antenna mechanisms for CubeSat applications.

The design requirements and constraints can be summarized as ₺17.500 for budget, 9 months for time, space compatibility for material, and 0.200 kg mass at most for size. The solution product will be subjected to ECSS-E-ST-32C [3] and ECSS-E-ST-32-08C [3] standards. Those standards are ESA standards for structural general requirements and space engineering materials.

[1] Introduction (2019) Virginia CubeSat Constellation. Available: https://vsgc.odu.edu/. [Accessed: 26-Apr-2023)].
[2] "Deployable Quadrifilar Helical Antenna,". Available: https://satsearch.co/products/. [Accessed: 24-Oct-2022].
[3] "Active Standards," European Cooperation for Space Standardization. Available: https://ecss.nl/standard/. [Accessed: 25-Oct-2022].

Design

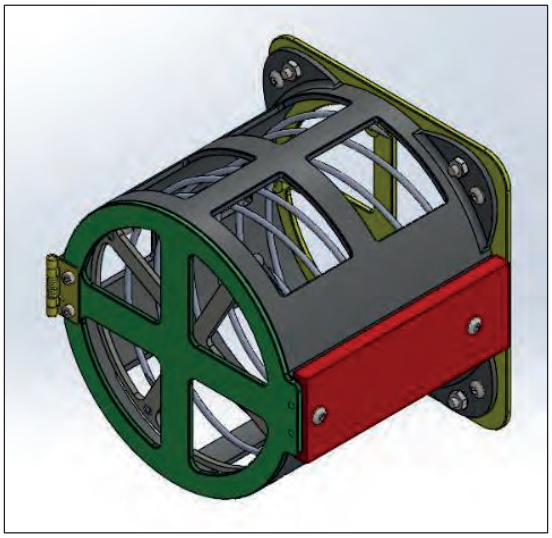


Figure 3: 3D Model of the System in deployed configuration

The design comprises a housing, housing cap, quadrifilar antenna, and antenna plates. The housing cap will remain closed to protect the antenna during launch and until the satellite is in orbit. To secure the cap in place, it will be attached to the housing using threads. Upon initialization of the deployment process, the satellite's heating resistor will melt these threads, releasing the cap. The cap will then be opened by the hinge, aided by a torsional spring, once the satellite reaches orbit.

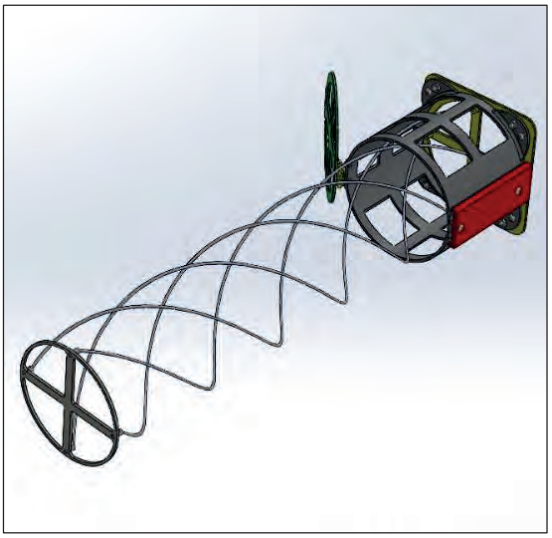


Figure 4: 3D Model of the system in stowed configuration

The quadrifilar antenna is securely attached to the antenna plate, which is in turn fixed to the housing. The antenna is constructed from Nitinol, a shape memory alloy that allows it to change shape in response to heat. During deployment, the stowed antenna will be heated until it reaches a specific temperature, causing it to transition into its deployed shape. To provide the necessary heat for this process, the satellite will utilize heat patches connected to the antenna.

Outcomes

The successful completion of this project requires the application of various mechanical engineering concepts, including system engineering, mechanics, material science, mechatronics, and manufacturing. The primary goal is to design a mechanical system that meets the requirements and constraints specified by Plan-S Satellite and Space Technologies. The project is structured into multiple stages, which will be completed throughout the 2022-2023 academic year.

The initial steps involve conducting a comprehensive literature review and identifying sub-systems and concepts that satisfy the requirements. After this, CAD drawings are created, and engineering analyses are performed to assess the system's natural frequency, random vibrations, temperature exposure, and thermal and static strain/stress. The design is then modified based on feedback from both Plan-S Satellite and Space Technologies and manufacturing companies to ensure manufacturability and efficiency.

The final stage of the project involves assembling the system, verifying the design, testing the functionality, and conducting vibration testing. Throughout the project, all relevant codes and standards for space applications are followed to ensure the system's reliability and safety.

*This project is supported by Tübitak 2209-B Programme.

Dishwasher Lower Basket Design With Mechanism

De_fault (13)

Academic Advisor: Dr. Müjdat Tohumcu
Industrial Advisor: Ömer Argınhan
Fatma İdil Aldı
Teaching Assistant: Emirhan İnanç

ABSTRACT

This project aims to design and produce a mechanism that lifts the lower basket of the dishwasher to increase consumer ergonomy and help people with skeletal diseases. Dishwashers are composed of two washing baskets, upper and lower. The upper basket is held in the washing cabinet of the dishwasher by two rails mounted on each side; however, the lower basket is placed on the bottom of the washing cabinet that is below the human reach level. To load and unload the lower basket, customers need to bend over. The mechanism designed for this project aims to lift the lower basket with the help of four-bar mechanism and gas struts. Since the mechanism is required to be placed in the dimensions of a dishwasher, it is decided to use a four-bar mechanism for movement and a pair of gas struts to actuate the movement thereby the mechanism can be placed inside the washing cabinet.

Problem Definition

In today's modern life, household appliances have huge role in people's lives. Dishwashers are one of these appliances when it comes to saving time. Dishwashers wash the dirty dishes that are placed in the lower and upper baskets in the washing cabinet by spraying hot water and detergent mixture on the stationary dishes with the help of the spray arms located under the upper and the lower basket. The water is circulated with an electric motor; however, after the wash cycle of the dirty water is drained by the pump, and rinse water is taken in.

With all the benefits dishwashers provide, they have several drawbacks as well. Since the lower basket of dishwashers is positioned below the stand-up reach level of a human, people need to bend over while loading and unloading a dishwasher, which can be problematic for the human skeletal system [1]. Because dishwashing is an everyday chore, loading and unloading a dishwasher can subsequently transform back pain into skeletal diseases. People who already struggle with skeletal diseases, such as scoliosis or lupus patients, are the main target of this project.

Figure 1: Bending Over when Loading a Dishwasher [2]

Figure 2: Beko Dishwasher [3].

A loaded lower basket of the dishwasher weighs 14 kilograms on average; however, the force applied on the lower basket when pulling or pushing the basket should not exceed 40 newtons for the user ergonomy.
Since the mechanism will be installed in the washing cabinet of the dishwasher, the materials that are going to be used in the designed mechanism should have protection against chemicals, water, and high temperature.

In terms of operation, any moving parts of the mechanism should not be in contact with the upper basket of the dishwasher to prevent any possible restriction of the movement of the upper basket. Moreover, the size of the mechanism should be compatible with the size of the lower basket or the lower basket size should be rearranged, which is approved by the Industrial advise

[1] T. Sawyers, “Lower back pain when bending over: Causes and treatment,” *Healthline*, 23-Aug-2018. [Online]. Available: https://www.healthline.com/health/lower-back-pain-when-bending-over#takeaway. [Accessed: 02-Oct-2022].
[2] “United States Patent (19) 11 patent number: 5,786.” [Online]. Available: https://patentimages.storage.googleapis.com/34/23/01/38678deb791610/US5786313.pdf. [Accessed: 15-Oct-2022].
[3] John-Bett, “Woman shares dishwasher drawer Hack that will transform how you wash glasses,” *mirror*, 12-May-2021. [Online]. Available: https://www.mirror.co.uk/lifestyle/woman-shares-dishwasher-drawer-hack-24094088. [Accessed: 15-Oct-2022].

Design

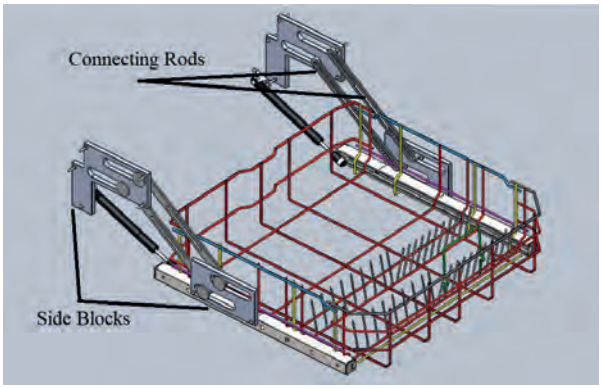


Figure 3 : 3D Model of the Mechanism

The main components of the selected concept can be given as a four-bar lifting mechanism, gas struts, and a rail mechanism.

The four-bar mechanism consists of a flexible and fixed bar housing with a connector rod between the sidebars. That system is supported by a gas strut together with the help of the user to move the basket. The rail sliding mechanism is found under the basket to distribute the load around the rails evenly at the sides.

The movement of the four-bar mechanism has both linear and rotary motion. Firstly, it goes forward for a certain distance toward the front casing. This linear motion is provided by the horizontal distance within the slots that are found on both side blocks; fixed and flexible. Once the bars reach the endings of the slots, the upward motion initiates with a specified angle from the reference point. It is the position of the fixed side blocks that end up with the rotary movement of the lower basket. This upward motion is also supported by the gas struts that are attached to the side wall of the dishwasher at a point below the fixed side block. This component aids to lessen the amount of force needed to be applied in lifting, as a result, the project aim is achieved.

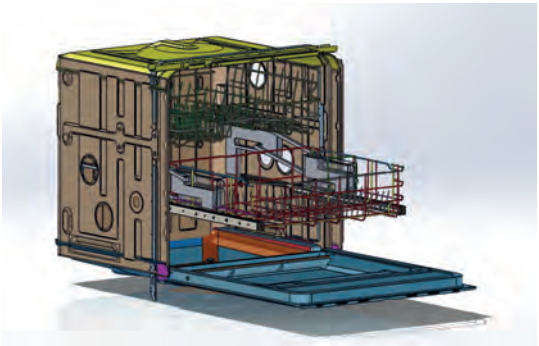


Figure 4 : 3D Model of the Mechanism

Outcomes

This mechanism is a mechanical design project that combines the mechanical engineering knowledge acquired at mechanics and materials design and manufacturing courses. The project is completed with the following the:steps through the 2022-2023 academic year given as below

- Literature research
- Determination of the concepts and components in terms of requirements and constraints provided by Arçelik.
- Preliminary and Detailed Design in SolidWorks

Engineering analysis including:

- Static Analysis
- ANSYS Analysis

- Modification of the design
- Risk Analysis
- Planning of manufacturing processes, assembly, design verification and testing of the system

Dynamic Belt Tension Measurement On Armored Vehicles

Master Oogway (Group 14)

Industrial Advisor : Alaz Can Ertekin
Teaching Assistant : Yunus Altıntop

ABSTRACT

This booklet aims to provide a comprehensive guide to the design and implementation of an optimal belt tension adjustment system for armored vehicles. The study initially focuses on calculating belt tension and sharing this information with the driver for optimal tension adjustment. A strain gauge measurement mechanism was selected for its precise measurement, ease of production, and cost-effectiveness. Key components, including the information transmission method, tensioner type and material, and belt shape, were chosen from the most optimal alternatives. Copper cables, spring tensioners, V-belts, and aluminum tensioner materials were selected based on static and control analyses. The booklet covers stress calculations in normal and unusual situations, as well as the static and dynamic aspects of the system moving with torque received from the power shaft. Detailed drawings and calculations are included to support the design and implementation process.

Keywords: armored vehicles, belt and pulley system, belt tension, strain gauge, dynamic measurement, v-belts, feedback.

Problem Definition

Belt and pulley systems carry immense significance for Military automobiles such as Ejder Yalçın due to their high power demands and the complexity of the mechanism. As seen in Figure 1, this power is distributed to seven different parts of Ejder Yalçın. In addition to being efficient in ensuring such high power demands, belt and pulley systems also offer geometrically adaptable solutions to these vehicles.

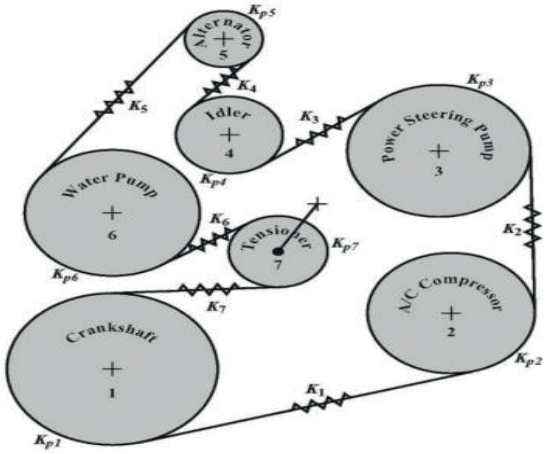


Figure 1: Belt pulley components of Ejder Yalçın

Reliability of the vehicles constantly has one of the biggest prominence. This is much more crucial when it comes to military vehicles. The vehicle ought to be prepared for battle under all operating conditions. There is no tolerance for unforeseeable errors of the belt, on account of this the belt has to be maintained before it fails.

In case of a belt failure, critical components directly shut down such as the alternator, air conditioning compressor, water pump, and power steering pump. Among these components, the water pump caters for coolant circulation to the engine. In the occurrence of a water pump failure, the engine quickly overheats and fails. In the occurrence of power steering rack failure, power steering rack needs to be handled manually as it lacks working in proper condition that is almost impossible to steer only with the steering column rack and pinion set in heavy-duty vehicles. In the occurrence of alternator failure, even though

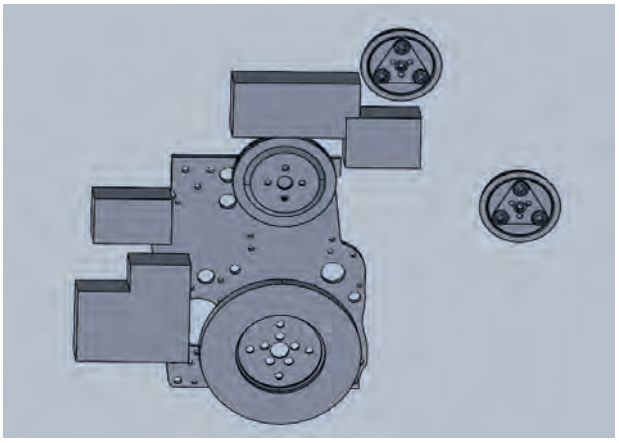


Figure 2: FEAD system

alternator failure is less critical than the failures of two attachments mentioned above, the car will operate for a short time and experience electrical problems. In the occurrence of, the vehicle will be inoperable as the battery will not be charged.

The serpentine belt or V belt is required to be inspected in specified intervals. Besides the belt failure; belt misalignment, erroneous tension or the belt tensioner failures such as damper or spring failure brings forth to excessive corrosion and heat on the belt. In the occurrence of belt misalignment, even 1° of misalignment conduces to a decrease in the lifespan of the belt stemming from overheat on the belt and accessory bearings. Failure of the belt tensioner damper results in vibration on the following component. This vibration strikes the accessory back and forth like a hammer. Failure of the belt tensioner spring has two outcomes. One of them is under tensioning which induces belt slippage, culminating in excessive wear on the belt and pulleys. Additionally when the belt slips that the slipping pulley does not work resulting in a non-operating engine accessory. When there is tension, the elements are subjected to excessive and unnecessary forces that cause them to overheat and shorten their lifespan. Therefore, it is necessary to measure dynamic belt tension, maintain it and adjust preventative maintenance.

Design

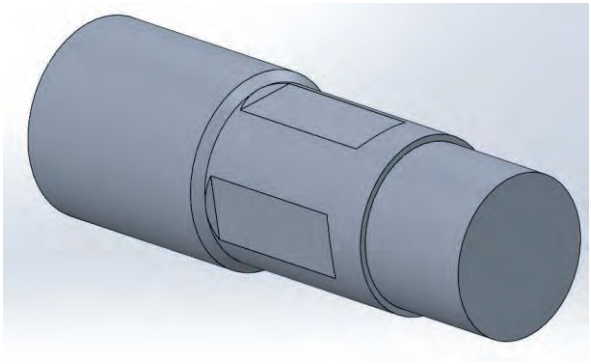


Figure 3 : Idler pulley pin

This system was designed according to the prototype of the vehicle given by Nurol Makina and its relationship with other parts. A strain gauge-based design was used to measure the tension of the v-belt in the vehicle. Strain gauges selected according to their dimensions, limits and use were placed on the idle pulley with the help of a pin. The figure 1 shows the pin. This pulley is one of the elements that the v belt is connected to.

The effect of the force created by the tension of the belt on the idle pulley is converted into a value with strain gauges. Thanks to copper cables, this value is transferred to the information center. Thanks to the algorithm in the control center, this value is converted to the tension value and given to the user. But this value is kept in the system where it is used to adjust the tension.

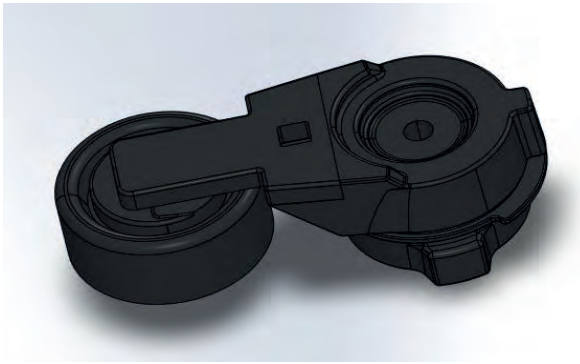


Figure 4 : Belt Tensioner

After this point, a tensioner which is shown in figure 2 is used to keep the belt tension at the desired level. Thanks to the obtained tension value, another algorithm calculates the tensioner's movement. This calculated movement shows how many degrees the tensioner will turn and in which tension range the belt will be held. This calculated information is transmitted to the tensioner again, this time with copper cables.

Idle pulley, copper cables, strain gauges and the control center where the algorithm is located will be purchased without processing or will be obtained from Nurol Makina. The pin used for measurement, which we placed on the Idle pulley, will be processed and made ready by CNC machines.

Outcomes

This system is a mechanical design project that combines the mechanical engineering knowledge acquired at statics, control systems and mechatronics courses. It is done in several steps through the 2022-2023 academic year given as below:

- Literature research
- Engineering analysis including:
- Control system construction and analysis
- Mathematical modeling
- Static and Fatigue analysis
- CAD drawings
- Safety Analysis
- Planning of manufacturing processes, assembly, design verification and testing of the system