BILKENT UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

INDUSTRIAL DESIGN PROJECTS

2018 – 2019

Editors: Dilara Uslu, Müjdat Tohumcu, Yıldıray Yıldız

June 2019

Printed in Meteksan Matbaacılık, June 2019

Publisher Certificate Number: 27028

Printing House Certificate Number: 13563

ISBN: 978-605-9788-30-4

"Para ile satılamaz. / ***For free distribution only"***

Bandrol Uygulamasına İlişkin Usul ve Esaslar Hakkında Yönetmeliğin 5. maddesinin 2.fıkrası çerçevesinde bandrol taşıması zorunlu değildir. / ***According to the second paragraph of Article 5 of the Regulation on Banderole Application Procedures and Principles, the use of banderole for this publication is not compulsory.***

CONTENT

PREFACE

The primary goal of university-industry collaboration is to provide future engineers with a broad understanding of industry and business. In support of this goal, we have a twosemester long design activity for the senior-level students. This year, fourteen groups, each consisting of 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, but also bring out their creativity in both the design phase, which is completed in the first semester, and in the manufacturing phase in the second semester.

At the project fair, the students are provided with a unique opportunity to present detailed design specifications of their products and the manufactured prototypes. The fair and this booklet demonstrate the design and manufacturing goals, constraints, challenges, and, of course, the students' efforts that led to their accomplishments. The continuous guidance and advice provided by their academic and industrial mentors, instructors, and teaching assistants are very much appreciated.

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.

Adnan Akay
Professor and Chair
Mechanical Engineering Department
Bilkent University

LIST OF CONTRIBUTORS

Supporting companies and organizations:

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

Bilkent University Industry Cooperation - Graduation Projects Coordinator: Yeşim Gülseren

Industrial mentors:

Prof. Dr. Adnan Akay (BILKENT UNIVERSITY)
Dr. Şakir Baytaroğlu (BILKENT UNIVERSITY)
Mustafa Çökmezoğlu (ROKETSAN)
Mehmet Alp Ertemir (NUROL MAKİNA)
Hüseyin Avni Güner (ROKETSAN)
Gürkan Güven (TÜRK TRAKTÖR)
Ali Murat Kayıran (ASELSAN)
Burçak Özonuk (BILKENT ANAOKULU)
Hamza Tarık Öztürk (ARÇELİK)
Dr. Hadi Sedaghat Pisheh (BILKENT UNIVERSITY, Hanay Research Group)
Ersun Sözen (FORD OTOSAN)
İhsan Burak Temeltürk (ROKETSAN)
Ozan Temiz (FORD OTOSAN)

Eser Üncüer (FNSS)
Hasan Mert Yetkin (GALEN GRUP)
Muhammed Yüksel (ROKETSAN)

Academic mentors:
Prof. Dr. Ömer Anlağan
Dr. Şakir Baytaroğlu
Asst. Prof. Dr. Luca Biancofiore
Asst. Prof. Dr. Melih Çakmakcı
Asst. Prof. Dr. Yegân Erdem
Asst. Prof. Dr. Selim Hanay
Asst. Prof. Dr. Onur Özcan

Teaching Assistants:
Cem Aygül
Levent Dilaveroğlu
Cem Kurt
Berkay Şahinoğlu
Alper Topuz
Dilara Uslu

Department Staff:
Ela Baycan

Mechanical Engineering Society:
Ekim Ekiz
Eda Kaplan
Batuhan Emre Kaynak
Alkım Büke Özduran
Yiğit Ünveren

Lecturers on Seminers:
Teamwork: Serdar Bilecen
Video and Poster Editing Workshop: Berkay Çelik
Introduction to Ostim: Nejat Ulusal
Business Life at FNSS: Gökhan Özyurt
R&D conversation by Ford Otosan: Ömer Rüştü Ergen, Berzah Ozan and Özür Ali Aktaş

MOBIUS (A1)

Incubator Device to Keep Single Cell Alive for Cancer Therapy

Özgür Ak	Turan Kerem Boy	Kaan Burak Karagöz	Arif Alkaç	Yücel Ataç	Ege Marangoz	Yaşar Kubuş

Academic Supervisor: Dr. M. Selim Hanay

Industrial Supervisor: Dr. Hadi Sedaghat Pisheh

- ABSTRACT-

The objective of this project is to design a closed chamber system which will be used to keep single cancer cell alive for cancer therapy. For keeping cell alive for desired time slot, the following parameters are controlled: Temperature, pH level and relative humidity. Literature survey, designing, manufacturing and testing steps have been followed. While developing the project, essential codes and standards were taken into consideration to make the system manufacturable and safe. Managing the cost of the project was also another important constraint. After the designed parts were manufactured and the selected components were purchased, the chamber system was completed by performing the associated tests.

Problem Definition

An incubator is a device used to grow and maintain microbiological cultures or cell cultures by maintaining optimal temperature, relative humidity and other conditions such as the CO_2 and O_2 content of the atmosphere inside. Incubators provide this by supplying a desired gas mixture with desired homogeneity and desired relative humidity into the control volume of the culture, while maintaining temperature control by means of various types of actuators, depending on the incubator type and application.

Due to their solid state nature and sustainability, incubators are essential for a lot of experimental work in cell biology, microbiology and molecular biology and are used to culture both bacterial as well as eukaryote cells. In recent microbiological applications, they can also be used to maintain single cells for research purposes, particularly for research concerning diseases like cancer, which is the purpose of the project problem.

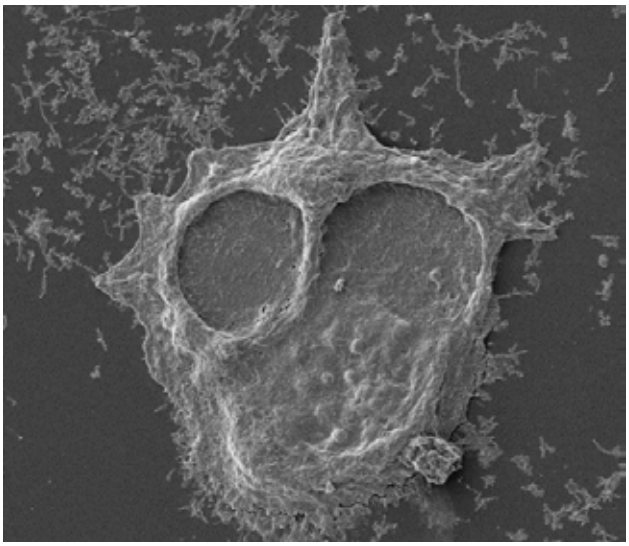


Figure 1. Cancer Cell Under an Electron Microscope[1]

A custom incubation device was demanded by the Mechanical Engineering Department of Bilkent University, whose aim is to keep a single cancer cell placed on a Lab-on-a-Chip (LOC) inside a small chamber alive for 36 hours, also allowing for live microscope observation of the cell in the meantime. To this end, the incubator is controlled in terms of temperature, relative humidity and CO_2 content of the chamber with the given constraints:

Constraints	Sensitivity
Temperature	+/- 0.5°C
Relative Humidity	1%
CO_2	2%

Table 1. Constraints of the Project

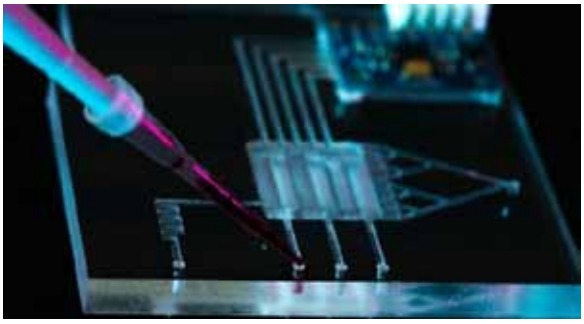


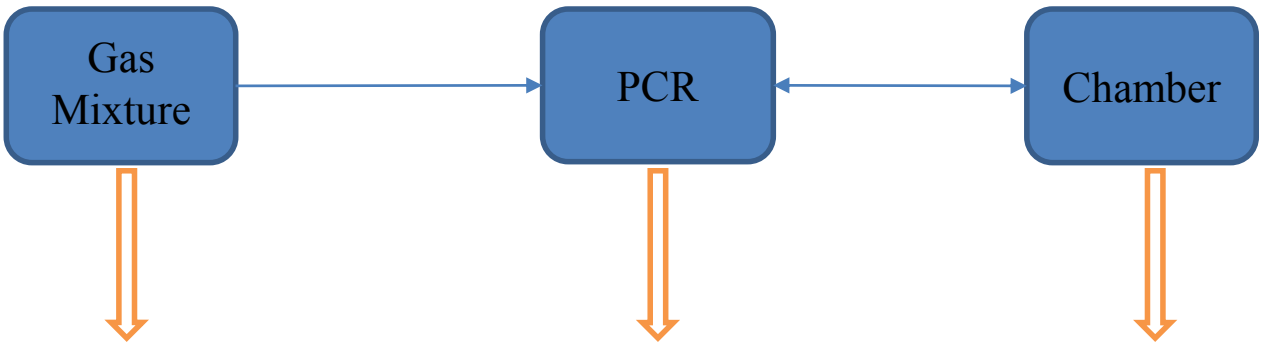
Figure 2. Lab-on-a-chip[2]

Although there are numerous incubators in the market for similar applications, none can be directly integrated into the research process due to their sensitivities in measuring the given parameters simultaneously not matching the desired constraints. Hence, a fully customized solution had to be proposed.

[1]Praetorius, Dean, and Dean Praetorius. "This Is The Face Of A Killer." *HuffPost*, HuffPost, 7 Dec. 2017, www.huffpost.com/entry/breast-cancer-cell-photo_n_905676.
[2] "Lab-on-a-Chip for Tracking Single Bacterial Cells - EPR." *European Pharmaceutical Review*, www.europeanpharmaceuticalreview.com/news/72373/lab-on-a-chip-bacterial-cells/.

Design

Separating the heating process of the gas mixture from the chamber that placed under the microscope was important to protect the cells from the temperature fluctuations. This requirement led to design a second chamber which is named as preconditioning room. All the heating, humectation and arranging the CO_2 percentage processes are controlled in the preconditioning room(PCR). The gas mixture transferred to the chamber after desired conditions are provided.



For providing the optimal conditions for keeping cells alive, 95% air and 5% CO_2 premixed gas is used.

- For heating process, Peltier elements are used to minimize over-shoots.
- For humectation process, ultrasonic nebuliser is used.
- More sensitive sensors are used in preconditioning room because necessary adjustments are done in there.

Chamber provides a substantial experiments with its ergonomic design. It is integrated with Lab-o-a-chip.

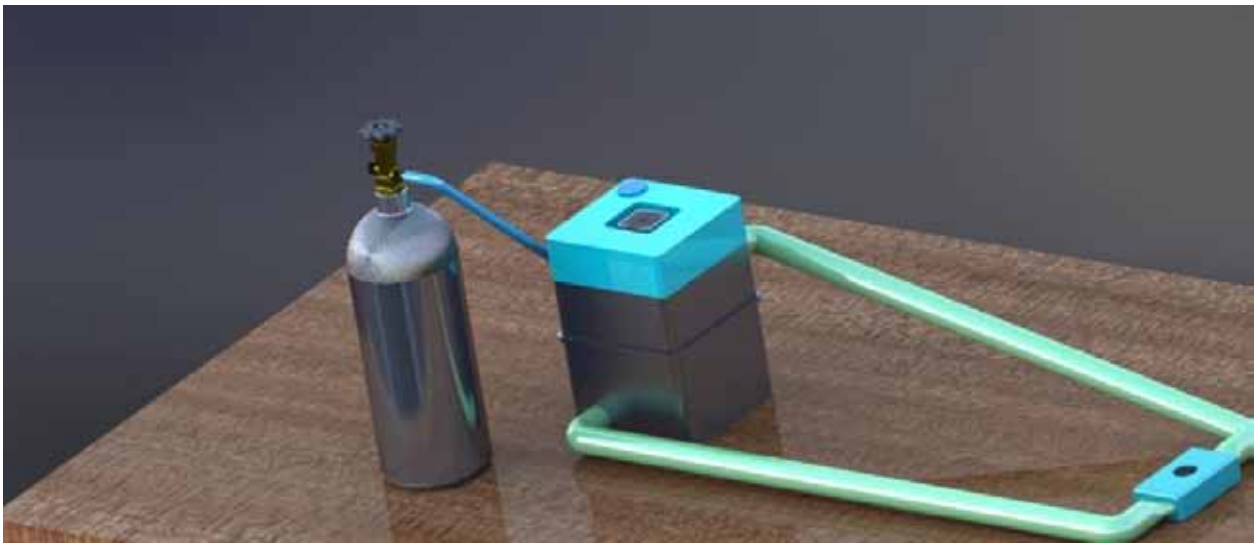


Figure 3: Final Version of Incubator System

Peltier elements in a thermoelectric cooler (TEC) setting, driven by a TEC controller is used to control the temperature of the preconditioning room and incubator.
Controlling various peripherals which consists of sensors and actuators used in the microscope incubator will require a control center which is called programmable logic controller (PLC). For this project Ardunio is used.

Outputs

Results:

- ✓ The main purpose of the project was to design and manufacture an incubator which could be integrated with the Lab-on-a chip device under the microscope for the observation of cancer cells. According to conducted test and observations, the incubator device and preconditioning room system are well integrated with the Lab-on-a chip device and capable of observation of cancer cells.
- ✓ System met all of the requirements such as physical constraints defined in problem statement, cost constraint, codes and standards, therefore the system can be used in laboratory applications for the purpose of cancer cell observation for 36-hour period.
- ✓ In order to use the designed system for a long time, the following criteria were taken into consideration:
    - Chamber was designed and manufactured from 3D printer so that whenever there is a wear or malfunction in it, it can be removed and replaced, or maintenance can be done at any time. The chamber which is designed apart from heating and other requirements has prevented errors in other parts of the system from affecting the chamber system. In this way, sustainability of the system was achieved.
    - Preconditioning room is designed to be divided into two from the half at any time. In this way, errors that can occur related to sensors, heating and humectation systems can be controlled during the service time and maintenance can be done at any time.
    - Premixed gas was used in the system. In this way, a mechanism whereby the user can integrate the desired gas mixtures to the system with the purpose of flexibility.

Outcomes:

Theoritical knowledge that learned during the academic life has transferred to the practical applications with this project. This project has prepared us for the industrial area with the applications such as design procedure, documentation, manufacturing, presentations and time management. During the project, not only lots of engineering calculations are procedeed but also engineering approach is followed. Thermodynamics approach, control engineering and material science are the basis of the project, therefore, the outcomes from these areas are consolidated.

Programs that are used during the construction of this project and the benefits acquired for the future career are listed as follows:

- Deep Literature Searches
- Analytical Thinking
- Engineering Analysis
    - -CFD Analysis
    - -Matlab
    - -Ardunio
- Solidworks Drawings
- Test Mechanisms And Procedures
- Manufacturing Processes
- Time And Cost Management

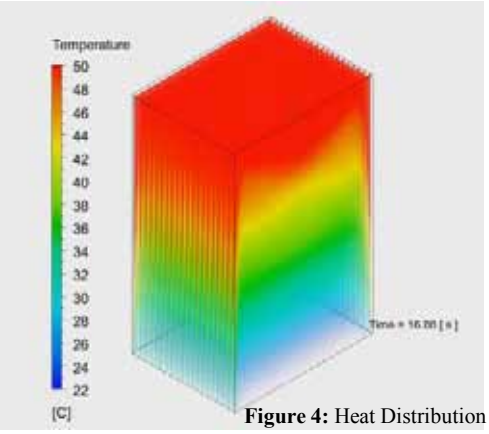


Figure 4: Heat Distribution

IMECH (A2)

Development of Spare Wheel Carrying Mechanism for Military Vehicles

Academic Supervisor: Prof. Dr. Ömer Anlağan

Academic Supervisor: Dr. Şakir Baytaroğlu

Industrial Supervisor: Mehmet Alp Ertemir

- ABSTRACT-

The objective of the project is to design and manufacture a spare wheel carrier mechanism which will be used in armored vehicles. Development procedure consists of computer aided design of the system, analysis and simulations, manufacturing and testing of the components. During these process several constraints need to be satisfied such as: operational, economic and manufacturing constraints, manufacturability and safety. By taking into consideration these requirements; a spare wheel carrier mechanism has been developed, manufactured and tested.

Problem Definition

The aim of the project is to develop a spare wheel carrying mechanism for Nurol Makina's armored vehicles. In the current mechanism, the spare wheel is connected to the back door of the vehicle and requires a movement to open the back door. However, since the spare wheel is so heavy to be lifted by hand, an additional electrical crane is used.

The main problem of the current mechanism is that the spare wheel cannot be lifted down while back door is opened. Being obliged to close the back door before lifting operation reduces the practicality of the system. As a result, new mechanism is designed to remove this downside. New mechanism pushes the wheel out when door is opened and pulls when wheel back when door is closed. This solution enables the lifting operation to be performed independent of the position of the back door, consequently improving the practicality.

Figure 1. The spare wheel carrying mechanism on Ejder Yalçın

Additionally, a nonintegrated electrical crane causes a problem such as a need additional effort to mount it on the vehicle each time when it is necessary. Solutions of these problems are listed below:

- The spare wheel carrier mechanism must be used whether the back door of the vehicle is opened or closed and the spare wheel should not hit to the back side of the vehicle.
- The crane must be integrated on the mechanism.
- A mechanical crane must be preferred instead of electrical one.

Figure 2. The location of spare wheel on the armored vehicle

Therefore the main objective of this project is to design, analyze and manufacture a spare wheel carrying mechanism for armored vehicles. The mechanism must satisfy reliability and maintanence requirements by considering harsh environmental conditions and the military standarts.

Design

The given process is followed during the project: Several solutions are considered and the most feasible one is determined. The system will be attached to the back side of the vehicle by two supports. Several axles are placed to allow the system to rotate The components and whole design are given in the figures placed below.

Basically the design procedure belonging to this system can be summarized as follows:

Literature survey → Virtual system → Prototype and tests → Final design

To design, analyze and manufacture a spare wheel carrying mechanism which satisfies requirements of the military and adaptable to the military vehicles.

After these procedures are completed, the requirements are completely satisfied.

➢ Other requirement is that the system could be opened at 90 degrees.

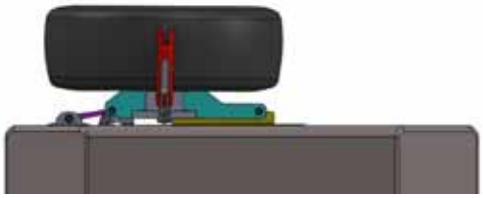


Figure 3. The spare wheel carrying mechanism when the back door is closed

Figure 4. The spare wheel carrying mechanism when the back door is opened

➢ The winch must be fully manual

Figure 5. The manual winch

➢ Most important requirements is designing a system that can carry the spare wheel, which weighs 180kg, under 4.5g of acceleration.

Figure 6. The spare wheel carrying mechanism

Outputs

Results:

- ✓ Main purpose of the design is to make the carrying and changing applications of the spare wheel easier for soldiers. Under the operation, electrical components for lowering and lifting the spare wheel is problematic since energy source could be damaged easily. Therefore, fully mechanical spare wheel carrier is more reliable than that of with electrical components. Hence, using mechanical winch make the process much more easy and compatible to any situation.
- ✓ System satisfied all the requirements defined in the problem statement and can be used in military vehicles.
- ✓ System does not prevent the required features of vehicle

Electrical Winch Manual Winch

Outcomes:

This project is consisted of several steps. In each step lots of engineering calculations are proceeded. Additionally, analysis and simulations are also used to see strength and the motion of the mechanism. Throughout this project all of the pre-learned engineering procedures are used, these can be listed as follows consisting of the software that are used:

- Literature searches
- Analytical thinking
- Team work
- Engineering analysis:
  - Comsol
  - Ansys
- CAD Drawings:
  - Solidworks
  - Catia
- Test mechanism and procedures for military standards
- Manufacturing processes

Practical implementations of theoretical information is observed by the students. Proficiency in offive and engineering softwares have been improved. Manufacturing methods and corresponding design adjustments have been observed. Students gained depper insight into enginnering applications while improving their teamwork skills.

VISIOM (A3)

Design and Production of Aerial Vehicle, Releasing a Useful Load on the Land Marked on the Land Photograph

Academic Supervisor: Asst. Prof. Emine Yegan Erdem

Industrial Supervisor: Hüseyin Avni Güner

- ABSTRACT-

The purpose of this study is to design and produce an aerial vehicle which uses computer vision system for navigation and releases a useful load on the marked area. Using GPS navigation systems in enemy territory is not reliable since GPS signals can be jammed or spoofed. Therefore, this design comes up with an alternative solution for navigation systems. Throughout the project, literature research, design processes, manufacturing, code design and optimization and testing procedures are conducted. At design stage there were some constraints that needs to be considered as flight time, flight distance and accuracy of release system. By considering these constraints an unmanned aerial vehicle has manufactured.

Problem Definition

In modern systems, the location of the airborne systems are determined with GPS and RF signals.. However, GPS is not a valid solution on a guidance system for an There are many navigation interference systems such as GPS spoofing or RF Jamming. Controlling the aircraft by RF signals is not a reliable solution for a guidance system. Radio frequency (RF) jammer device is used to prevent the operations of the aircraft. This disruption may lead to several results;

- landing on the spot,
- halting any further movement
- enabling return to "home" function,

Spoofing refers to taking the control of an aircraft by a third party by impersonating the remote control. This allows the third party to take over the aircraft and direct the flight, download data from the aircraft or view its camera feed [1]. Jamming and spoofing are very common disruption technologies which are used in military operations.

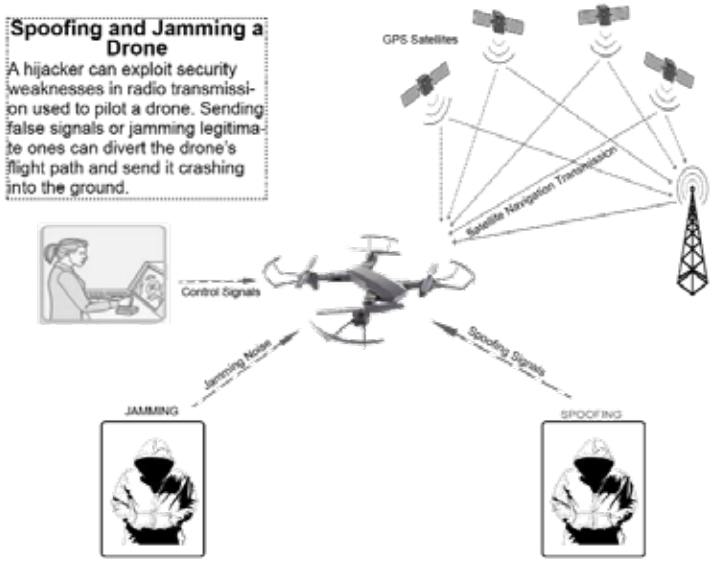


Figure 1. Spoofing and Jamming a Drone

This project is asking for an autonomous UAV that cannot be manipulated by RF Jamming or GPS spoofing. This system will find the desired location without a GPS and drop a payload on the target. To perform this task, a computer vision system will be implemented to a quadcopter by a camera and a single board computer. It will detect the predetermined objects on the ground. And then, it corrects its' direction with the help of electronic compass and continues to perform its mission until it reaches final destination.

Operating time	• 8 minutes - 15 minutes
Payload Mass	• 50-150 g
Flying Height	•20 meters – 40 meters*
Navigation Constraint	•Navigation without GPS and RF

[1] "A Primer on Jamming, Spoofing, and Electronic Interruption of a Drone," *Dedrone Blog - A Primer on Jamming, Spoofing, and Electronic Interruption of a Drone*. [Online]. Available: https://www.dedrone.com/blog/primer-jamming-spoofing-and-electronic-interruption-of-a-drone. [Accessed: 25-Mar-2019].

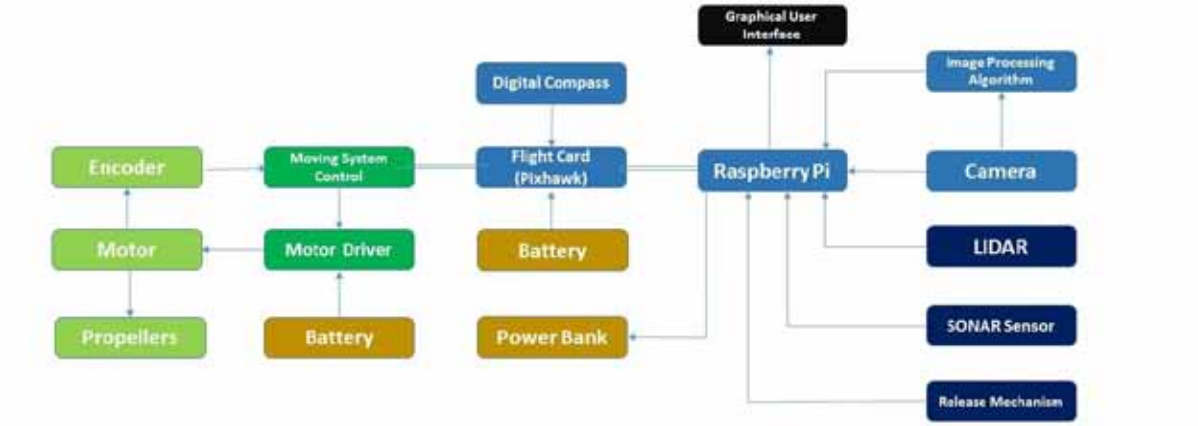
* For demonstration purposes the flight height will be between 3-5 meters.

Design

In order to satisfy design requirements final system should include two main subsystems. Those are

- image processing subsystem for navigation
- release mechanism for releasing payload.

Navigation system is chosen as image processing computer vision which is supported by electronic compass. Quadcopter consists of battery, ESC (Electronic Speed Controller 60A), brushless motors (30A), propellers, flight card, and quadcopter chases. Computer vision system consists of camera, gimbal, single board computer. Solenoid is to be used for the release system.



A graphical user interface is developed to let the user operate the autonomous system beforehand. After that, the image processing algorithm proceeds the live camera data with the proximity sensors and the digital compass. Accordingly, the flight card is informed on how to fly by the flight algorithm.

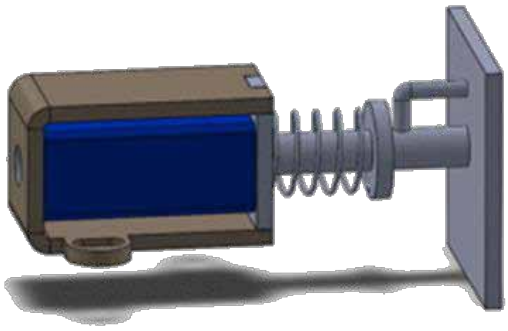


Figure 2: Solenoid Release Mechanism

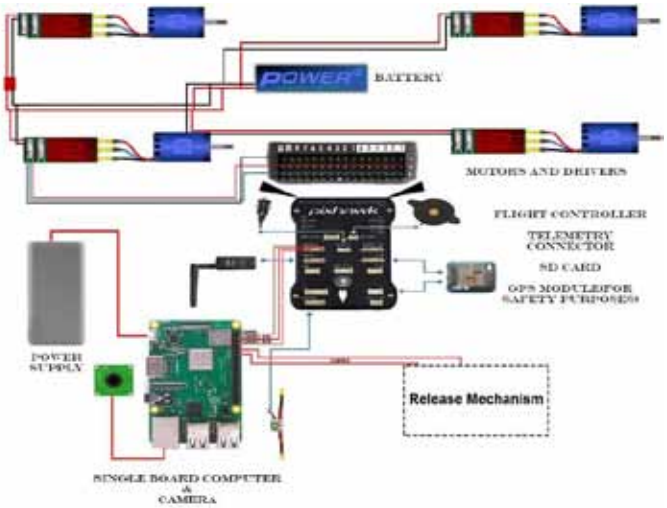


Figure 3: Schematic Representation of Electrical Setup of Components

Outputs

Results:

- ✓ The main purpose of the project is to design and produce an aerial vehicle which uses computer vision system for navigation and releases a useful load on the marked area.

- ✓ The quadcopter satisfies all of the requirements and constraints which were given in the problem statement.

Figure 4: Quadcopter

Outcomes:

- ✓ This project will pave the way for people to accomplish such a mission, since conducting this project required detailed literature research on how to control a quadcopter through an autonomous system instead of radio control.

- ✓ The group has worked on mechanical, electrical and software components of the project.

NORMECH (A4)

Development of Non-Destructive Bonnet Fatigue Testing Machine

Academic Supervisor: Prof. Dr. Ömer ANLAĞAN

Industrial Supervisor: Gürkan GÜVEN

- ABSTRACT-

Main purpose of this project is to develop a fatigue testing machine for bonnets manufactured at Türk Traktör. Development process consists of literature research, design, manufacturing and testing. While designing the fatigue test machine, various constraints were taken into account such as material constraints, size constraints, weight constraints, manufacturing constraints and economic constraints. By taking into consideration these conditions, a non-destructive bonnet fatigue testing machine is designed, manufactured and tested.

Problem Definition

Fatigue tests are made with the objective of determining the relationship between the stress range and the number of times it can be applied before causing failure. These tests are performed by fatigue test machines which are used for applying cyclically varying stresses and cover tension, compression, torsion and bending or a combination of these stresses [1].

Throughout this project, a fatigue testing machine will be developed for tractor bonnets. This machine will determine a single axial stress, while lifting the bonnet to a certain angle with the help of pneumatic actuators and suction pads and while lowering, it will close the bonnet up to a point at which the bonnet can fall with its own weight. In addition, as a requirement, a latch opener will be developed to unlock the bonnet in order to lift it up.

Figure 1: Tractor Bonnet Opened

Türk Traktör currently uses a system that damages bonnets and lacks a control unit system which causes a long test process. It is observed that the current system is both costly and operator-dependent. Therefore designing and manufacturing the fatigue test machine will decrease the human resource used and eliminate the damage done to the bonnet.

The currently used fatigue test machine in TürkTraktör is inadequate since the test takes a long time to complete and requires more human resources. For current test setup, it is also required to drill new holes on the bonnet to attach the lifting arm. This procedure ruins the tractor bonnet. For this reason, a new alternative is necessary.

The main purpose of this project is to eliminate the damage done to the bonnet and reduce operator-dependency of the system. Also, the new mechanism must be applicable to every type of tractor bonnet manufactured in TürkTraktör. It is known that making engineering analysis, designing and manufacturing the bonnet lifting/lowering mechanism by using local sources is significant, as it will satify the need of the sector and decrease the import.

Figure 2: Current Used System

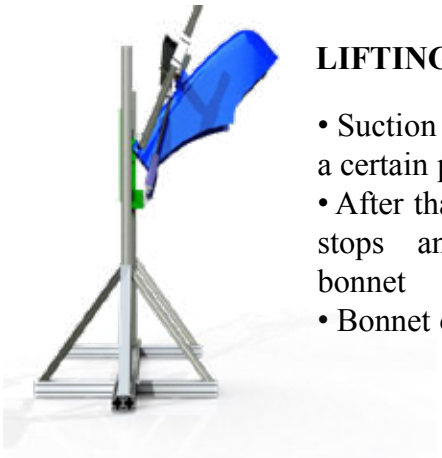
[1] What-is-Fatigue-Testing. (n.d.). Retrieved from https://www.ametektest.com/service-and-support/faq/what-is-fatigue-testing

Design

Considering the problem definition and constraints, a solution was reached. This solution consists of dual adjustable vacuum/suction pumps with portable platform and pneumatic actuators. Basically, it is a structure that lifts and lowers the tractor bonnet with the help of suction pads connected to its horizontal beam. The design system is demonstrated in figures below.

The design processes can be summarized simply:

The emphasized processes confirmed that the solution found resolves the problem. The working principle of newly designed mechanism satisying the requirements is based on converting energy from compressed air into mechanical energy by pneumatic actuators and using the converted to energy to lift/lower a tractor bonnet. The system is mathematically modeled to specify the circular trajectory of the horizontal frame and the bonnet. The motion of the horizontal frame is maintained by pneumatic actuators and a stopper mechanism assists the motion by nullifying any axial force on the horizontal bars. Engineering analysis ensures that the solution remains within the constraints defined. Two different state of the design can be seen below:

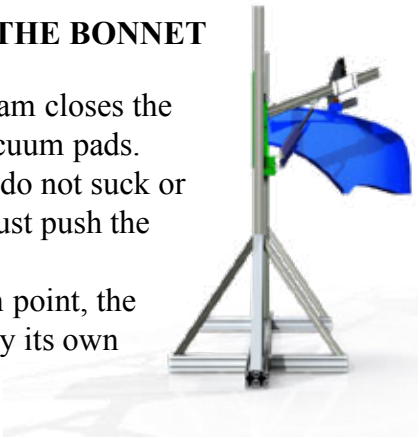


LIFTING THE BONNET

- Suction continues until a certain point.
- After that point, suction stops and leaves the bonnet
- Bonnet opens

LOWERING THE BONNET

- Horizontal beam closes the bonnet with vacuum pads.
- Vacuum pads do not suck or blow air, they just push the bonnet
- After a certain point, the bonnet closes by its own weight.



DESIGNED MECHANISM

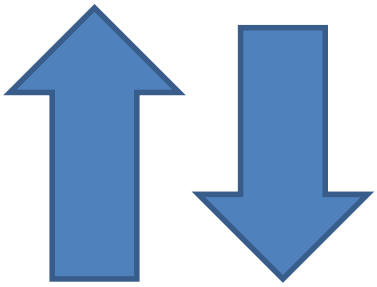
Outputs

Results:

- Apart from the technical aspects of the design, the main purpose of the project is to eliminate the damage to the bonnet and reduce human resource used. This project proved that it is possible to design and manufacture a fatigue test machine by domestic sources. Therefore, the cost reduced and technological experience gained.

- Prototype and tests proved that the analysis and simulations of the system were free of error.

- The system has met all requirements declared in problem definition and can be used for tractor bonnets in TürkTraktör.



Before starting our careers as engineers, we had the opportunity to create a fatigue test machine from scratch. On top of that, we were able to apply what we previously learned theoretically to real life. We have experienced all one-to-one production stages.

Outcomes:

This project has been a long journey and had several phases. Every phase, many engineering calculations were performed. However, these are not the only path followed. The analysis and simulations such as mathematical modeling of the bonnet and frame and stress analysis of the critical components are also benefited from. Engineering stages taught clarified our progress throughout the project. Information used throughout the project is:

- Literature
- SolidWorks
- Comsol
- Test Material and Tools
- Production and Assembling

MECHANICAL UNITED (B1)

Designing and Manufacturing of a CNC Lathe Machine

Emre Alper	Mert Onat	Abdülkadir Dilmen	Kadri Onuk	Erdem Karaca	Berke Daloğlu	Ahmet Varol

Academic Supervisors: Prof. Dr. Ömer Aka Anlağan
Dr. Şakir Baytaroğlu

Industrial Supervisor: Eser Üncüer

- ABSTRACT-

The purpose of this study is to design and develop a CNC lathe machine for educational purposes aiming micrometer sensitivity. This project aims to introduce a CNC lathe machine that is suitable for students with zero experience to use and produce the final product with gaining familiarity with the operating conditions of CNC lathe machine, generation of the G-Code, satisfying the safety requirements of similar products. By taking into consideration these requirements; a CNC Lathe Machine has been developed, manufactured and tested.

Problem Definition

For both educational and usability purposes, there is a need of developing a manual lathe machine into a CNC lathe machine. Available CNC machines in the market generally made for the industry purposes and both technical parts and user interface are ready to use for well-experienced people. This situation makes CNC lathe machines expensive and hard to learn the basics of the working principles and software behind them [1].

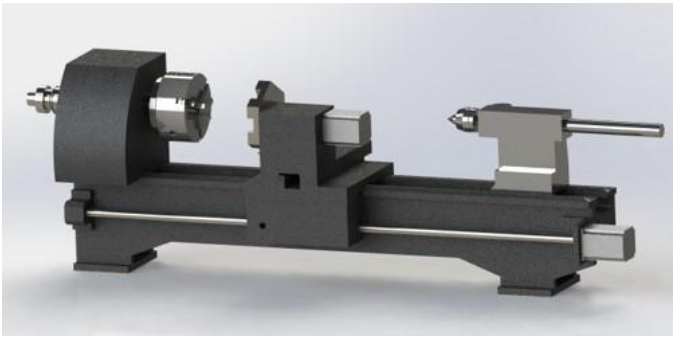


Figure 1: The main components of the CNC lathe machine.

The main purpose of the aimed design of the CNC Lathe machine is to be used for the education of the students and to provide students to have a chance to get experienced in one of the most commonly used manufacturing method with all aspects such as CAM programming, G-Code generation, working principles of the machines, and to bring out desired product from the theory behind the process along with the manufacturing of useful parts.

Developments which will be implemented to the system are the movement of the axes will be fixed and measured by the encoders, a rigid table will be put under the lathe bed in order to prevent vibrations which will cause higher tolerances in the manufacturing, a user friendly software will be written and implemented to the software in order to serve the educational purposes fully and a safety cover around the workspace which is needed for the safety and usability regulations.

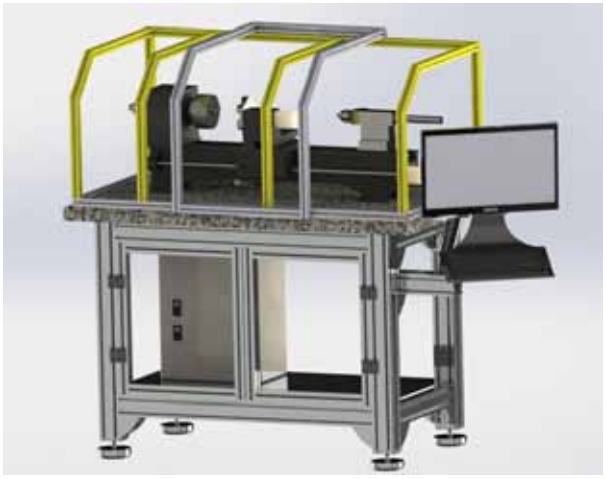


Figure 2: Assembled components of the CNC lathe with enclosure.

Therefore the main purpose of this project is to design and manufacture a CNC lathe machine with its' own user friendly software that meets all the required criteria to serve for engineering students' education as a domestic produced product.

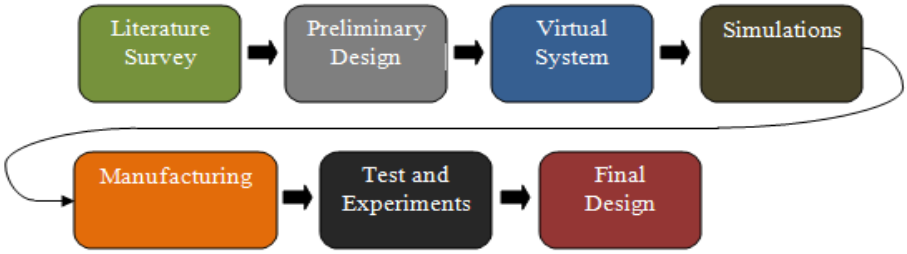
[1] "Is CNC Lathes different from 3-D Printer," Colchester CNC, 13-Jan-2018. [Online]. [Accessed: 04.11. 2018].

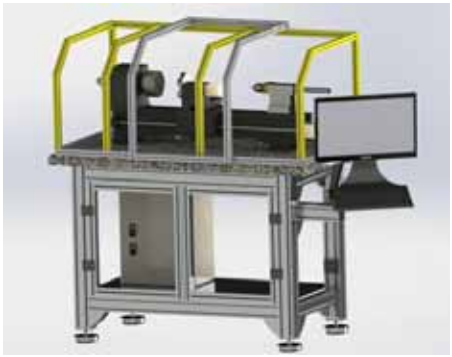
Design

As a solution to the problem definition given previously, we came up with a design that you can see below. This solution provides both manual and computer numeric controlled usage of the lathe.

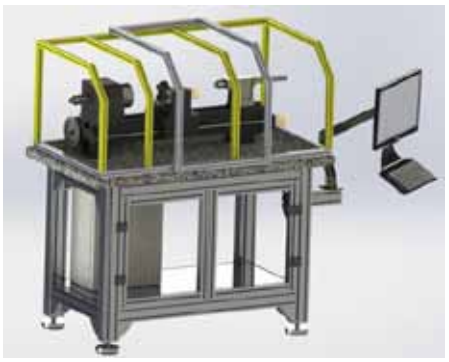
Designing and manufacturing of the system has many substeps and they can be visualized as follows:

To design, analyze and manufacture an CNC Lathe machine using **local sources**, which can be used safely for educational purposes thanks to its easy-to-use design and software.





Right View



Left View

After completing these substeps consecutively, we have completed our project successfully. The designed and manufactured CNC Lathe machine satisfies the needs of educational purposes as well as safety features. System computer is embedded with Mach3 as well as the software that we made ensuring a better understanding of the CNC programming basics. Control box will control the system electronics and motors and protect users from electric shocks by electrical breakers and residual-current relay. Upper encloser will provide users a good view along with safety if a part breaks during working.

Included Extra Features to the System:

- Breakers and Residual-Current Relay
- Start-Stop Switches
- Emergency Buttons

} For Safety

- Lighting
- Camera for Close-Look Monitoring
- User Interface
- Manuel or Automatic Control

Outputs

Results:

✓Main purpose of this study is to design and develop a CNC lathe machine for educational purposes aiming micrometer sensitivity. Considering that ready-made products are expensive and complicated to use, the project will give students insights about CNC machines and their controls.

✓System can work automatically with computer or manually with handwheel.

✓System is working properly with all the safety and emergency features.

✓System satisfies all of the requirements and constraints as well as some additional features.

✓Designed software is easy to use and efficient in generating G-codes.

Outcomes:

This project procedure consisted of several substeps. In each step lots of engineering calculations and computer simulations proceeded. Analysis and simulations are used mainly in vibration analyses. Throughout this project not only the engineering knowledge are used, but also we have learned the manufacturing steps and their processes. Some of which can be listed as follows:

- Literature Search
- Analytical Thinking
- Preliminary Designs
- Engineering Analysis
  - -COMSOL Simulations
  - -SolidWorks Analysis
- Finalization of the Design
- Manufacturing processes
- Vibration Tests and Experiments
- Calibrations for Accuracy and Persistency

Throughout the project, we have gained certain skills as a result of the production and manufacturing our own project. Familiarity with production facilities in addition to learning manufacturing processes with experimentation.

BROOM BROTHERS (B2)

Hydraulic Broom Attachment for Forklifts

Berke Yiğit Safi	Deniz Ali Altuntaş	Yalın Yılmaz	Kutlu Türkoğlu	Orkun Batuhan Yıldız	Gamze Nur Tübençokrak

Academic Supervisor: Prof. Dr. Ömer Aka Anlağan

Dr. Şakir Baytaroğlu

Industrial Supervisor: Hasan Mert Yetkin

Project Assistant: Emre Eraslan

- ABSTRACT-

Broom attachment is a system that enables cleaning of the floor by placing at the front of a forklift. The objective of this project is, to design and manufacture a broom attachment that will eliminate using of human force in the cleaning process of factories. This system will be used in cleaning of warehouses/factories and the design will be manufactured using local sources. Several constraints such as economic, aesthetic and operational are followed during the design and manufacturing processes.

Problem Definition

Cleaning of production areas is one of the fundamental challenges companies faced with. Essentially, in factories/ warehouses floor has to be cleaned in a regular basis.

KEY BENEFITS

- *Worker Health*
- *Manufacturing Efficiency*
- *Long Lifetime of the Machines*
- *Easy to Use*
- *High Quality*

The main motivation behind the broom attachment design is to come up with a solution that will make usage of forklifts convenient in terms of cleaning of production sites and warehouses.

Figure 1: Forklift Workers [1]

Most of the attachments are produced as a single product and an employee is needed for operating it or does not include a tank to collect the contaminants.

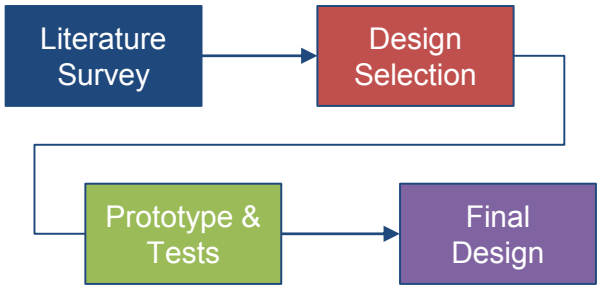
GOAL of this project is to design a broom attachment, which will be attached to forklifts, can accomplish both of the tasks.

The Broom Attachment is a cost-effective addition to the versatility of a forklift. By simply driving the forks into the pockets and connecting to the forklift's hydraulics, it sweeps the most arduous environments in a fraction of the time than conventional methods. The large debris container is opened hydraulically from within the safety of the Forklift Cab.

[1] ''Forklift Workers'', Accessed: *www.pngtree.com*.

Design

For successfully accomplish the problem definition, a broom attachment is developed. As a consequence of the several steps that followed during the design procedure, the main power supply for the attachment is chosen as hydraulic motor because of its advantages over the other alternatives in concern of many criterias. The design procedure can be summarized as:



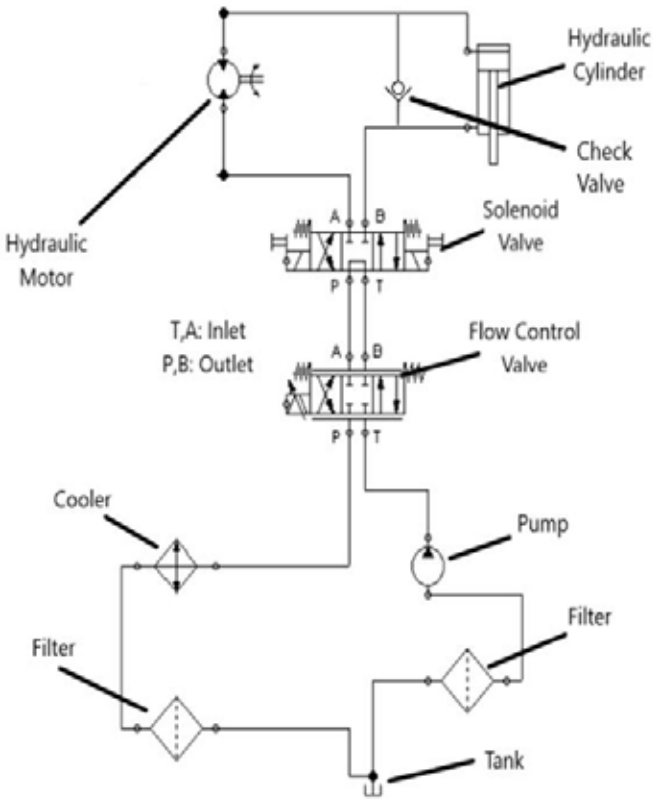


Figure 2: Hydraulic Circuit

The attachment consists of broom. The broom designed in cylindrical shape placed at the end of the attachment to collect dust and particles and transmit into the tank. The rotational movement of the brooms are obtained from the hydraulic motors and the required hydraulic oil for the motors is provided by the forklift's hydraulic pump. Power delivery from motors to brooms is handled by the shafts.

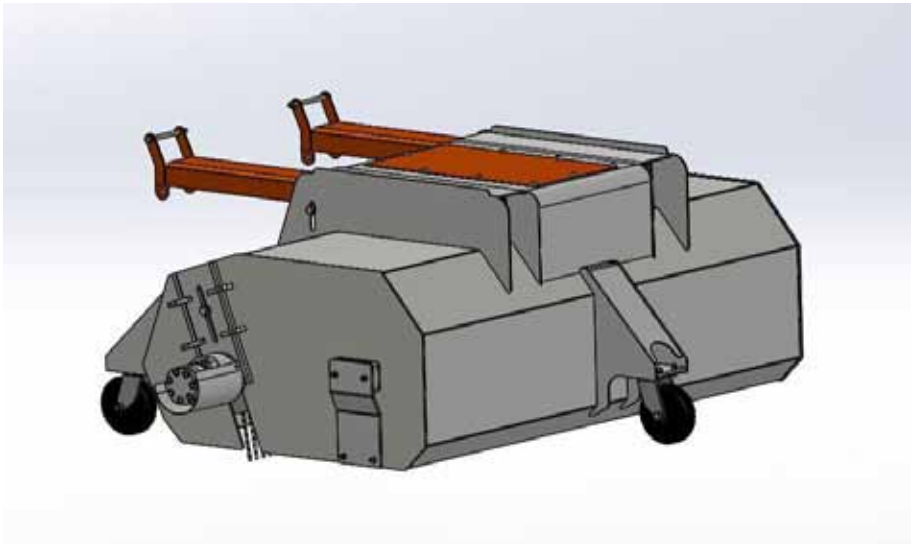


Figure 3: Final Design

Outputs

Results

Cleaning of warehouses is crucial for many reasons such as worker health, manufacturing efficiency. Goal of this project which is to design a broom attachment, which will be attached to forklifts, capable of accomplishing cleaning task with the help of movement of forklift and hydraulic system is achieved. Moreover, safety will be enhanced by putting button into the cab to open/close the collector tank. All virtually fictionalized systems proved to be working even the prototypes and test mechanism.

System satisfied all of the requirements defined in the problem.

Outcomes

This project procedure consisted of several steps. In each step lots of engineering calculations are procedeed. However, calculations are not the only engineering approach that is followed, tests and simulations are also used such as the welding test, dimensional control with 3D scanning and the hydraulic calculations. Throughout this project all of the pre-learned engineering procedures are used, these can be listed as follows consisting of the softwares that are used:

- Deep literature searches
- Analytical thinking
- CAD drawings
- Test mechanisms and procedures
- Manufacturing processes

DRIVEME (B3)

Camera Based Path Planning and Autonomous Drive of Scaled Semi-Trailer Truck in a Port

Ahmet Yasin Oruç	Ege Cenk Köknaroğlu	Şizen Deniz Doğan	Kazım Yüksel	Merve Çetiner	Buğra Beytullahoğlu	Ali Kerem Erdem

Academic Supervisor: Asst. Prof. Onur Özcan
Industrial Supervisors: Ersun Sözen
Ozan Temiz
Teaching Assistant: Levent Dilaveroğlu

- ABSTRACT-

The main aim of this project is to design system that can autonomously drive scaled semi-trailer truck in a scaled port environment. The design problem for this project is to build a kinematic model of an autonomous semi-trailer truck which will be driven by the data taken from the static cameras on the port via image processing and to implement path planning and path following algorithm to be able to drive the truck along the optimal path. To obtain this system; parts of scaled truck and port have been manufactured and their assembly has been made. Image processing, path planning and path following algorithms have been developed and tested by using multiple cameras.

Problem Definition

Autonomous systems have been used especially for cars, robots and also in many production lines of factories for years. The main reason underlying these autonomous systems being used is that companies are trying to apply self-governing systems to make the process faster, safer and cheaper. For this purpose, such an autonomous system can be used in ports in order to transport the goods. Generally, in the ports, cargo are transported without any autonomous systems. The reason behind this is that the infrastructure of the ports and the vehicles are not suitable for some aspects.

In this project, Ford Otosan demands to create a scaled diorama of a harbor and build an autonomous controlled scaled semi-trailer truck. A system is designed to convert an actual truck driving system into an autonomous one. Such a system aims to minimize problems about the human error. These problems cause the majority of the accidents which can be avoided by an autonomous driving.

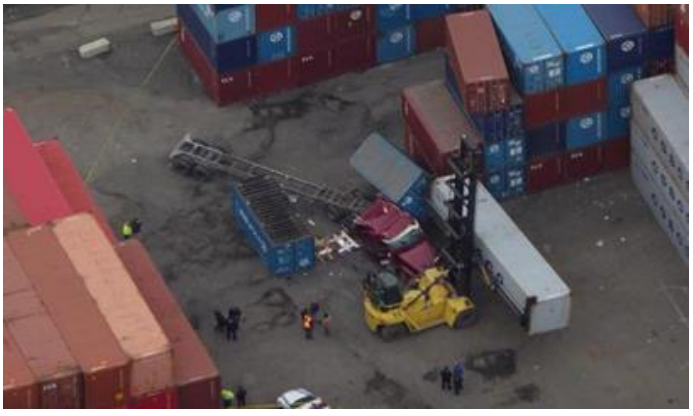


Figure 1: An accident occured in a port [1]

Figure 2: Autonomous Vehicle [2]

Recently, the harbor contains cameras to track the environment and the security of the transportation of the goods. Nevertheless, there is no use of these cameras to observe the whole port and take the image data for the use of image processing. In the scope of the project, in the scaled diorama of the harbor, there are at least two static cameras to observe the whole harbor and collect the image data. Data taken from static cameras are sent to the main station for the image processing. As a result of image processing, the optimal path from point A to point B is determined and then followed by an autonomous semi-trailer truck.

Design

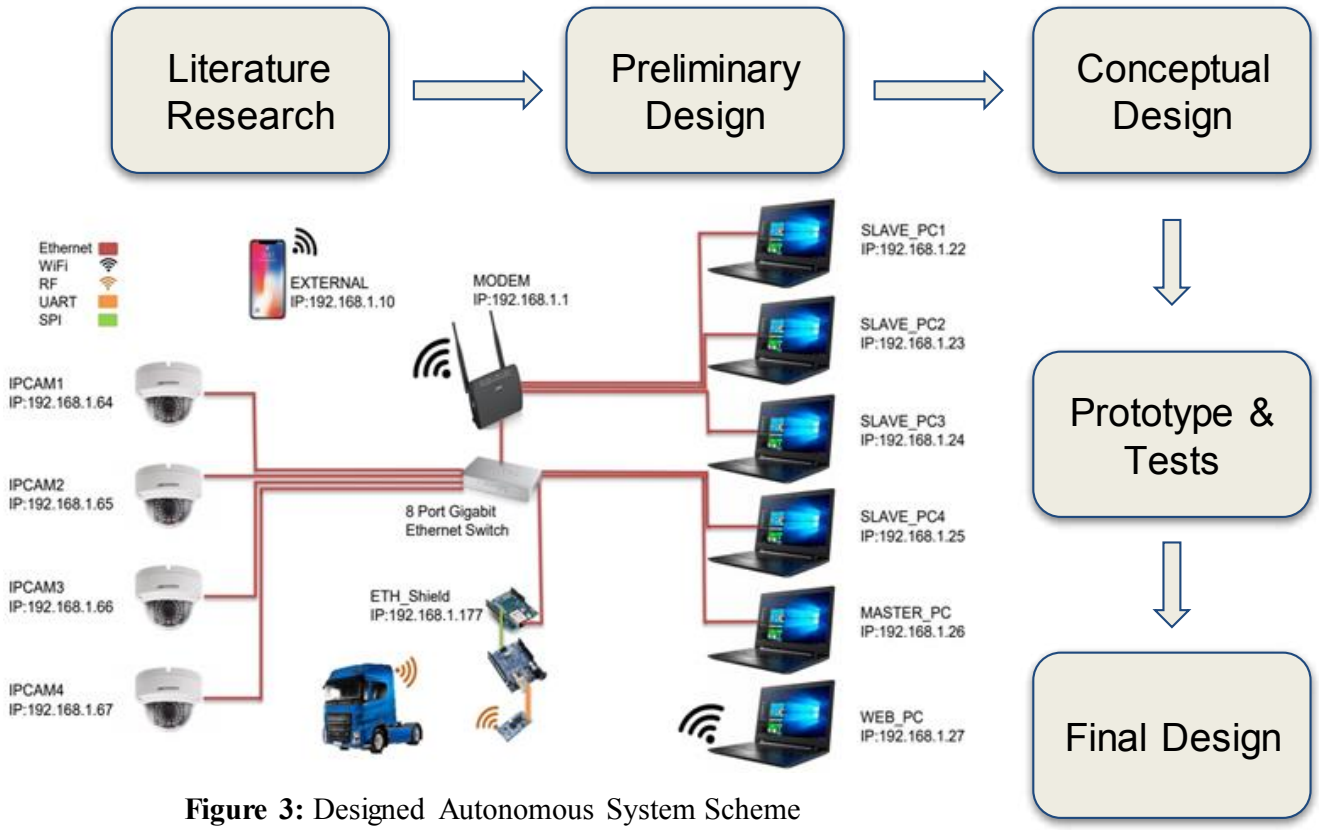


Figure 3: Designed Autonomous System Scheme

1:14 scaled diorama harbour is observed by four IP cameras. Different images taken from these cameras are stitched and getting one complete image. The final image is used to define occupied and non-occupied places in the scaled down port. The information of occupied and non-occupied areas is used to calculate the path between where the truck initially is and the final destination. After path is calculated, the next step is to control the truck via path following algorithm along the path. Through this defined path, some static obstacles may obstruct the motion of the truck. To overcome such an instance, path planning algorithm is working in collaboration with image processing and when an obstacle is detected by image processing, path planning algorithm redefines the path.

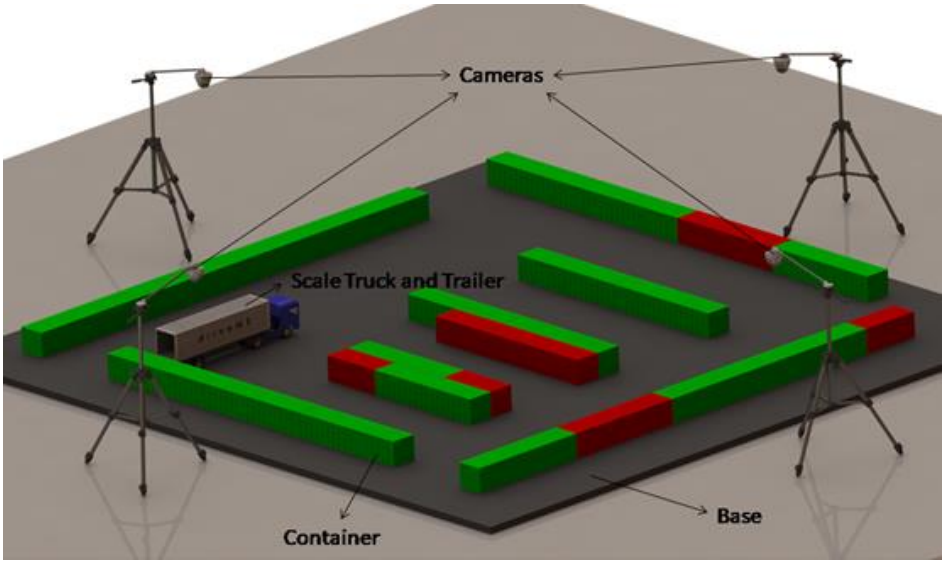


Figure 4: Drawing of Scaled Port and Camera System

Outputs

Results:

- Autonomous truck and trailer system is designed in scale port with the help of path planning, path following, and image processing algorithms which are combined in one system.
- Truck and trailer system avoids static obstacles and follows planned path without the help of any sensor except camera.
- Image processing algorithm stitches four different images, gets bird eye view image of whole port and produces occupancy grid for path planning algorithm.
- Server is established to provide communication between all algorithms. Thus, multiple computer can share computational burdens of different algorithms and system executes fasters.

Outcomes:

Several steps were followed to complete the project. To complete these steps, there was a requirement for information about closed loop control systems, kinematic of vehicles with nonholonomic constraints. The steps of project are as following:

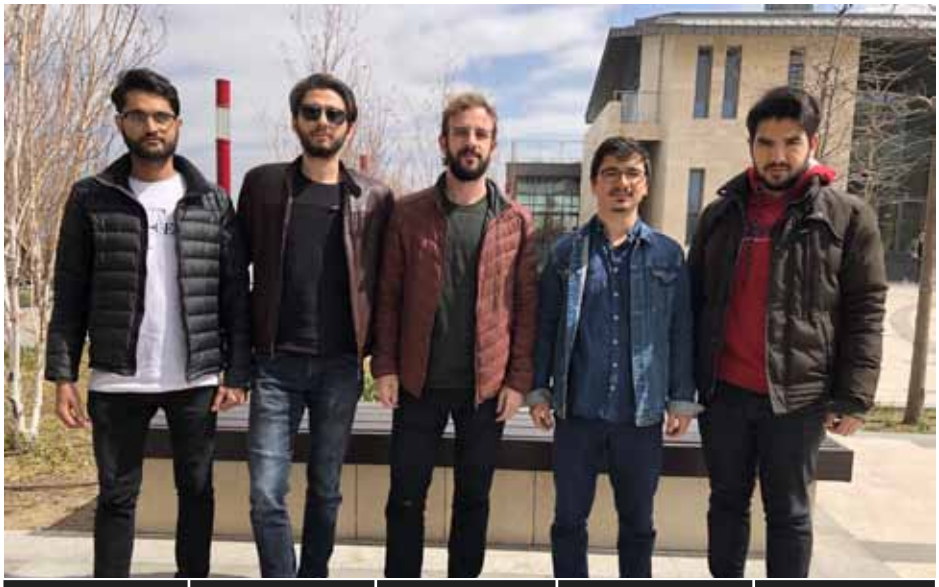
- Literature research for algorithms and kinematic model
- Preliminary design
- Kinematic model of truck and trailer
- CAD drawing of trailer
- Manufacturing of trailer, port and camera systems
- Electronic design of truck controller
- Integration of the algorithms into the system
- Test procedures for algorithms and controllers

References:

[1] CBSNewYork, "Truck Driver Injured In Port Newark Accident," CBS New York, 20-Nov-2014. [Online]. Available: https://newyork.cbslocal.com/2014/11/20/truck-driver-injured-in-port-newark-accident/. [Accessed: 03-Jan-2019].

[2]Ford Motor Company and Ford Motor Company, "What it Takes to be a Self-Driving Leader," *Medium*, 03-Apr-2017. [Online]. Available: https://medium.com/self-driven/what-it-takes-to-be-a-self-driving-leader-71928b94870e. [Accessed: 19-Apr-2019].

Design and Manufacturing of a Model Plane with Counter Rotating Wings



Uzair Qazi	Emirhan Köroğlu	Halil Şirin	Akın Düşünceli	Ahmet Işık

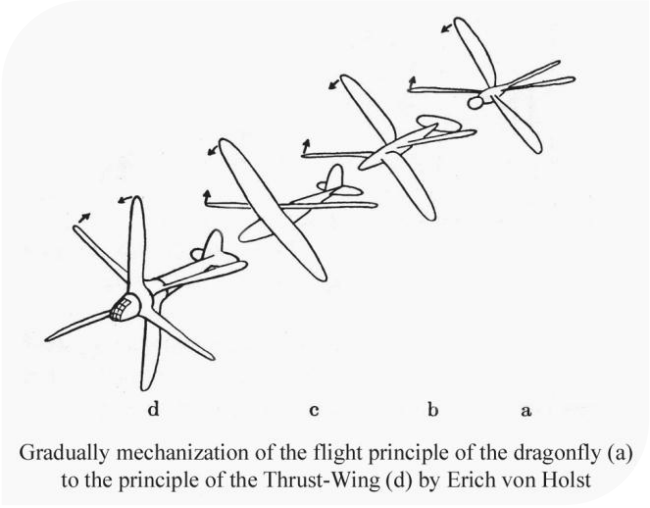
Academic Advisor : Prof. Luca Biancofiore
Industrial Advisor : Prof. Adnan Akay

Abstract

The purpose of this study is to design and manufacture a model plane with rotating wings in opposite direction. Finalized design has been updated to make it easy to manufacture and efficient. With this aim, several changes have been made to the design such as gear type, gear reduction changes, material changes, motor and battery choice changes, bearing changes. Then, manufacturing and purchasing of the designed components have been made. Some of them 3D printed, some of them directly purchased and some of them purchased and then machined. Several analysis also have been conducted such as CFD analysis using ANSYS and stress analysis using COMSOL and Solidworks to understand flow and material behaviour of the design.

Problem Definition

This project seeks to undertake the investigation and development of flight principles of model aircraft based on the dragonfly design of Erich Von Holst. Such an aircraft, for this project, will feature two pairs of wings that rotate around the axis of the fuselage. Conventional aircrafts generate thrust from jet engines and lift from their aerodynamically shaped wingspans while helicopters produce lift using rotors that could also be tilted to obtain forward and backward movements. The challenge, which happens to be the core purpose of this project, lies in determining the optimum and most efficient design for the wings that simultaneously produce enough lift and thrust to actually lift the aircraft off the ground and push it forward.



Gradually mechanization of the flight principle of the dragonfly (a) to the principle of the Thrust-Wing (d) by Erich von Holst

Figure 1. Inspiration from Dragonfly

It would require extensive theoretical knowledge and experimental testing in wind tunnels to determine suitable parameters that could aid in comprehending and analysing the aerodynamics of the new wing design. Determining the appropriate power source, suitable motor types and their RPMs would be additional challenges for ProjectX. Motor will be powered by the power source and it will drive the gear box that would distribute the power between the wings by moving them contrary to each other. Power transmission and its distribution between the two wings would require a transmission system and a gear box, both of which would have to be designed from scratch. This report shall explain the final chosen design and the manufacturing procedures and techniques that we deem suitable to produce the final product.

Figure 2. Model of Final Design

Design

The design has been made according to constraints and requirements given at the beginning. Constraints were “50 cm in fuselage” and “50 cm in wingspan” and requirements were “counter rotating wings” and “rotation axis is body of the aircraft”. In this design, we have 8 different components and 18 components in total which form the mechanism to meet the requirements and constraints.

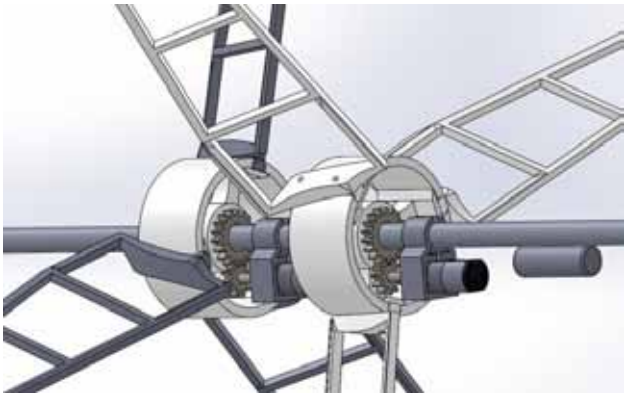


Figure 3. Internal mechanism of design

Components

Wing Blade Frames: There are 6 of them and three of them have 25° angle of attack and the other three have -25° angle of attack. They have flat surfaces and cross section has a special geometry. In order to decrease the weight, wing frame is covered by a thin film.

Wing-Rings with Gear: There are 2 wing-rings to rotate the wings. Due to the difficulty of assembly of gear and wing ring, they are designed as one component and manufactured accordingly. Wings are assembled to the rings via holes of the rings and screwed after assembly to avoid linear motion.

Pinion: The gear ratio of gear and pinion is 1:1.63. It has 11 teeth and 0.9 module with 3 mm inner diameter.

Aluminum shaft: This is a stationary tubular shaft placed in the middle of the fuselage. There are holes at some points to allow cables to pass through the tube.

Bearing: Suitable bearing allows the rings to rotate and the shaft to be stationary. Deep groove ball bearing type is chosen.

DC motor and battery: Selected motor is a 6V micro-motor since the model is relatively small. There are 12V small batteries which can be used to power the both motors.

Motor mount: Motors should be stationary. Therefore they are assembled on the shaft by using a part which has rectangular and circular cross sections.

Working Principle

1) Battery provides power to motors.
2) Motors are arranged to rotate in opposite directions and to rotate pinion.
3) Pinion transmit the power to gears with 1/1.63 ratio.
4) Gears rotate, wing-rings rotate, wings rotate.
5) Wings rotate in opposite direction and same velocity.

Outputs

Results

Different kind of wing shapes have been analyzed and results have shown that counter rotating mechanism of flat wings can only create small amount of thrust force while twisted wings can create more thrust force. In addition, tilted body design helps to create lift force out of thrust force.

Outcomes

Conventional aircrafts with wings can fly because of airfoil feature of the wings while the others with propellers can fly because of pushing the air due to high rotation per time. For this design, we have neither airfoiled wings nor high rotation per time but counter rotating wings. This provides us to generate thrust and lift force by not spending so much energy. Therefore, energy efficiency can be observed in this design. This is in *«Small UAV»* class that can be used for gathering meteorological data or for armed forces unmanned duties.

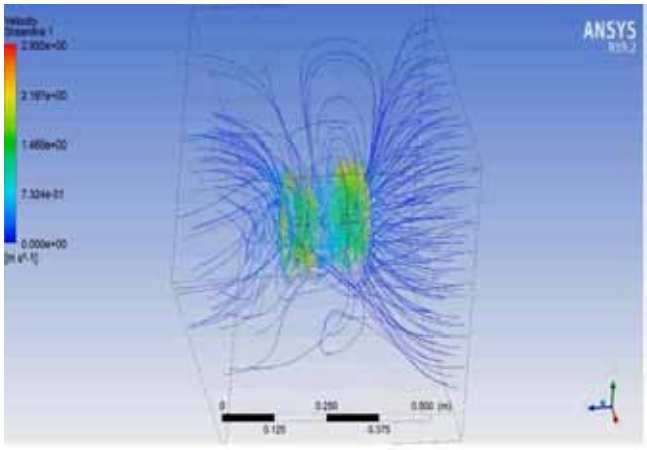


Figure 4. CFD analysis by using ANSYS

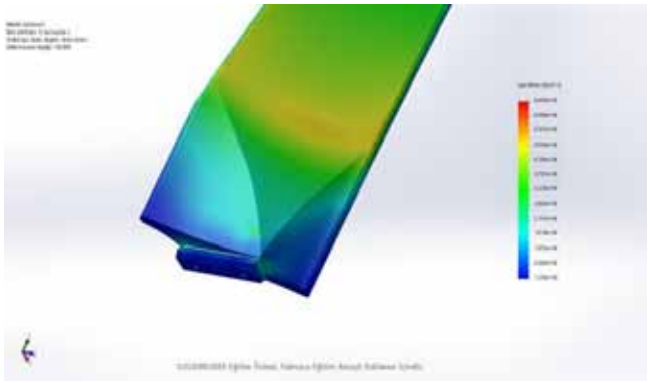


Figure 5. Stress analysis on SOLIDWORKS

Figure 6. Final look of the design

Mert **LİMONCUOĞLU** | Şehmuz Ali **SUBAY** | Öykü Tüzün **ERİM** | M. Kemal **KÖYSÜREN** | Hakan **YANIK** | Faruk Emre **YILDIZ** | Oğuzhan **KÖKSAL**

supreme

Academic Supervisor
Onur **ÖZCAN**

Industrial Supervisor
İhsan Burak **TEMELTÜRK**
Muhammed **YÜKSEL**

Semi-Autonomous Reconnaissance Vehicle

Unmanned Ground Vehicles (UGV) are used in various purposes in industrial, military and civil applications. The purpose of this project is to design and manufacture an enhancement kit for a manually controlled unmanned ground vehicle system that brings semi-autonomous and reconnaissance capabilities to the platform it is installed on and a turret system which is able to track and engage a predefined target. The scope of the concept includes both mechanical and electronic systems. In mechanical concept, turret system is designed and electrical component placements are made. In electronic concept, software design, algorithms and subsystems are developed and integrated to the kit.

sponsored by

roketsan

Problem Definition

Unmanned ground vehicle (UGV) is a general term used for vehicles that are operated by automatic or remote control. UGVs are becoming more and more widespread in industrial, military and civil applications. This senior project intends to develop a semi-autonomous concept that serves for reconnaissance activities in military context. Collecting environmental information during a mission and target detection is a great risk for soldiers, however, with this project, it is possible to replace soldiers with a semi-autonomous UGV to eliminate the casualties in the battlefield. The aforementioned environmental information can be temperature, damp, wind or visual information for detecting targets. Furthermore, this UGV is aimed to be capable of target elimination. After a target is detected, a weapon turret mechanism is expected to attack or defend. Dealing with challenging terrains is also required for this purpose.

Figure 1: Fornox Fire Extinguisher Vehicle without kit

Figure 2: After a concept integration of enhancement kit on the vehicle

In the project there are six different fields of requirements and constraints.

Mechanical Constraints

FORNOX-mini platform vehicle
Maximum 200kg load weight
Mechanical Requirements
T-107 missile launch capability
Tip over avoidance in 11kN impulsive force

Electronic – Firmware Constraints

Nvidia Jetson TX2
Robot Operating System (ROS)

Requirements

Image Recognition & Processing
Path Planning
Mission Requirements
Autonomous Navigation
Target Detection, Tracking & Elimination

Design

The design stage of the proposed enhancement kit consists of the design of the missile turret system that will enable target elimination capabilities to the vehicle it is installed on, the design of the electro-optic sensor and processor hardware pack that will bring autonomous capabilities to the vehicle, and finally the design of the control and communication software which will enable the operator to receive environmental data from the surrounding and control the vehicle manually or in autonomous mode if preferred.

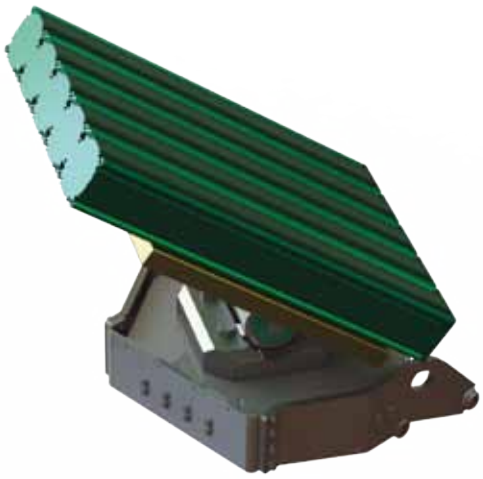


Figure 3: Turret design integrated on the vehicle

Missile Turret System

The 2 DoF geared turret is a system that points out the missile pods into a desired direction to acquire the optimal missile launch state. The motion is done in 2 principle directions, which are along the yaw axis and the pitch axis. The yaw motion is decided to be constrained for 270° rotation along the axis. The pitch axis motion is constrained between 15° and 60° as this envelope is the most frequently used one in the missile launches of ROKETSAN.

Electro-optic Sensor & Processor

Electro-optic Sensor & Processor Hardware Pack is the core part of the enhancement kit where all of the sensors that are both required and optional for the vehicle operation, and also the main processor NVIDIA Jetson is located. The compartment is designed so that it is self-contained which means that it can be readily implemented to any vehicle system. Embeded CAN bus protocol which is highly standartized in automobile industry makes the system easier to integrate any ground vehicle. In addition to autonomous driving features, the enhancement kit facilitates real-time telemetry and video communication between the vehicle and user interface.

Figure 4: Hardware Pack

Results:

Turret and hardware pack are manufactured and installed on the vehicle.

Path planning and following algorithms are integrated to the system and working functionally.

UGV is detecting and avoiding obstacles on the way to the predetermined path.

User interface is created to give orders to the UGV.

Navigation and localization work properly.

Turret can detect and target the predetermined enemies.

Figure 5: Electro-optic Sensor & Processor Hardware Pack

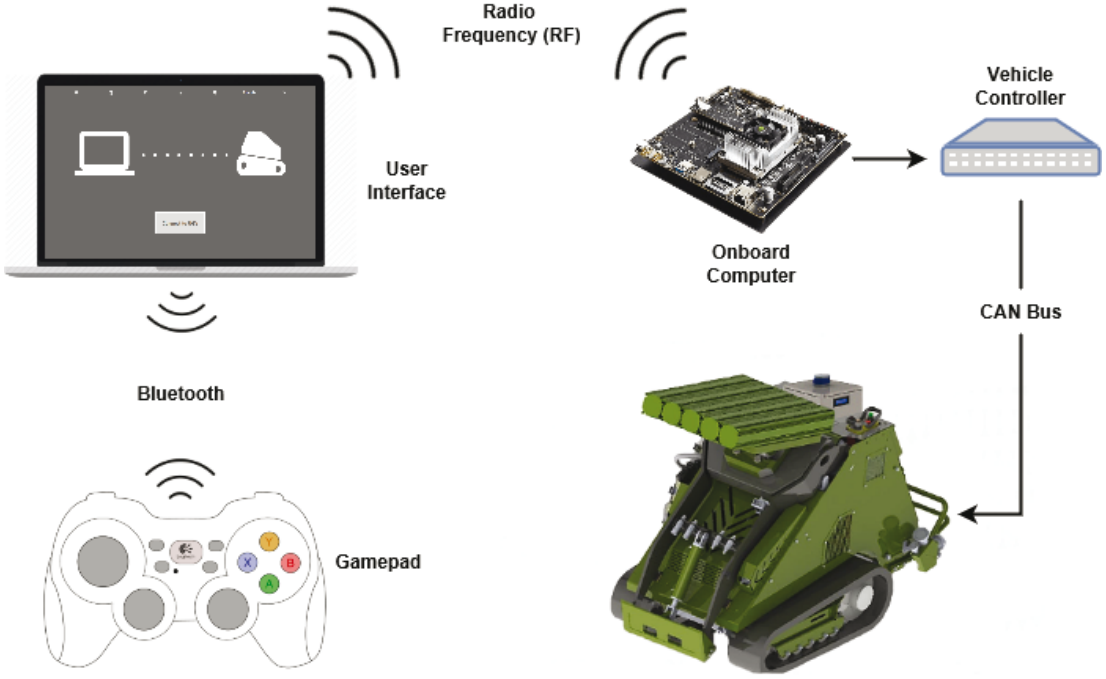


Figure 6: Communication Schematic

LAGARI (C3)

Development of a Control Actuation System with Variable Phase Difference

Batuhan Erdurcan	Alper Bilgiç	Merve İlter	Rüzgar Tez	Utku Balıkcıoğlu	Gürcan Cengiz	Onuralp Şimşek

Academic Supervisor: Asst. Prof. Melih Çakmakcı

Industrial Supervisor: Mustafa Çökmezoğlu

- ABSTRACT-

Main purpose of this project is to develop a control actuation system for military missiles in the ROKETSAN inventory. Development procedure consists of literature research, design procedures, manufacturing and testing. While developing the control actuation system, there were several constraints to be satisfied which can be summarized as; budget, working bandwith, holding torque, weight, dimension and manufacturability constraints. By taking into consideration these requirements; an appropriate control actuation system to be used on millitary missiles has been developed, manufactured and tested.

Problem Definition

In order to control a guided missile, one of the solutions is a control actuation system (CAS) that controls canards near the front end. Canards are wing-like structures that are generally much smaller than stationary wings. Apart from controlling the movement, canard systems help to decrease instability of the missile by creating more laminar air flow around the missile. Such systems control the missile and enable the missile to be fully guided and increase accuracy. Currently, ROKETSAN A.Ş uses several combinations and prime movers and number of canards as a CAS. These systems vary such as:

- Controlling one set of two dependent canards with using single prime mover.
- Controlling two dependent sets of four canards with using double prime mover.
- Controlling four independent canards with four prime-movers

ROKETSAN A.Ş aims to decrease purchasing cost of CAS's as well as increasing efficiency of the systems.

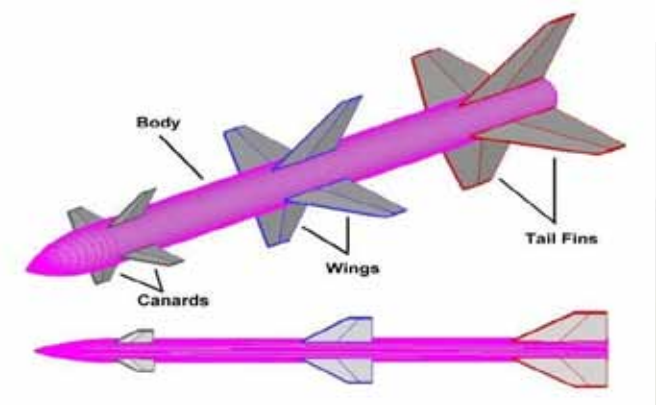


Figure 1. Representation of canard systems

In order to answer this need of ROKETSAN A.Ş, this project aims to control two dependent sets of four canards with using a single prime mover. The two sets of canards will move completely from each other with a variable phase difference. It is aimed that by using a single prime mover, purchasing cost will decrease and efficiency will increase.

Therefore, the main purpose of this project is to design, analyze and manufacture a Control
Actuation System to drive a missile using local sources, which consists of only one prime mover
that can give power to four canards dependent to each other in a dual way.

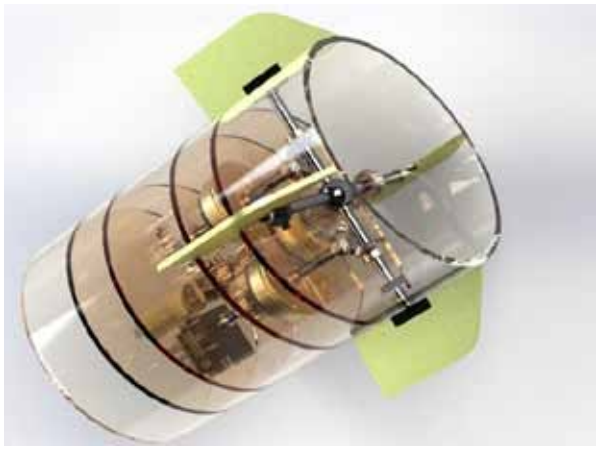


Figure 2. The location of electro-mechanical clutch in the military system

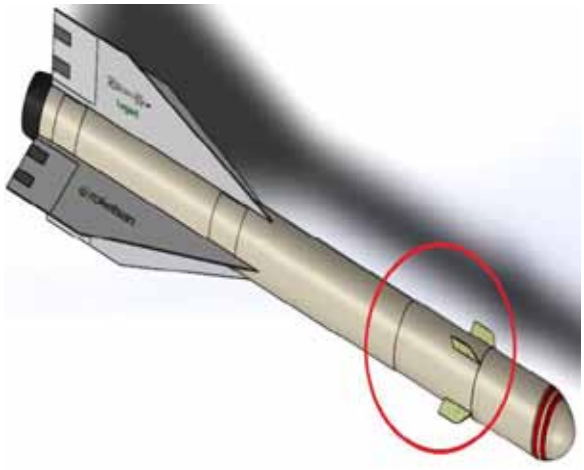


Figure 3. The location of electro-mechanical clutch in the military system

[1] Aerospaceweb.org | Ask Us - Missile Control Systems. [Online]. Available: http://www.aerospaceweb.org/question/weapons/q0158.shtml. [Accessed: 05-Nov-2018].

roketsan

Design

For the problem definition given in previous pages a solution is produced. This solution will consist of both manual and electrical motor drive modes and will not draw all of the current in the system. Regarding these facts the designed system and can be seen in Figures placed below.
Basically the design procedure belonging to this system can be summarized as follows:

To design, analyze and manufacture a **Control Actuation System(CAS),** which consists of **one prime mover** that can give power to **two independent canard sets.**

Literature survey → Preliminary Design → Prototype and tests → Final design

Canard

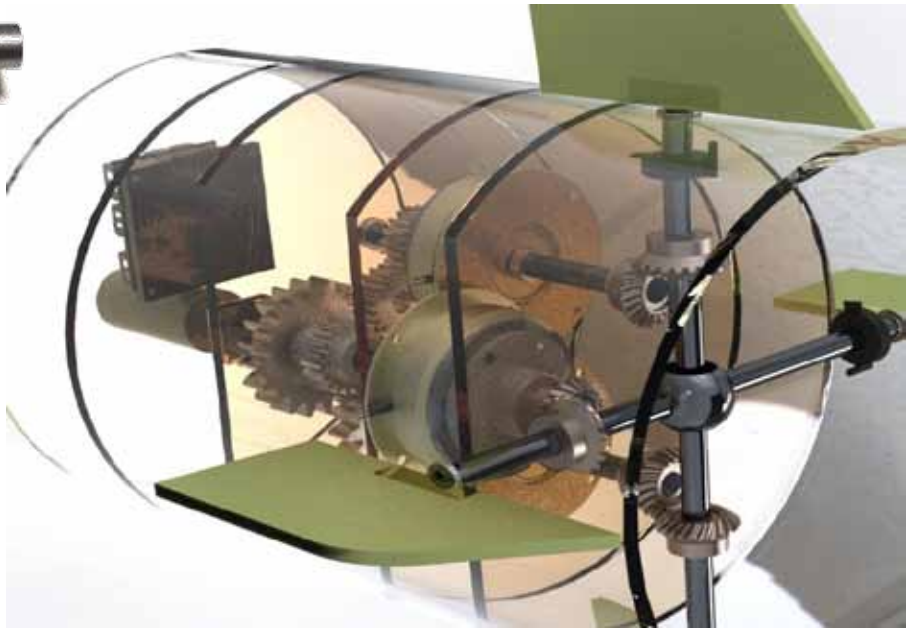
Power of the primemover drives one of the shafts. This power is distributed to the remaining 2 shafts with spur gear pairs. Each shaft houses an electromagnetic clutch. The engagement and disengagement of these clutches according to the readings of the sensors for the canards lead to different modes of motion. These modes can be grouped up into 2 main outcomes. These outcomes are **independent canard control** and **variable phase difference**

Canard Independency ✓

Variable Phase Difference ✓

Prime mover

Electromagnetic Clutch



CAD Design of the System

Outputs

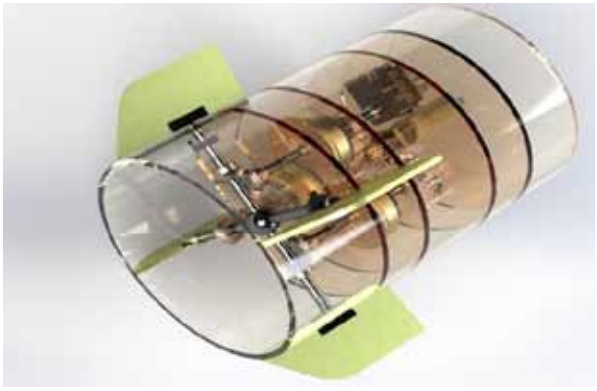
Results:

✓ The main purpose of the project is to design and manufacture a control actuation system to be used on missiles that consists of one primemover and controlling 2 independent canard sets.
✓ Variable phase difference and independent canard control is achieved
✓ System has satisfied all of the requirements and constraints defined in the problem statement and can be used for military purposes.
✓ Concept of using electromagnetic clutches for missile control actuation system for the first time is unique to this project and is proven to be effective for being used with a single primemover

Outcomes:

This project procedure consisted of several steps. In each step lots of engineering calculations are procedeed. Yet calculations are not the only engineering approach that is followed, analysis and simulations are also used. Through out this project all of the pre-learned engineering procedures are used, these can be listed as follows consisting of the softwares that are used:

- Deep literature searches
- Analytical thinking
- Engineering analysis
  - SolidWorks design and simulations
  - ANSYS simulations
- CAD drawings
- Test mechanisms and procedures
  - Raspberry Pi/Python
  - EPOSStudio
  - Simulink simulations
- Manufacturing processes



This project is supported by ROKETSAN and TUBITAK 2209/B Program

ANAOKULU
A BÖLÜMÜ

FOURIER (D1)

morfobot

ChulHyeong Lee | Ayman Manzoor | Şükrü Yağız Ölmez | Hassan Ahmed | Arham Zaheer | Arda Karaşahin | Eren Yiğit Güler

Academic Supervisor Asst. Prof. Onur Özcan

Industrial Supervisor Burçak Özonuk

Teaching Assistant Osman Berkay Şahinoğlu

ABSTRACT

Main purpose of *morfobot* is to introduce kindergartners with STEAM (Science, Technology, Engineering, Arts, Mathematics) education. *morfobot* allows children to physically realize how algorithms work. *morfobot* is designed to support teachers while they teach children one-to-one or in groups. Children can manually guide *morfobot* to accomplish tasks like solving mazes and recognizing objects, use line following and free-roam modes for fun activities. On top of everything, using algorithm building cubes, children can create sequences of codes for programming *morfobot* and solving problems.

Problem Definition

It is becoming increasingly important for children to learn about technology at an early age so they can easily understand and adapt to the current trends in technology. Understanding technology and its uses allow the children to command technology innately.

This is possible through using devices as a means of education by integrating technology seamlessly into their curriculum from an early age.

Current products are not geared towards kindergartners, specifically towards those under 5 years old. In order to establish a healthy relation between children and technology, there are already some educational robots in the market.

However, there are some drawbacks of them. To start with, most have very basic features compared to their cost and are infeasible for use in education. Some of the more feature rich options are geared towards adolescents and older children. The availability of many robots in Turkey is also limited, which further increases the cost of these products.

The main purpose of this project is to design, analyze and manufacture robots that are suit for kindergartners and can be used educatively and productively in an kindergarten environment.

Figure 1. Rendered *morfobot*

Product Details

Track width: 20cm
Robot Diameter: 16cm
Height of Robot 18cm:
Ground Clearance: 1cm
Battery Capacity:10000mAh
Run Time: 2-3 hours
Motors: Dual Electric DC Motors
Number of Modules: 4

- Eye Module (Proximity & Light Sensor)
- Color Module (RGB Color Sensor)
- Ear Module (Sound/Clap Sensor)
- Speak Module (Speaker)

Module dimensions:
5cm x 6.5cm
(diameter x height)

Electronics include:

- Various Sensors
- Arduino Nano
- Motor Driver
- Charging Circuit
- Bluetooth Module
- Batteries

Figure 2. *morfobot* logo

Figure 3. On-board electronics

Design

About *morfobot*

morfobot originated from the idea that toys have the power to change.
Both change themselves and those who play with them.

morfobot will morph current teaching methods in kindergartens and help morph children into advanced individuals.
morfobot will morph in functionality with different modular attachments and suit the classroom needs.

to morph (verb)

to gradually change, or change someone or something, from one thing to another

Figure 4. *morfobot* module

Modularity

Modules can be added to the base robot to give the robot extra functionality.
Each module has different functions.
Ear Module has a microphone and is used for interactive games.
Eye Module has a proximity sensor to know if something is front of the robot and an ambient light sensor.
Color Module has a sensor which helps to identify different colors.
Speak Module has a speaker for giving audio feedback.

Control Application for Android

morfobot is controlled using an Android application developed during the project.
The application interface is designed to guide the teachers easily through the different functions.
It is also very simple, to allow the children to take control easily if needed.
Different functions are color coded for simplifying the interaction experience.

Figure 5,6: Application main screen and menu screens.

Results

An educational robot is developed to be used in Bilkent Anaokulu.

morfobot is an affordable blend of educational and entertaining robots for kindergartners.

The robot can be operated in the following modes:

- **Programming Mode:** *morfobot* can be programmed by children by arranging physical cubes (with QR codes) in order and then scanning them using the app. A desired sequence of actions can be executed, actions can be repeated a given number of times and conditional logic can be implemented using the sensors.
- **Line Following Mode:** *morfobot* can be used to follow lines or boundaries of shapes drawn by children.
- **Free Mode:** *morfobot* can be driven manually using the mobile app.
- **Game Mode:** *morfobot* can be used in custom-designed games like a maze run in which a series of movements are sequenced beforehand to move the robot in a maze and avoid walls or «dangerous» encounters.
- **Rover Mode:** *morfobot* can just randomly move around the room, avoiding obstacles, like a drone or a pet.

Outcomes

For the development of the project a variety of requirements and constraints regarding size, shape and functionality had to be overcome to produce an engineering and aesthetically feasible product. This is being achieved by introducing a simple and pleasant mechanical design, implementing the necessary programing modes, integrating a user friendly mobile app and interfacing the necessary electronics,

This project was funded by Bilkent Anaokulu and TÜBİTAK 2209-B Grant

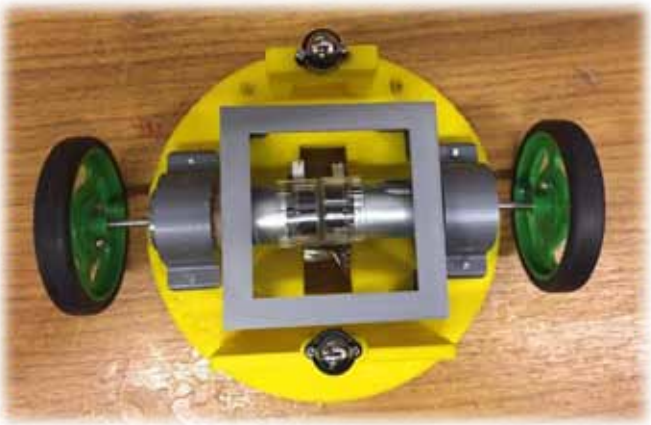


Figure 7. *morfobot* prototype chassis

Figure 8. *morfobot* prototype

MECHAMARVELS (D2)

Academic Supervisor: Professor Omer Aka
Anlağan and Dr. Şakir Baytaroğlu
Industrial Supervisor: Mr. Hamza Tarik Öztürk
Project Assistance: Osman Berkay Şahinoğlu

BEARING WEAR PERFORMANCE SET-UP

ABSTRACT

The purpose of this project is to address the reasons for the bearing wear through principal changes that will be made to a testing machine at Arçelik. The friction torque produced inside the ball bearing amid its use has been recognized as the fundamental issue behind the wear. Accordingly, the working principles of the machine were researched upon in order to further test them. The two different components that were principally engaged upon are oil temperature variation and inducing vibrations. Furthermore, the addition of two new parameters to the existing machine is proposed in this report; for heating the oil, installation of 250W Clamp Resistance Heater and for inducing the vibrations, installation of Brüel & Kjær mini-shaker type 4809 will be used.

From left: Umut Kurnaz, Ammar Haider, Umar Ul Haque, Hammad Aamir, Taha Bin M. Ali Sheikh, Hassan Bin Mazhar, M. Zunair Azhar, Wali Hussain

PROBLEM DEFINITION

Bearings enable smooth rotation of crank shaft in a compressor. The rotation of the crank shaft runs a piston which compresses the refrigerant inside the compressor. The bearings used are axial thrust bearings. A simple layout of the axial thrust ball bearing is given in Figure 1.

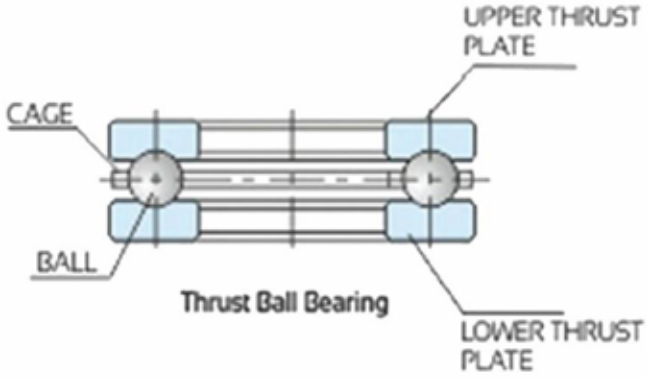


Figure 1: Ball Bearings

Figure 2: Machine's CAD Drawing

Figure 3: Crankcase and Crankshaft

The upper thrust plate moves while the lower thrust plate remains stationary. As there are moving parts in the bearing, it's expected that with time they will wear out. To study the reasons that influence the wearing of these bearings, a test rig has been designed and is being used by Arçelik.

The bearing test rig currently owned by Arçelik has only three parameters: axial load, rotational speed and working time. The problem with the current machine is that it does not have temperature variations and means of inducing vibrations of known amplitude and frequency.

This is imperative because if we understand the reason for the failure for the bearings we can improve on that factor and increase compressor's life as well as COP. Such type of bearing rig and tests for refrigerator compressor's axial thrust bearings are not common. Therefore, reasons for failure would be one of the important and pioneering outcomes from this project.

Therefore the main purpose of this project is to design a heater to introduce temperature variations and design a shaker to introduce vibration variations. The introduction of these parameters would better simulate the field conditions.

DESIGN

Literature Review → Mathematical Modeling → Purchasing and Implementation → Preliminary testing

We needed to introduce a heating system that could increase the temperature of the bearing region in the test rig up to 80°C. Similarly, vibrations up till 200 Hz needed to be introduced nearby the bearing region.

We made a mathematical model for the heating system so that the temperature could be reached to 80°C in less than 100 seconds. Similarly a mathematical model for vibrations was built to understand if the given vibrations would not breach the constraints and the system would be functional.

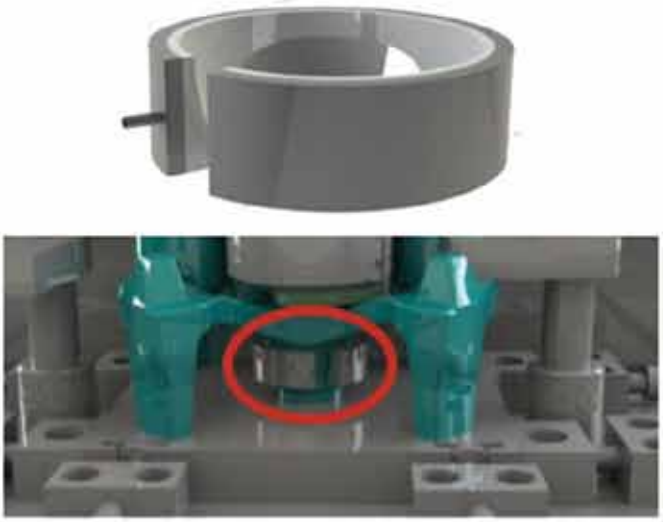


Figure 4: Heater's Placement

Based on these models, a heater was bought to satisfy the requirements. This heater is able to provide the desired temperature. Initially, a different kind of heater was proposed but the decision was changed based on the company's requirements. A shaker already present in Arçelik aligned with our requirements so we have decided to use that shaker to satisfy our demand.

Figure 5: Shaker's Placement

OUTPUTS

RESULTS

The main purpose of this project is to introduce the variations on temperature and vibration to better simulate the field conditions. We have installed a heater and shaker which aligned with our proposed mathematical model. With these new parameters, the company can test the reason for their bear-

Both the heater and the shaker are working properly and as per expectations in the test rig. The heater can reach a temperature of 80°C and vibrations from the shaker are not causing any failure of the system. Therefore, these vibrations and increased temperature are working toward increas-

We had done some tests on the bearings with the existent machine. Now we will do preliminary tests with the newly added parameters in order to compare the results of with and without temperature and vibrations variations.

OUTCOMES

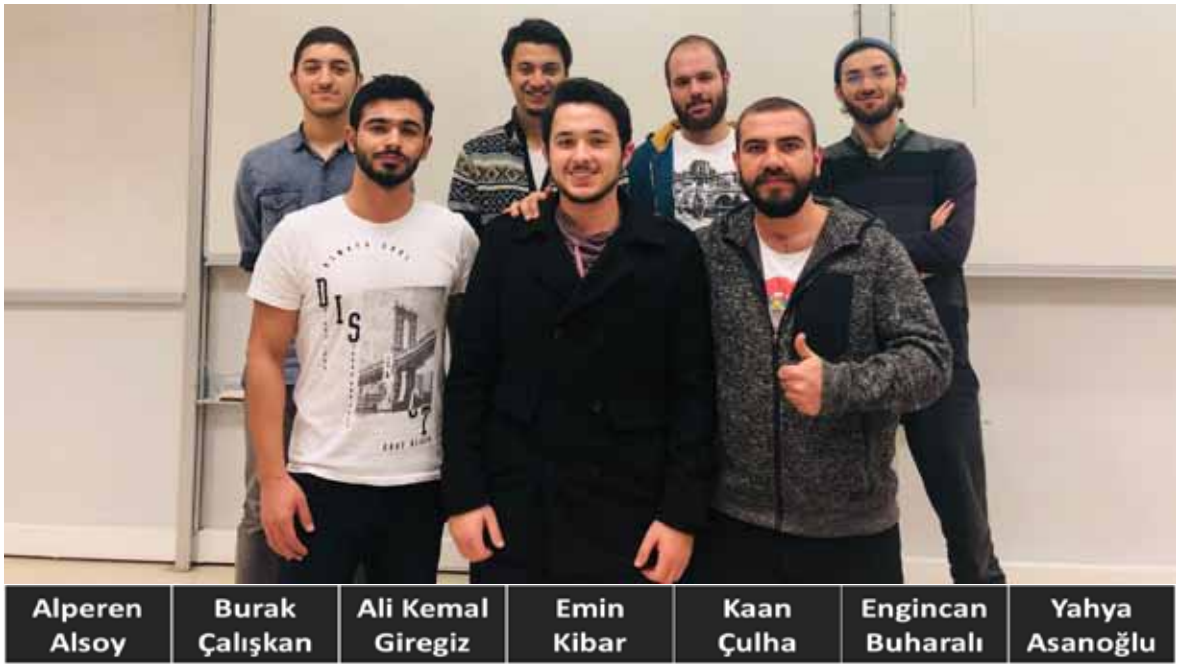
This project went through several steps before arriving to a conclusion. In each step, engineering calculations and decisions were necessary to proceed to the next step. Moreover, analysis and simulations were also used to answer many problems such as heater and shaker modeling. The engineering procedures and softwares employed in our project are as follows:

1. Literature review
2. Systematic thinking
3. CAD drawings
4. Mathematical modeling
i. Heating system
ii. Vibration system
5. Engineering analysis
i. ANSYS simulation
ii. Fast Fourier Transform analysis
6. Engineering decision
i. Changing of heater
7. Manufacturing
i. Assembly of parameters and their implementation
8. Preliminary test outline determination

Besides using the softwares, making important decisions at crucial times was a valuable skill to obtain. Similarly, hands-on experience with manufacturing parts and assembling them into the machine helped us understand the problems faced during the implementation. This implementation and preliminary testing phase marked the difference between calculations on paper and real life applications, which was a refreshing yet a dire reminder. Also, determing the outline of the preliminary testing phase in order to check the functionality and proper impact of each introduced parameter was a good skill to obtain.

Imperium (D3)

Development of Open Field Target Motion Simulator Tower



Alperen Alsoy	Burak Çalışkan	Ali Kemal Giregiz	Emin Kibar	Kaan Çulha	Engincan Buharalı	Yahya Asanoğlu

Academic Supervisor: Asst. Prof. Melih Çakmakcı

Industrial Supervisor: Ali Murat Kayıran

- ABSTRACT-

The aim of the project is to design and manufacture an active radar testing system which includes a truss tower as a vertical motion base and an antenna replica that moves vertically on the tower. Antenna replica represents the vertical motion of a projectile, in order to test the Weapon Locating Radar (WLR) that is to be developed by Aselsan. Project consists of literature survey, solid model design, manufacturing, testing of the final product. Constraints for the project includes operational constraints, safety, manufacturability and budget that has been taken into account during the process.

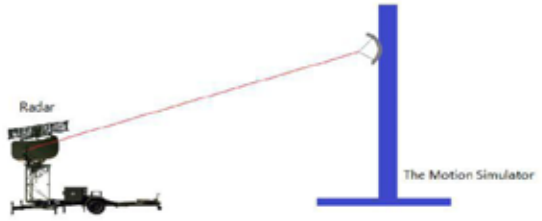
Problem Definition

Communication technologies, particularly radars, require very precise and accurate testing. Standardized tests are severely important and must be performed with attention considering every detail. Our main aim with this project is to develop a stationary tower and a moving antenna replica on this tower. This antenna movement is going to simulate a projectile on vertical axis to test the precision of the radar developed by Aselsan shown in Figure 1.

Figure 1: Representative Weapon Locating Radar

Aselsan is testing their radars statically in their research and development activities. The testing process includes a fixed antenna on a tower and this antenna is positioned different heights each time for radar to perceive its height. Therefore, the dynamic accuracy, which means if the antenna is in the correct position when it is moving, of the radar cannot be tested. However, the radar of a newly developed defense system of Aselsan requires high dynamic accuracy in order to detect the incoming rounds and locate the artillery or infantry unit by tracking the trajectory of a projectile. The system is generally called Weapon Locating Radar (WLR), thus the project provides an instrument for testing the radar of a WLR System, which is expected to be highly functional in combat environment. One way to provide dynamic testing is building a motion simulator that imitates the possible movement pattern of the target precisely and accurately.

For this purpose, the motion simulator is expected to trace a predetermined route precisely in the vertical direction and make angular motion in pitch axis while carrying an antenna and cables attached to this antenna. These conditions enforce the system to be able to move in 2 degrees of freedom. In addition, the simulator should be operational under outdoor conditions. Thus, operational tests will be conducted for the environmental conditions and the assembly that is designed is expected to work in such conditions. In addition to this, in extreme environmental conditions, system is not expected to operate but must keep its form for Aselsan to test the radar with following testing setup.



Radar *Simulator Tower*

Figure 2: Testing Setup

The main scope is to have a system that should be accurately positioned. One of the main challenges of the design is to provide precise and accurate positioning for the antenna within a limited budget. This positioning must also be accurate while the system is moving. Therefore, the main purpose of this project is to design, analyze and manufacture an open field target motion simulator tower, which can move within limitations and also meet the military standards.

Design

For the problem definition given in previous page, an active radar testing mechanism has been designed. Final design is a two degree of freedom system uses two servo motors for vertical and pitch angle motions. In design phase, constraints have been considered for decision making. However due to some budget issues and purchasing of components; constraints and design has been altered various times. Schematic below represents the design process.

At the end of these procedures, Aselsan will be using the final product to test their weapon locating radars. The working principle can be divided into four parts; linear movement guide, control and feedback system, actuation system and antenna replica. Movement guide is assembled using two truss bases, two linear rails and fasteners. Control and feedback system consists of a servo motor driver, draw wire sensor and a microprocessor for motor control. Actuation system is a pulley attached to an AC servo motor and steel wire connected to the antenna module. Antenna module has an L-shaped plate, linear rail blocks attached , a DC servo motor, a representative antenna and its connectors. Steel wire around the pulley is attached to the L-shaped plate, where antenna module is controlled by an Arduino and adjust its angle according to data coming from the draw wire sensor. Final design is capable of satisfying the following operational constraints.

Operational Constraints	
Maximum Velocity	1 m/s
Maximum Acceleration	1 m/s^2
Static Accuracy	1 mm
Dynamic Accuracy	5 mm

Figure 3: Solid Model of Final Design

Outputs

Results:

✓ Main purpose of the design is offering an improved radar testing mechanism for additional testing purposes. This feature makes the design unique, compared with other radar testing systems in Turkey. TUBITAK support of the project also demonstrates this uniqueness of the project.

✓Another goal for this project is improved cost efficiency. Achieving the maximum possible accuracy with minimum cost was the number one priority for the project. This feature is ensured by domestic purchasing and manufacturing, that is provided by local suppliers.

✓ Best option for cost efficiency offered in the early stages is turned out to be easily manufactured design which makes the system accessible.

✓System satisfied all of the requirements defined in the problem statement and compatible with military conditions.

Outcomes:

This project procedure consisted of several steps. In each step different engineering techniques are used for best possible outcome. For both design and manufacturing phases following skills are trained for project members.

- Literature research:
  - Positioning sensors
  - Motor types
- Analytical thinking
- Engineering analysis:
  - Analytical calculations
  - Numerical calculations using finite element analysis
- Electrical connections
- Coding
- Test mechanisms and military standards
- Design for manufacturing
- Manufacturing processes suitable for each part of the system

Bilkent University
Department of Mechanical Engineering

Mechanist (D4)

Design, Position, Control and Realization of Robot Arm with Flexure Bearing

Academic & Industrial Advisor : Dr. Şakir Baytaroğlu

Teaching Assistant : Emre Eraslan

- ABSTRACT-

The main objective of the project is to design a robotic arm joint with flexural bearing. The robotic arm will be attached to a linear actuator which is controlled by a microprocessor. The design phase includes detailed literature research, Solidworks designs, analysis, manufacturing and calibration. The project had to satisfy several constraints that can be listed as: design, manufacturing, size, timing and cost constraints. Based on these requirements a robotic arm joint with flexure bearing is manufactured, calibrated and controlled using a graphic user interface in accordance with international codes and standards.

Problem Definition

Owing to the increase in automation in industries especially in the assembly lines to reduce workforce, the demand in robotic arms has significantly increased which has also increased the demand of bearings that form the joints of such robot arms. Due to the choreographed and programmed movement of the robotic arm in one or more axis, bearing plays the pivotal role in their motion control. Such bearings should be specified for the desired task according to their type, material and lubrication. The bearings used in robotic applications must be high precision with good rotational accuracy and reliability. A new contender for these types of bearings is the cantilever pivot bearing also known as a flexural bearing.

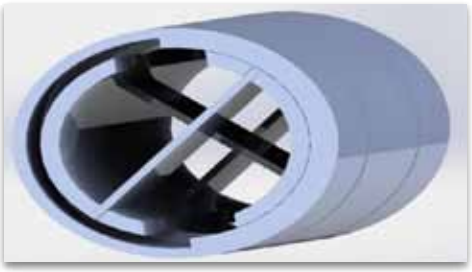
The scope of our project is to design a robotic arm with a flexural bearing joint. This is because a torsional load will be generated when the actuator, which is attached to the hind-arm, rotates the forearm. Moreover an actuator controlled by a microprocessor should accurately and precisely be able to rotate the forearm ±20° about the neutral position. This motion should be achieved in such a way so as to rotate the arm accurately with an error of ±1°. Graphic User Interface (GUI) will be designed to control and measure the movement of the robot. Hence calibration of the robotic arm is also required.

Applications

Unlike conventional bearings flexure bearings do not have any contacting surfaces and hence negates the need for lubrication. this is because there is negligible wear due to friction between the moving parts as all of the load is carried by the flexure springs. As a result they can have myriad of applications :

- ★ Assembly line operations in industries: Welding, painting, placing, picking, soldering, 3D printing
- ★ Potential use in Space (vacuum) applications (Flexural bearing do not require lubrication)
- ★ Replacing traditional robot arm joints: Due to high life cycle and low maintenance can be used in difficult-to-reach areas
- ★ Replacing traditional robot arm joints
- ★ Due to high life cycle and low maintenance can be used in difficult-to-reach areas

Robot Arm Assembly

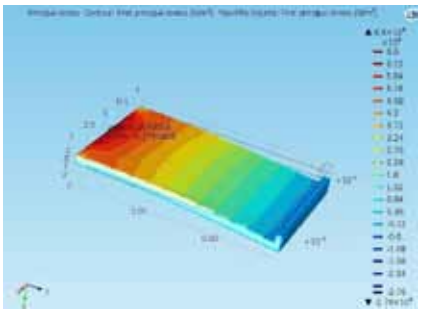


Flexure Bearing

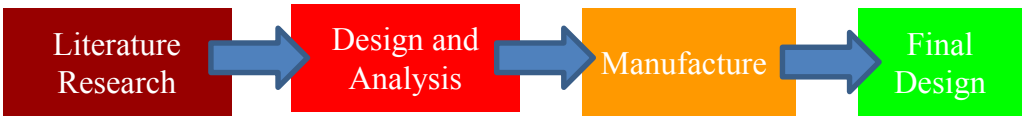
Design

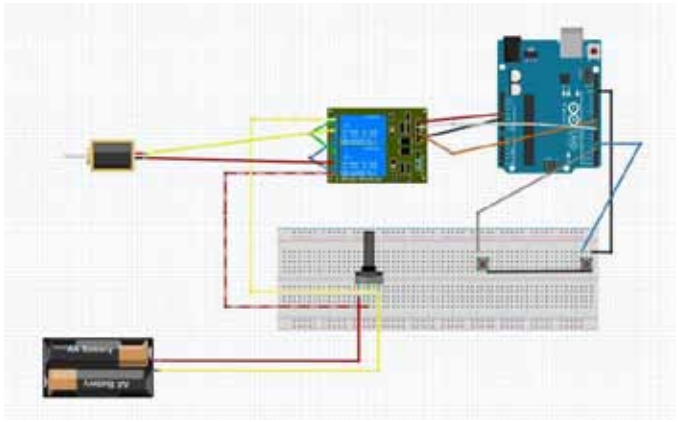
In accordance with the given problem and constraints, a design is developed in SolidWorks and analyzed using both COMSOL and trivial stress analysis. The final design consists of the robotic arms, flexure bearing, electronic motion control circuit and GUI. The figures of the components of the system can be seen below:

The basic design procedure of the project can be summarized in the following flow diagram



Flexure Spring under stress





Mechanical Components:

1. Flexure Bearing
2. Forearm
3. Rear-Arm
4. Support Platform
5. Linear Actuator
6. Hinges

Electronic Schematic:

1. Linear Actuator
2. Arduino UNO
3. 4-Channel Relay
4. DC Power Source
5. Switches and Potentiometer

The mechanical components are manufactured in the Machine Shop while the electronic components are bought off the shelf. Both the parts are integrated and tested. The robotic arm assembly is calibrated and the GUI is used to move the arm ±20° through a computer.

Goal:
Design, Position Control and Realization of Robot Arm Joint with Flexure Bearing (±20°)

Outputs

Results:

★ The main aim of the project was to control and measure the motion of a robotic arm with flexure bearing. The designed system was functional completely as it was visualized.
★ The final design shows the analysis and the preliminary calculations are correct.
★ The final design satisfied all the constraints defined in the problem statement.
★ Calibration of the system is done; the speed and the angle can be controlled accurately.

Outcomes:

The project consisted of several steps. Each step tested the knowledge gained during 4 years of learning mechanical engineering. We followed the design procedure from the start to the end, giving our progress report and presentations along each step. The procedure included engineering analysis of the bearings and arms using simulations and calculations. Several engineering procedures used during the design and manufacturing of the project are as follows:

★ Literature Research
★ Analytical Thinking
★ SolidWorks Design
★ Comsol Analysis
★ Analytical Stress Analysis
★ Electronic Design and Coding
★ 3D Printing Prototype
★ Manufacturing through CNC
★ Calibration
★ Testing the GUI

Apart from the literature research, designing, calibrating and testing the robotic arm assembly, one of the most vital experiences for the team was the manufacturing phase in the machine shop. One of the team members was always present in the shop to monitor the manufactured parts. Another commendable affair was the team effort and passion towards attaining all of our desired objectives.