BILKENT UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING

INDUSTRIAL DESIGN PROJECTS

2016 – 2017

Editors: Anıl Alan, Müjdat Tohumcu, Yıldıray Yıldız
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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 two-semester long design activity for the senior-level students. This year, fifteen groups, each consisting of six students, were provided with a 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, completed in the first semester, and in the manufacturing phase in the second semester.

At the project fair, the students are provided with the unique opportunity to present detailed design specifications of their products alongside the manufactured prototypes. The fair and this booklet explain 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 Technology Transfer Office:

Yeşim Gülseren

Industrial mentors:
Salih Okatan (ROKETSAN)
Hüseyin Avni Güner (ROKETSAN)
Nagehan Demirci (ROKETSAN)
Semih Tanıker (ROKETSAN)
Esat Tuğla (FNSS)
Erkal Özbayramoğlu (FNSS)
Hakan Mencek (TÜRK TRAKTÖR)
Koray Koska (ARÇELİK)
Oğuz Altuğ Önal (ARÇELİK)
Arda Kutlu (ASELSAN)
Ahmet Oral (NANOMAGNETICS INSTRUMENTS)
Bülent Başaran (PROINO)
Tolga Susuzlu (UNILEVER)
Serdar Güryuva (FORD OTOSAN)

Academic mentors:
Prof. Dr. Ömer Anlağan
Asst. Prof. Dr. Melih Çakmakçı
Asst. Prof. Dr. Barbaros Çetin
Asst. Prof. Dr. Yegân Erdem
Asst. Prof. Dr. Selim Hanay
Asst. Prof. Dr. Mehmet Z. Baykara
Asst. Prof. Dr. Onur Özcan
Asst. Prof. Dr. Luca Biancofiore
Dr. Şakir Baytaroğlu

Teaching Assistants:
Anıl Alan
Cem Kurt
Levent Dilaveroğlu
Dilara Uslu
Doğan Öner
Kubilay Kaan Bahçeci
Rico Morasata

Department Staff:
Ela Özsoy

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

Lecturers on Seminers:
Dr. Ersan Ocak
Nejat Ulusal
Serdar Bilecen

MECHANICS (A1)

Design of Sliding Wooden Door for a Dishwasher

Academic Supervisor: Dr. Şakir Baytaroğlu

Industrial Supervisor: Oğuz Altuğ Önal

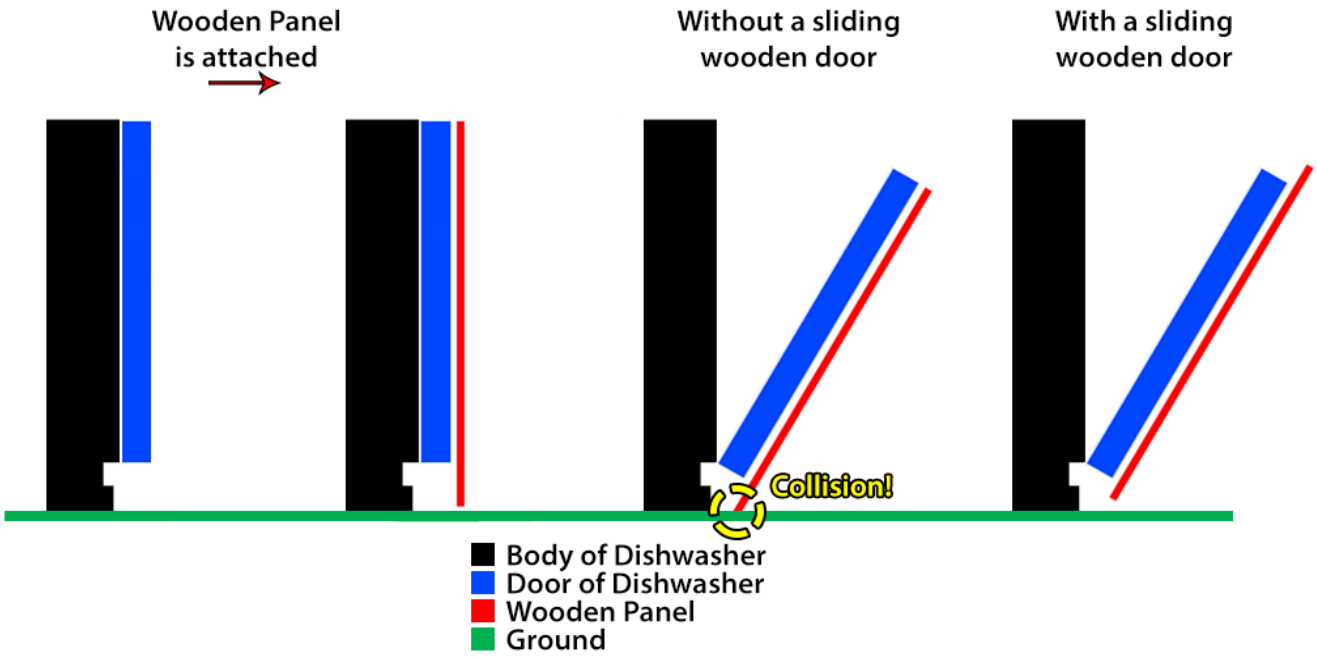
Teaching Assistant: Kubilay Kaan Bahçeci

- ABSTRACT-

Aim of this project is to produce a sliding hinge mechanism for Arçelik dishwashers. This mechanism should satisfy constraints of the company. In order to do that, a comprehensive literature search is done to see current applications in industry. Then, different mechanism solutions are designed to choose the proper one with our mentors. Chosen design were improved by engineering approaches. Prototypes of the design were manufactured. Test and evaluation were done on the prototypes. As a result of these stages, final product was created.

Problem Definition

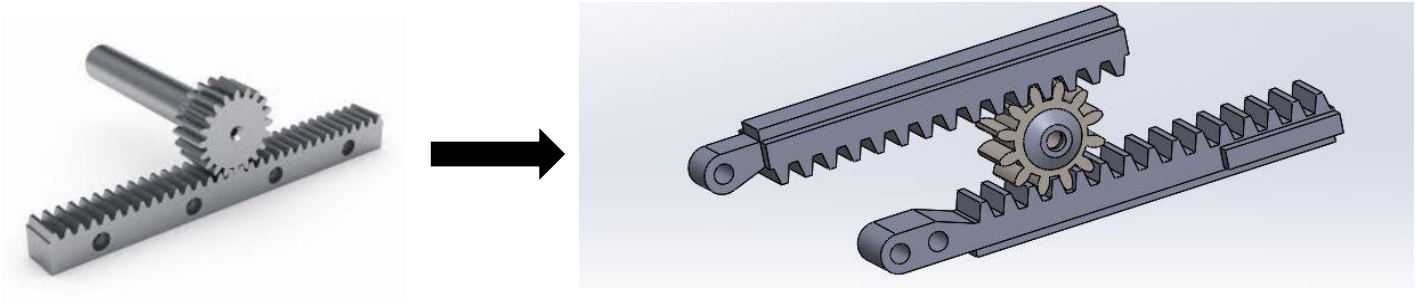
New trend in home decoration is making white goods' look harmonious with kitchen cabinets. To make this possible, an additional wooden panel with the same color of kitchen cabinets should be added to front face of the dishwashers. However, to prevent a collision between wooden panel and the ground, the wooden panel must slide out. This problem is solved by sliding the wooden panel outwards while opening the machine door.



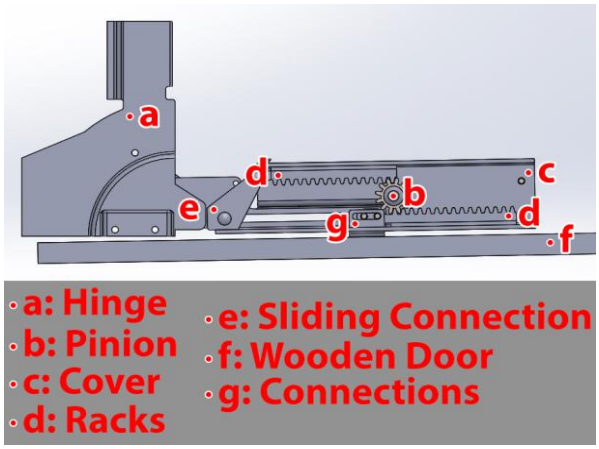
The mission of the project is to make a hinge mechanism which ensures the sliding operation occurs up to 80 millimeters. Thus, dishwasher door can be opened with a wooden panel. In terms of sliding amount, our project will be the longest sliding amount in the market. In addition to that, this mechanism will be the first sliding hinge mechanism which is produced in Turkey.

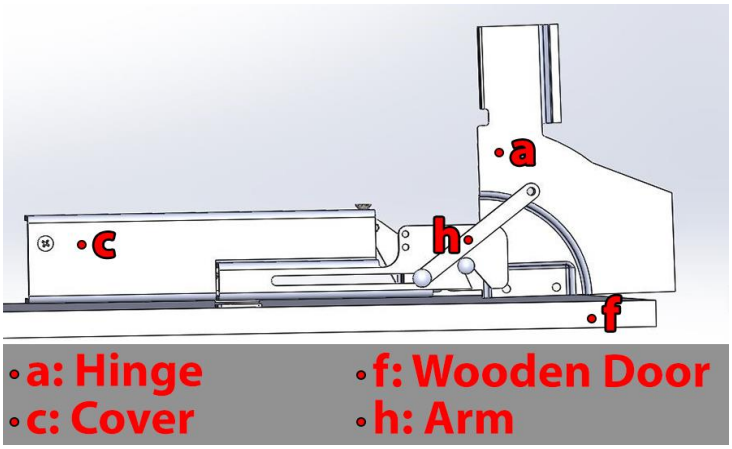
Design

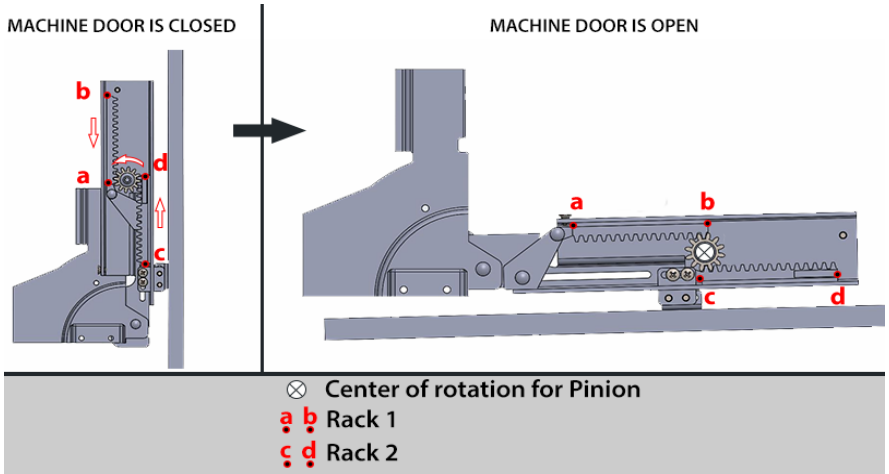
The design is inspired from rack and pinion system. A rack and pinion system is commonly used for translating rotational motion to linear displacement in industry. The traditional rack and pinion is modified by adding another rack to the system.



Cover, arm and connection elements are added on the modified rack and pinion system to create the mechanism. Arm lets wooden panel to slide out via rack and pinion system, using translational motion obtained from the rotational motion of the hinge of machine door.







Outputs

- With this hinge mechanism, contact problem between wooden door and ground were solved. Harmony is established in kitchen.

- Our design became the first sliding hinge mechanism which is produced in Turkey.
- In terms of sliding amount, we actualized maximum sliding amount in the market. This is important for customer satisfaction because when you increase the sliding amount you can put longer wooden doors. Thus, keeping harmony in kitchen cabinets becomes easier.
- A unique design was created as a result of the project. Thus, we applied to Arçelik patent institute and a patent application process is now conducting by Arçelik.

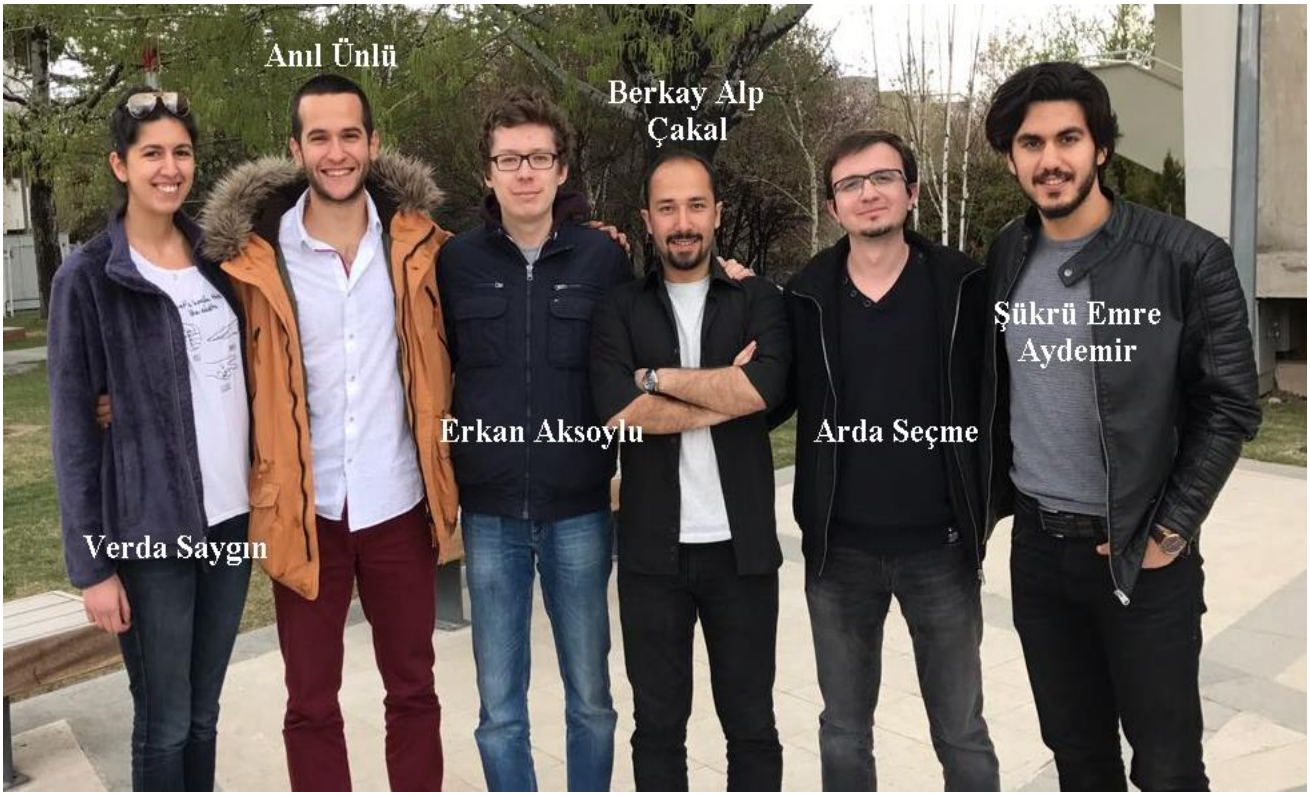
This project is application of four year engineering education. We used not only knowledge from the lectures but also gained information from the literature state of the senior project. During this design and manufacturing process:

- CAD drawing tools
- Technical drawing rules
- Engineering calculations
- Program based engineering analysis (COMSOL analysis)
- Test and manufacturing techniques (including 3D printing)

were used.

ATLETİKO MAKİNE (A2)

Active Vibration and Shock Isolator



Academic Supervisor: Dr. Melih Çakmakcı

Industrial Supervisor: Dr. Semih Tanıker

Teaching Assistant: Levent Dilaveroğlu

ABSTRACT

The aim of this project is to design, analyze and manufacture an active vibration isolator for the avionics inside the missile systems. An active vibration isolation device is developed which operates by tuning the effective length of the load carrying rods. With the change in the effective length of the rods, stiffness of the system is tuned according to the characteristic of input vibration. The device is manufactured and tested. It is verified that the designed vibration isolator can perform at least 70% isolation in 3-axis within the frequency range from 10 to 100 Hz.

Problem Definition

Missiles are one of the most complicated structures in the engineering area. They are obliged to perform various challenges where avionics systems have crucial role in order to accomplish the missions. Vibration, on the other hand, is one of the deleterious problems for these avionic systems.

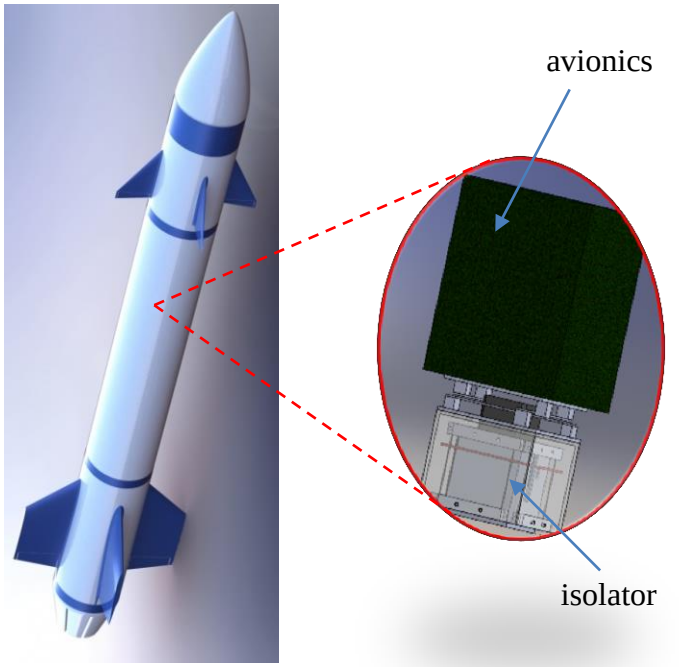


Figure 1: Representative CAD for the use of vibration isolator in a missile systems

An illustration for the use of vibration isolator in a missile system can be seen in Figure 1. In missile systems, critical components are exposed to vibration which directly alters the performance of avionics systems. The avionics systems include many subsystems that are fitted to projectiles to perform individual functions using sensors such as accelerometer, gyroscope and compass. Therefore, for providing optimum working conditions, vibration isolators are essential for avionics systems.

Currently available solutions are mainly based on passive systems that consist of viscoelastic materials. It is known that rubber mounts are provided from abroad for vibration isolation purposes in the missiles. However, such passive systems do not perform well particularly in low frequency band.

Active systems, on the other hand, are more successful since they are able to adjust characteristics of the system in accordance with the exposed vibration. Some well-known active vibration isolators can be seen in suspension systems or optical table supports. However, the active systems are relatively more expensive and they are not available in the local market.

There are efforts recently to reduce the dependency on imported products for active isolators. The main purpose of this project is to design, analyze and manufacture an active vibration isolator using local resources.

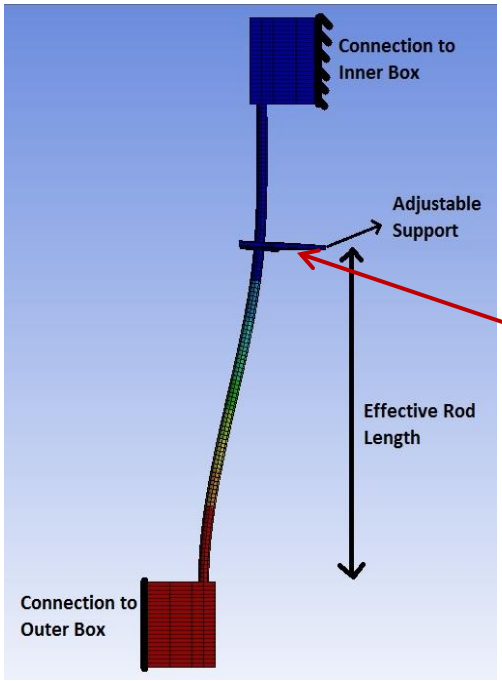
The low frequency band is critical for avionics systems, and the current available solutions barely provide isolation performance in such frequency band. One of the requirements in this project is to perform at least 70 % isolation in the 3 axis within the frequency range of 10-100 Hz.

Since the missiles offer small amount of volume for the subsystems, the design of the active isolator system should be as compact as possible. Thus, achieving a creative and unique design is another requirement for this project.

Design

For the problem definition given in the previous page, by following the requirements and restrictions a solution is produced. The design consists of one inner box, which receives the incoming vibration and secures the electronics inside, one outer box with a subsystem for the passive vertical isolator to carry the payload. The inner box and the outer box are connected with 8 identical rods.

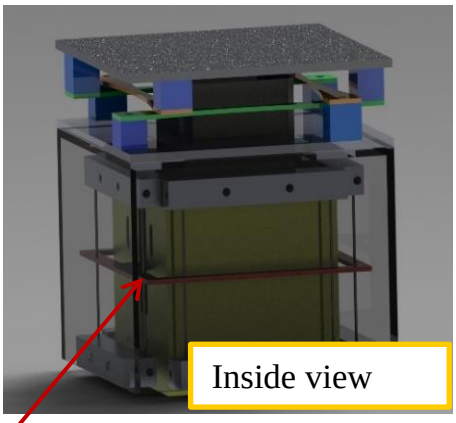
Selected isolator concept basically utilizes rod stiffness tuning phenomena, that is, as the parameters of the rod changes, its effective stiffness also changes. In this design, length of the rods will be changed by positioning the support points of the rods in order to control the stiffness of the system to isolate in lateral directions.



Adjuster, which its position is controlled by a stepper motor, adjusts the support fixes of the rods.

Stepper motor is controlled by a micro controller, which receives frequency information from the accelerometers.

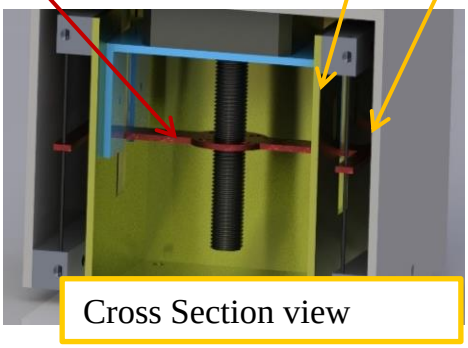
Two accelerometers are placed in the design; one to measure incoming vibration, the second one to measure vibration on the payload.



Inside view

(inner box)

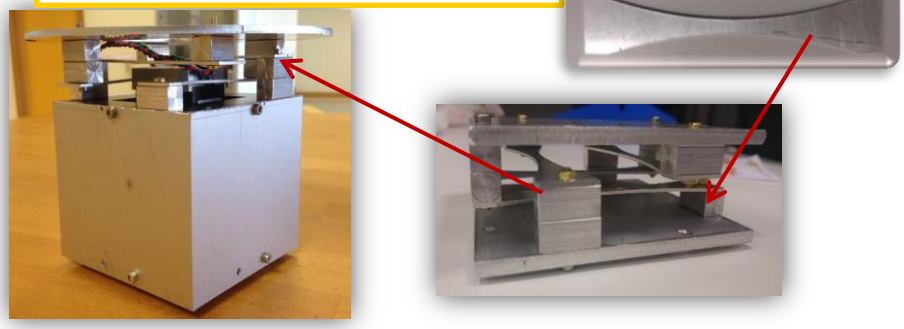
(outer box)



Cross Section view

The isolation in the lateral directions is actively controlled, which is explained above, where the isolation in the vertical direction is passive. For the vertical direction, the subsystem has 4 beams that carry the payload and perform isolation. The beams operates independently from the rods that are responsible for isolating the payload in the lateral directions. The beams are used as simple springs to is isolate the vertical vibration energy.

Subsystem for the vertical design



This design for the vertical direction is unique and it has been developed through structural optimization. The thickness of the beams have been determined after several simulation results.

Outputs

Results:

- This project proved that an active vibration isolator system can be developed using local resources at low cost.
- The design is packed within 10 cm x 10 cm x 10 cm volume.
- System performs more than 70% isolation at low frequencies according to test results
- Unlike springs and rubbers as the conventional solutions, rods and beams are employed in this design in a unique way. The geometry of beams are finalized after an iterative design procedure so that the system is stiff enough to carry payload while performing vibration isolation at low frequency.
- Common materials are used in the design so that it can be produced in local industrial zone with basic manufacturing techniques at low cost. From that perspective, this project is a national project.

Active isolation in the lateral directions ✓

Compact design with everything packed inside ✓

Unique beam design for particular functionality ✓

More than 70% isolation at low frequency ✓

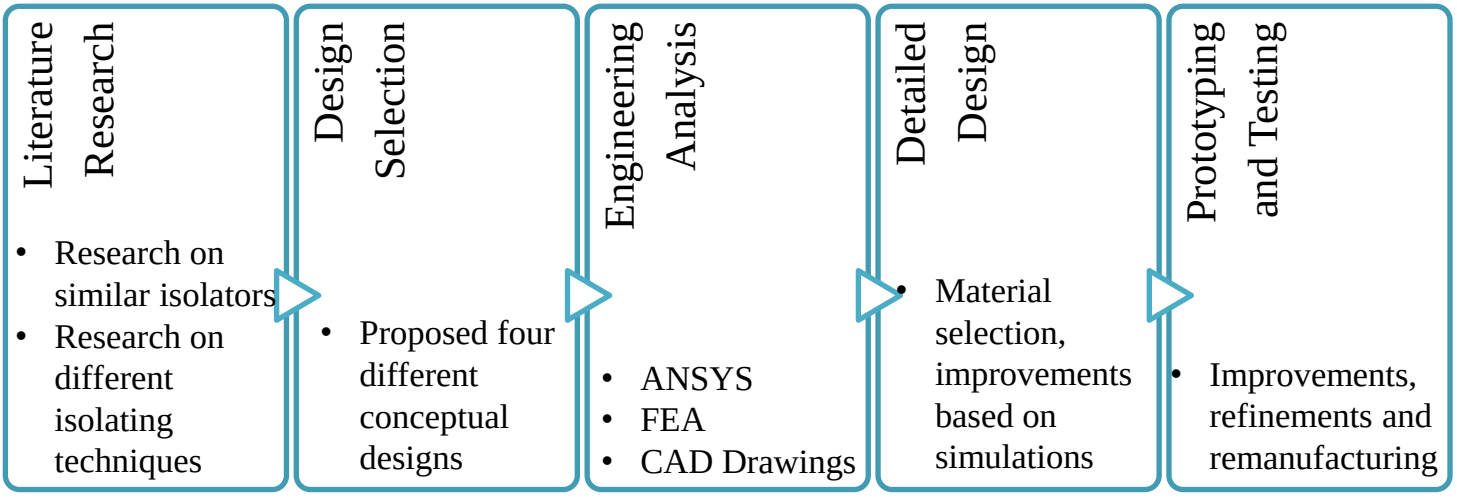
Produced by using only local recourses

Produced with easily found materials, with basic manufacturing techniques at low cost

Operating with self developed software

Outcomes:

Developing this design required many engineering analysis and testing procedures. The project team has gained hands on experiences on manufacturing processes, instrumentation and measurements during experimentations and tests. The design procedure below is followed throughout the project:



SPAOSA (A3)

Design and Optimization of Ice Cream Molding Process to Increase Rate of Heat Transfer in Pilot Plant Scale

Academic Supervisor: Dr. Luca Biancofiore

Industrial Supervisor: Dr. Tolga Susuzlu

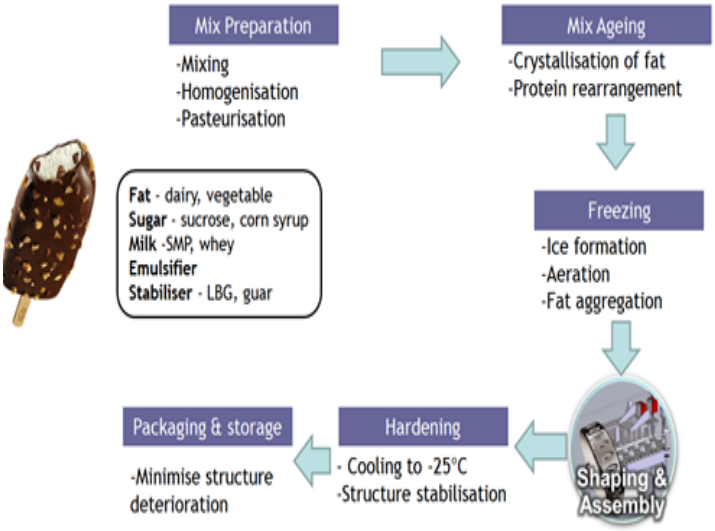
Teaching Assistant: Dilara Uslu

ABSTRACT

The goal of the project was to develop a mathematical model of the ice cream molding process to model the rate of heat transfer and determine the freezing time for a particular sample, and use the model to optimize the existing system to improve the rate of heat transfer and hence reduce the freezing time of the ice cream. The working model was developed using the one term approximation model, and was validated using experimental data. During the final design planning, several constraints were taken into account such as cost, manufacturability, mold geometry and health and safety. In the final design, circulation inside the tank was introduced with the help of a pump to increase the convective heat transfer coefficient and subsequently, improve the rate of heat transfer during the freezing process.

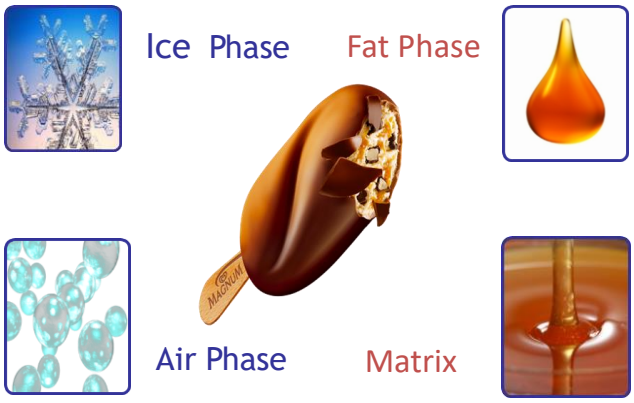
Problem Definition

Textural characteristics of ice cream are an important factor that determines the satisfaction of the consumer. Consumers have indicated that a coarse (icy) structure is generally unappealing as compared to a smooth (creamy) structure[1]. Businesses in the ice cream industry are therefore seeking ways to improve the textural characteristics of their products in order to increase sales. In the manufacture of ice cream, the formation of ice crystals is critical in determining the quality of the ice cream to be produced. Quality is measured as the extent to how creamy the final product is; that is, the sizes of the ice crystal are required to be as small as possible to avoid an undesirable coarse ice cream structure.



Molding is a technique to produce ice cream products with stick for easy handling. One of the production stage is the final (static) freezing stage, where the ice cream mixture is passed on to a mold of specific geometry for freezing. In this process, the ice crystals formed during the dynamic freezing stage recrystallize, and become larger and increase in surface area. This effect increases the coarseness of the ice cream. The time taken for the ice cream to freeze is directly proportional to the production time of the ice cream, and the size of the ice crystals. The primary problem is the long freezing time of specific ice cream types, resulting in coarser ice cream with a high production cost

In the factory condition, ice cream freezing occurs at a rapid pace, close to around 2 minutes for a mold ice cream. This pace is achievable due to the closed environment inside the factory, which allows brine to be used as a coolant, and also allows for forced convection to implemented. However, in the pilot plant, the process can take up to 30 minutes due to the fact that it is an open system and so brine must be replaced by glycol as it is highly corrosive, and liquid coolant can no longer be stirred and so only free convection is available inside the tank.



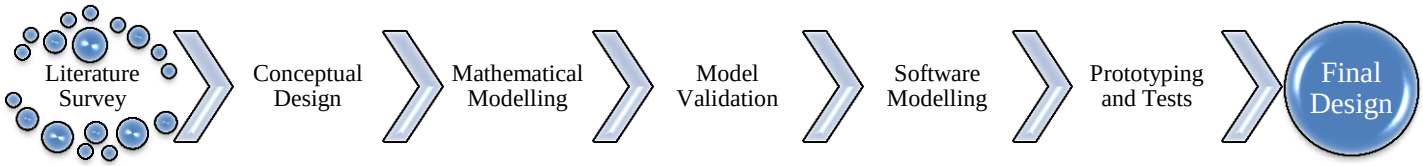
Reducing the freezing time by modifying the mold geometry makes it possible to save production time per unit product while improving the ice cream quality. Since the proposed approach changes the mechanical aspect of the system, no additional power cost will be introduced. Consequently, more products can be manufactured for a given time and for the same energy cost. In addition, the proposed solution aims at reducing the freezing time regardless of the mixture content. This solution would allow for the production of better quality ice creams with low fat content which would typically have a higher freezing time and larger crystal size.

[1] Marshall, R. T., Goff, H. D., and Hartel R. W., 2003. *Ice cream*. 6th ed. New York: Kluwer Academic/Plenum Publishers.

Design

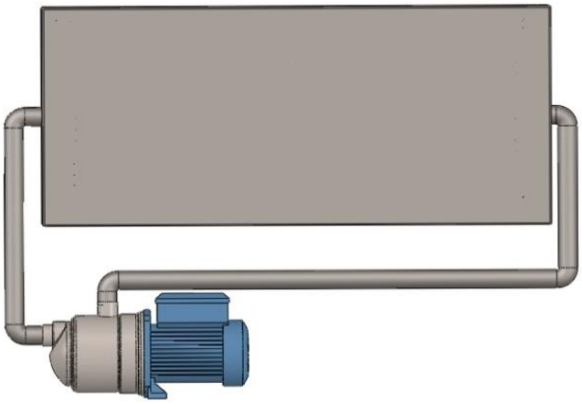
A solution to this project has been designed and produced in accordance to the requirements and constraints of the project. This solution involves the implementation of fluid circulation within the tank so as to induce a forced convection around the ice cream mold.

The design of this system followed a gradual procedure which can be condensed into the steps shown below:

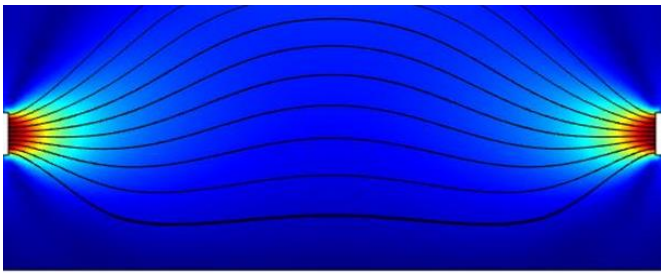


This design consists of a cooling tank with a fixed mold immersed in coolant liquid at the center of the chamber. The coolant used is propylene glycol which has been selected for its low freezing point and non-corrosive property. The tank is designed to be sufficiently large so that the fluid is well dispersed and cooled during circulation. The circulation is introduced using a system of a pump and pipes which are attached to both ends of the tank. Propylene glycol is drawn through the suction pipe and pumped into the system via a return line. The fluid being circulated is constantly cooled by a heat exchanger at the bottom and sides of the tank. The fluid acts on the walls of the mold and significantly improves the rate of heat dissipation at the mold-coolant interface.

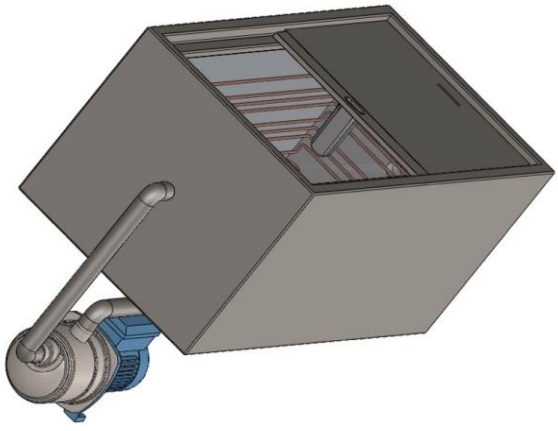
The system is insulated to prevent heat loss to the surroundings and the pump is placed rigidly on a platform below the tank to reduce the effects of vibration. The tank is covered such that there is no direct contact between the surrounding environment and the propylene glycol within the tank; this also reduces heat loss from the system to the environment. All parts used in the design of this project are safe for the production of ice creams as the safety concern in the food production industry is the number one priority.



Front view



Velocity streamlines of the induced fluid flow inside the tank (from the front)

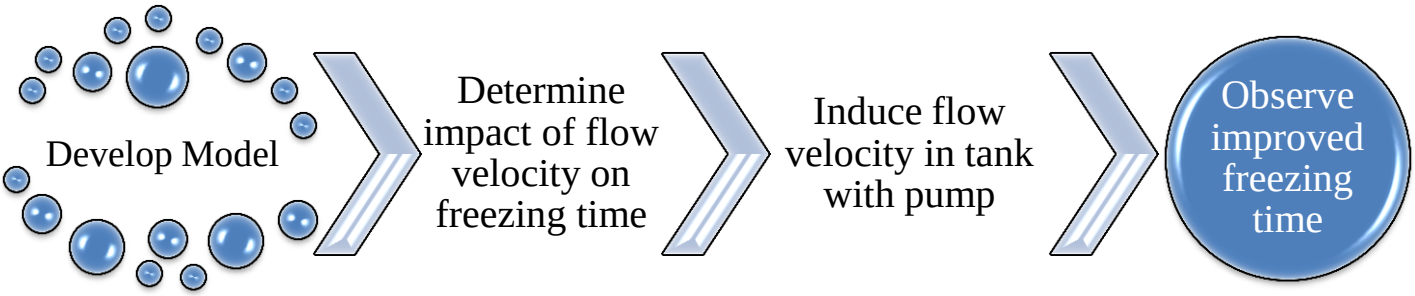


Inside view

Outputs

Results

- As part of the project, an analytical, multidimensional, transient heat conduction model was developed which can be used to calculate the freezing time for any molded ice cream sample.
- The model can produce results with an approximate 15% error margin.
- Based on the model, the heat transfer coefficient inside the tank was increased by inducing a circulation with the aid of a pump, and the flow velocity was further increased with the use of buffer plates.



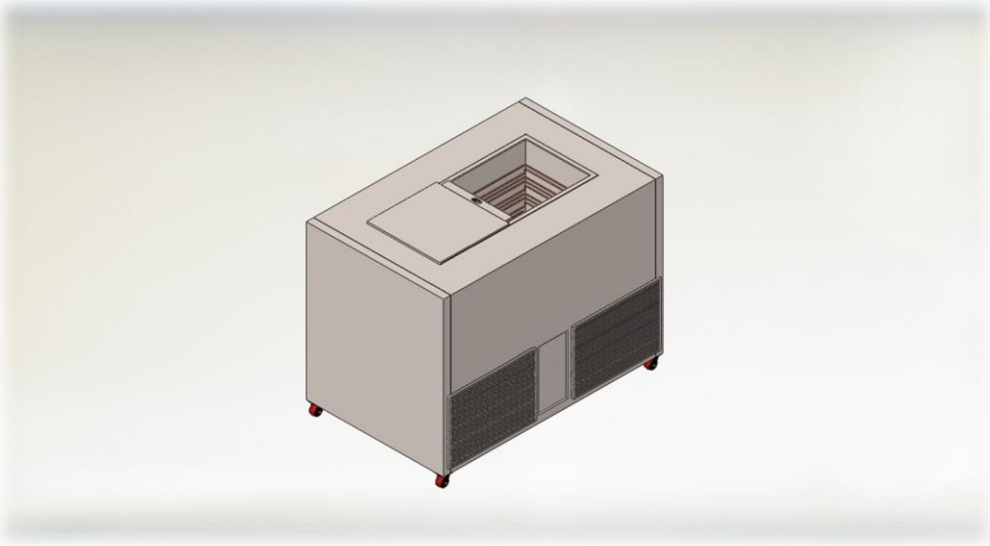
Outcomes

The Outcomes of the project are listed below:

1. A working model to predict the freezing time during static freezing stage in ice cream production
2. Reduced freezing time for ice cream production stage in a pilot plant scale.
3. Improved ice cream texture for the products produced in the pilot plant.
4. Better comparability between samples produced in the pilot plant and actual factory products.

Appreciation:

The SPAOSA team is grateful to everyone who contributed towards the success of this project. We are indeed grateful to:
Dr. Tolga Susuzlu
Asst. Prof. Luca Biancofiore
Asst. Prof. Yildiray Yildiz
Dr. Mujdat Tohumcu
Dilara Uslu,
for their immense support and contribution throughout the development of this project.



Final Product: Tank, Pump and Heat Exchanger together.

HERMANOS (A4)

Aerospace Hydraulic Flexible Hose Design and Prototyping

Academic Supervisor: Dr. Yegan Erdem

Industrial Supervisor: Salih Okatan

Teaching Assistant: Cem Kurt

- ABSTRACT-

This project is about designing of a flexible hose used in hydraulic systems that works in space environment. One end of the hose will be attached to a pump integrated direction block whereas the other end will be attached to the actuator of the system. The hose that is prototyped should work in the range of -54 oC ~ +204 C and should stand up to 210 bar. Even there are similar products in foreign market it is impossible to import aerospace flexible hoses between defense industries and supplier due to bureaucratic barriers and everlasting documentation. The main goal of the design project is to nationalize this high technology product in order to reduce foreign dependency by using Turkey resources

Problem Definition

Modern missile systems have an actuator, which is a component of a machine that is responsible for moving or controlling a mechanism or system and requires a control signal and a source of energy [1]. The control signal may be electric voltage or current, pneumatic or hydraulic pressure, or even human power. The supplied main energy source may be electric current, hydraulic fluid pressure, or pneumatic pressure. When the control signal is received, the actuator responds by converting the energy into mechanical motion [1]. In order to provide mechanical motion in missile systems, actuators should be connected to the fix points with the hoses. A hose is basically a flexible hollow tube designed to carry fluids from one location to another. Hydraulic hoses can be used to transfer fluids in aerospace products. As it is said before, hydraulic fluid pressure can be needed in missile systems to provide motion or energy source to drive the actuator. For this reason, hoses should be watertight

Figure 1. Basic Flexible Hose [3]

The term flexible is the most important requirement of this project because one end of the hose will be attached to a pump integrated direction block whereas the other end will be attached to the actuator. Since the actuator will be mobile, the hose should be flexible enough to be not damaged or kinked and over-stressed while on service because over-stressing drastically reduces hose service life.

The main problem is design of a flexible hose, which is used in hydraulic systems and works in space environment. The hose that will be prototyping should work in the range of -54 ^{o}C ~ +204 ^{o}C, which is essential constraint for hose to be operated in space environments. Not only temperature, pressure is another requirement for hose to be functional in outer atmosphere. Hose will be used in high pressure applications and stand up to 210 bar (3000psi). Prototyping and choosing appropriate material for the hose according to the requirements and constraints are to be done.

In foreign market, there is an aerospace flexible hose, which meet all requirements [2]. However, the problem is that while ROKETSAN, which is an establishment of Turkish Armed Forces Foundation, wants to import these types of items there is a military protocol that creates difficulties. Also, in foreign market there are only few types of dimensions, in terms of length and diameter that are not enough for specific applications.

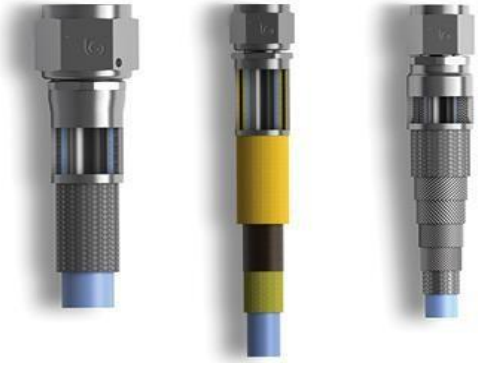


Figure 2. Types of aerospace hydraulic hoses in foreign market [2]

So, the aim is while prototyping the hose, learn the production steps and will be able to produce all desired dimensions, create domestic and cheaper hose, which will be used, in aerospace conditions.

[1]"Actuator".[Online].Available:https://en.wikipedia.org/wiki/Actuator. [Accessed 19 October 2016].
[2] *Handbook for the Design and Specification of HoseAssemblies*, NAHAD - The Assoc. for Hose & Accessories Distribution, Annapolis, 2015.
[3] "240 Series" Aerospace Flexible Hoses. [Online]. Available: http://www.titeflex.com/aerospace/product/240/. [Accessed 19 October 2016].

Design

The chosen concept has the structure of a basic hydraulic hose. It has three main parts, which are called tube, reinforcement and cover, and it is shown at Figure 3.

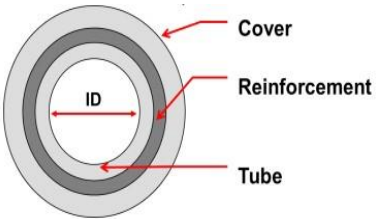


Figure 3. Classical Structure of a Hydraulic Hose [2]

To design, analyze and manufacture a hydraulic hose using **local sources**, which can work in **aerospace condtions,** adaptable to the standards of the **missile systems**.

Literature survey → Mathematical Modeling → Prototype and tests → Final design

The most inner part of the hose is called the tube. The tube is the inner most lining of a hydraulic hose and comes into contact with the fluid being conveyed, tube and fluid compatibility is most critical [2]. Basically, its function is to contain and conveys the fluid in service and also protects the outer elements of the hose from the fluid. The chemical compatibility is very important.

Reinforcement material is the “Muscle/Strength” to resist internal or external pressures [2]. The tube itself cannot resist the internal operating pressure itself and actually the tube design only gives importance to the tube’s compatibility with the fluid. Additional material is required to give the hose strength and durability. In this concept, the reinforcement type will be braid reinforcement.

Braid means to interweave three or more strands, strips, or lengths of in a diagonally overlapping pattern. The idea is to use steel wire or some other textile to create such a pattern outside the tube to create reinforcement. Braid reinforcement usually has one or two layers depending on the specifications of the desired product.

Figure 4. Hydraulic Hose with Double Layer Braid Reinforcement [4]

Advantages

- Braid reinforcement is extremely strong and also very flexible. If the material is chosen with care, it can increase the hoses flexibility drastically.
- Braided hose can handle low to high-pressure impulse applications [2]. It can also be used in constant high-pressure applications.
- Braid reinforcement usually have one or two layers so; dimension constraint will be easily satisfied.

[4] "Hydraulic Hose EN854-2TE from QIJUN INDUSTRY CO., LIMITED B2B Keyword hydraulic hose hydraulic rubber hose industrial hose", *Tradekorea.com*,2016.[Online].Available:http://www.tradekorea.com/product/detail/P290497/Hydraulic-Hose-EN854-2TE.html. [Accessed: 05- Dec- 2016].

Outputs

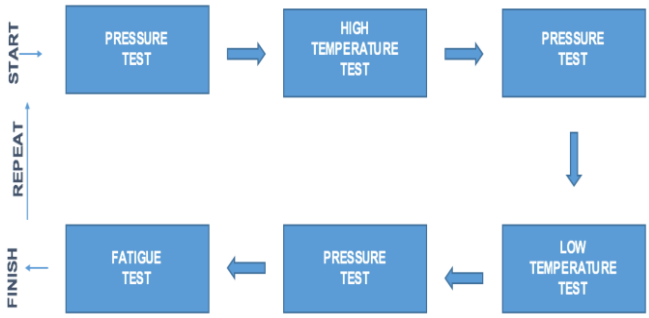
Results:

✓ Main purpose of the design other than its technical aspects is producing a reliable technology with national resources. This project showed that an aerospace hose can be developed and manufactured by using sources from different local manufacturers.

✓ Mathematical modeling developed satisfied all the necessary pre-test requirements.

✓ Prototype ensured all of the requirements defined in the problem statement and can be usable in aerospace conditions

✓ A test matrix is given at Figure 5 which includes all testing procedures that are Fatigue Test, Pressure Test, High and Low Temperature Tests. Our manufactured product has successfully completed all of these test stages.



Outcomes:

This project procedure consisted of several steps. In each step lots of engineering calculations are proceeded. A mathematical model is developed for flow and structure for the aerospace hose using hydraulic circuit analogy.

Although mathematical calculations are satisfied, simulations are also used to prove the results of the calculations. A test mechanism for flexibility is developed and manufactured. Pressure and temperature tests in hydraulic conditioning cabin are done in Roketsan.

Various engineering procedures and designed steps are performed, these can be listed as follows consisting of the software that are used:

- Literature searches
- Material selection
- Engineering analysis and mathematical modeling
  - HOPSAN simulations
  - FMEA analysis
- CAD drawings
- Test setups and procedures
- Manufacturing processes

With the help of this project, we gained the ability of simulating a hydraulic system, developing a mathematical model for a hydraulic hose. Since, this product has never been manufactured in Turkey before, the biggest challenge is to design a prototype that is both reliable and manufactured using local sources.

HERMANOS
HYDRAULIC FLEXIBLE AEROSPACE HOSE

5th SENSE (B1)

Design of fully integrated system which can automatically open the dishwasher door with a sense of sound or knock

Academic Supervisor: Dr. Yegan Erdem

Industrial Supervisor: Koray Koska

Teaching Assistant: Dilara Uslu

- ABSTRACT-

Main purpose of this project is to design fully integrated system which can automatically open the dishwasher door with a sense of sound. The process starts with literature survey, preliminary design, detailed design, selection of components, manufacturing selected components, integrating all of the manufactured/ purchased parts and testing. Design and production of this system made according to several constraints given by Arçelik such as; functional constraints, safety constraint, timing, manufacturability, economic, ergonomic, aesthetic and life cycle constraints. All of these constraints and requirements shaped our design. Consequently, a dishwasher door which can sense a sound has been designed, manufactured, integrated and tested.

Problem Definition

Dishwashers are commonly used kitchen equipment. In the early designs, dishwasher doors had handles to open the door and this became as a common feature in industry. However, nowadays aesthetics of these systems become much more important, and for this reason companies are trying to find news ways to open a dishwasher door without a handle. Companies come up with several solutions to open a dishwasher door with absence of handle but all of them were made just for aesthetics not the ease of usage. Need for this project just comes in that point. This design makes the current dishwashers more usable

Figure 1: Automatically Opening Dishwasher Door Sample

The project is to design a fully integrated system to open a dishwasher door automatically with a sense of sound. The dishwasher door should open up to 10 degrees angle and stand firm at this position. Generally dishwasher doors open manually as mentioned before; our aim is to design hands free opening system for the ease of usage. The project has two main challenges, first challenge is to filter out the correct sound and use it as an input to trigger the mechanism. Second challenge is to ensure that the opening mechanism will operate and open the door without any problem.

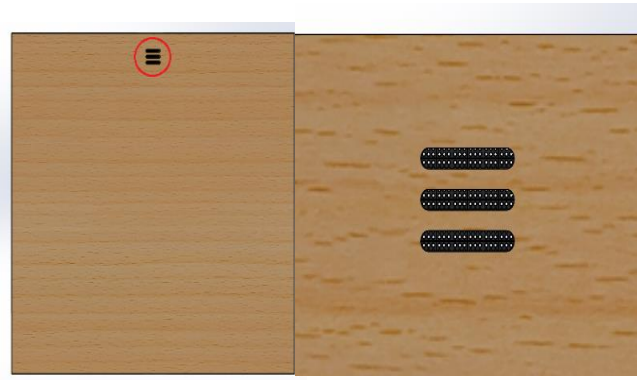


Figure 2 : Location of Microphone (Left) and Grid (Right)

There are some constraints and requirements for this project. The system should provide 70 N force and 43.4 Nm torque. The door should open within 5 seconds. Undesired activations must be prevented to provide safety, especially for children. Since this mechanism is considered for mass production, it should be easy in term of manufacturing and assembly. In addition, the project has upper cost limits which are 6 euros for mass scale production and 3000 TL for prototype production. Finally the system should be durable for 50000 cycle's life time.

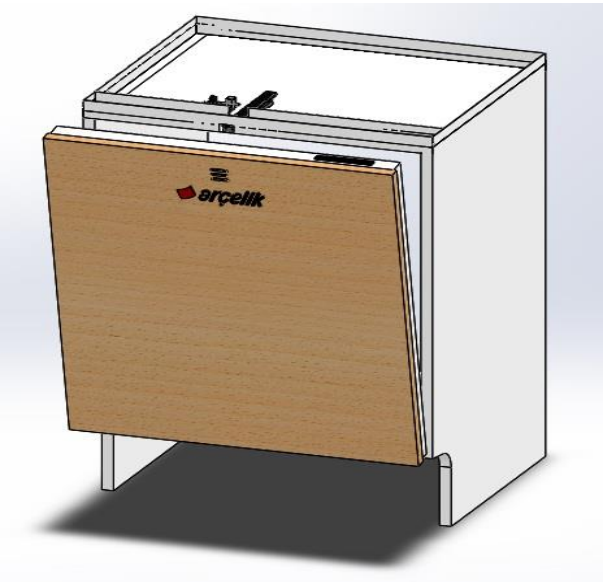
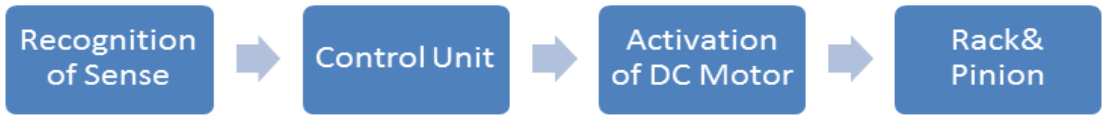


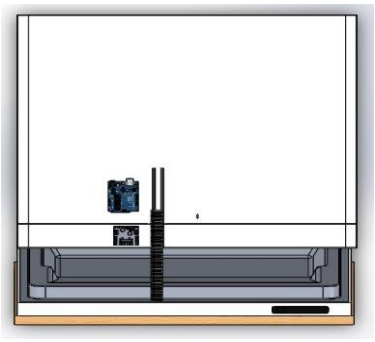
Figure 3: Solidworks Drawing for the Diswasher Design

Fig. 1."G 6587 SCVi XXL K2O AUS." G 6587 SCVi XXL K2O AUS Fully integrated dishwasher XXL Stainless steel - Dishwashers. N.p., n.d. Web. 20 Apr. 2017.

Design

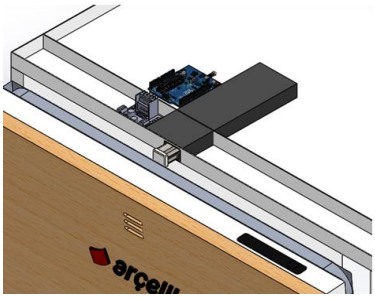
The solution for this problem mainly consists of 4 subsystems. Those systems are recognition of sound input, control unit, DC motor activation and rack and pinion movement respectively. The following schema demonstrates these operation steps.





Up view

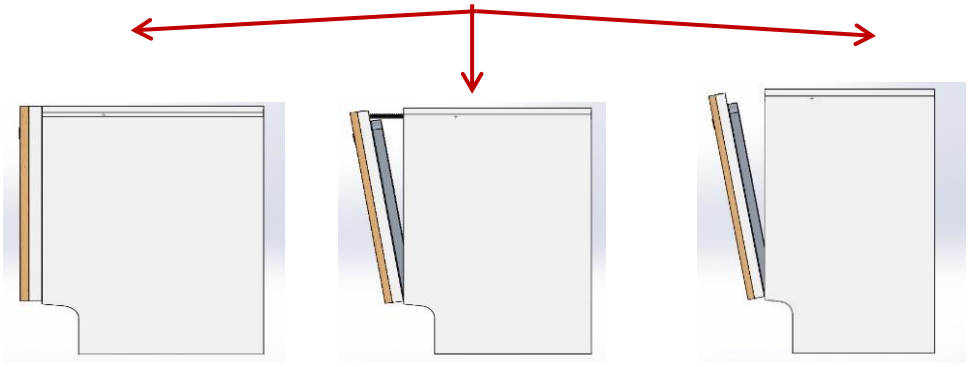
Front view



Operation view

Design should detect the sense (sound or knock) by the sensors located inside the encastered door or around the dishwasher. The information provided by the sensors are gathered and evaluated in the controlling system and further operations are driven by this unit. A response occurred according to information provided by the sensors. If that information is correct, DC motor run by the power delivered by the control unit or main system. Rotation of the DC Motor activates the rack & pinion system which is located in the top center of the dishwasher. Rack & pinion provides required force to open the dishwasher door and weight of the encastered door helps to maintain the door position at 10º angle which is obligated by Arçelik. Moreover, rack & pinion system should be insulated in order to prevent undesired noise.

There are three main operation in this system: Listening, Opening and Relaxation Operations



LISTENING OPERATION

• EasyVr is on and listening.
•Door is closed.
•DC motor is off.

OPENING OPERATION

- EasyVr has taken the user command.
- Door is opening.
- DC motor is on.

RELAXATION OPERATION

- EasyVr is off.
- Door is open and retaning 10 degree angle.
- DC motor is off.

Outputs

Results:

✓ In this project it can be seen that with the human sound dishwasher door can be opened hands free.
✓ The designed system for the dishwasher, satisfies all of the requirements and constraints defined in the problem statement and it is manufacturable in white good industry.
✓ Innovative in white good industry and can be used as a part of future, smart houses.

Figure 4 :Smart house features

Outcomes:

From the beginning of this project there are several processes have been carried out. Each process involves some engineering calculations and design improvements. Several engineering approaches, -fatigue, life cycle calculations, stress simulations, deformation tests- have been performed to meet the constraints set by Arçelik. Voice recognition phase includes Arduino programming and Quick Synthesis usage. In every aspect of the project, 4 years of mechanical engineering knowledge is used and moreover some new techniques and software are learned.
These processes that are followed can be listed as:

- Literature search for similar systems
- Patent research
- Design of the system with calculated data
- Engineering analysis and technical drawings
- Voice recognition and control unit programming / integration
- Manufacturing processes and budget adjustments
- Test setup and testing procedure
- Installation of the system on given dishwasher

SINGATA (B2)

Design of a Stable Platform for Turret Mechanism

Academic Supervisor: Dr. Onur Özcan

Industrial Supervisor: Hüseyin Avni Güner

Teaching Assistant: Levent Dilaveroğlu

- ABSTRACT-

This project aims to develop a stabilizer for the turret mechanisms on a modern warships or cruisers. Turret mechanisms are able to detect a target, track the particular target and fire projectiles with the help of image processing systems. To eliminate given vibrations, disturbances and demonstrate firing instance, project will have 3 sub-systems; image processing system, stable platform, and test setup. Economical, operational, material, manufacturability, reliability, effectiveness and speed constraints help to shape every step of project. In the light of requirements and constraints, image processing system, stable platform, and test setup developed, manufactured and tested.

Problem Definition

Modern warships such as cruisers and frigates are often equipped with weapon systems which are able detect a target, track that particular target throughout its motion and fire. These weapons systems are referred as gun turrets and often utilize image processing systems to track targets which are vulnerable to the disturbances such as vibrations. These vibrations have many sources, such as the Diesel engines which power these ships and propellers. Although it is difficult to eliminate these mechanical vibrations completely, they are controllable to an extent. Another major source of the vibration is the sea waves which originate from the winds. These vibrations range in frequency and magnitude and often have more significance. This is because these waves are nonlinear as the amplitude is coupled to the frequency. This means that as the frequency changes, the amplitude of these vibrations changes. The vibrations caused by these waves are the main vibration sources that needs to be eliminated. So, these weapon systems require subsystems which stabilizes the platforms that they're mounted.

Figure 1. Sample of Turret Mechanism [1]

The main requirement for the project is to have a stabilizing platform that can hold the top platform horizontally stable while the bottom platform is subjected to various modes of vibrations, mainly originate from sea waves. These waves often have large amplitudes but comparatively lower frequencies, mostly ranging from 10^{-1} Hz to 1 Hz. Therefore, the system should be able to keep the image processing equipment horizontally stable.

Figure 2. Sample of Tracking System [1]

Another aspect of this system is to demonstrate the tracking capabilities of the system, meaning that, the end product should also have an operational tracking system which can track a specified target throughout its motion. The system should be able to mark a specified target, located within 10 meters distance from the platform. System should also produce a reasonably accurate distance data to this target, speed at which the target moves so that the aiming mechanism should be properly aligned. The system should work as follows: After the target is specified, tracing operation should start and by using proper distance measuring device, distance to target should be determined within $\pm 2\%$ accuracy. Also, the speed of the target should be calculated by using image processing techniques which is called predict aiming. In this technique, the firing point is determined by considering speed of the target, distance to target, and speed of the projectile. Since these three data are known travelling time of the projectile can be calculated. In other words, the system will able to forecast the expected location of the target. These points then need to be shown specifically to the user, via a display. For further application, the technique called adjust fire whose firing point will be attained by user. The operator will input a point on the system, indicating where the projectile actually hit. This point is then processed by the system to correct the heading of the projectile, so that for the second time the projectile and the target will perfectly collide.

[1] "Missile Gun Turret ", The Military and Asian Region, Available at: *https://thaimilitaryandasianregion.wordpress.com/2016/01/18/*

Design

The project consists of three subsystems. As the main requirement for the project is to have a stabilizing platform that can hold the top platform horizontally stable while the bottom platform is subjected to various modes of vibrations, mainly originate from sea waves, it is decided that Stewart platform which employs servos for actuation is best choice. A Stewart platform, or Gough-Stewart platform, is a parallel robot with six prismatic actuators/joints between two plates, a base platform and a mobile top platform demostrated in figure at the right.

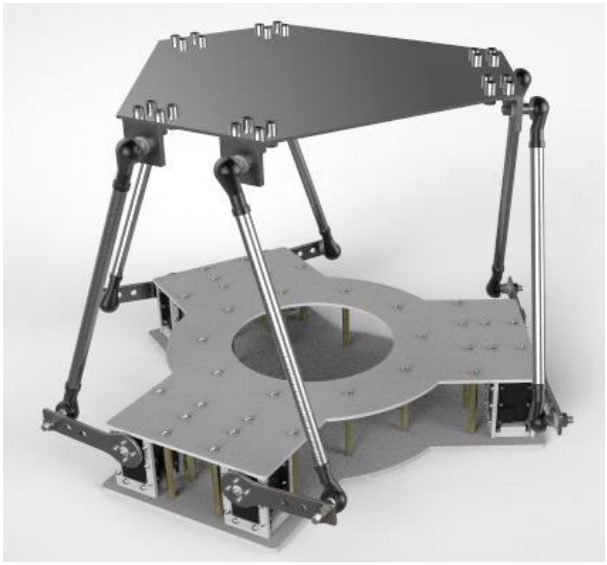


Figure 3. Stewart Platform

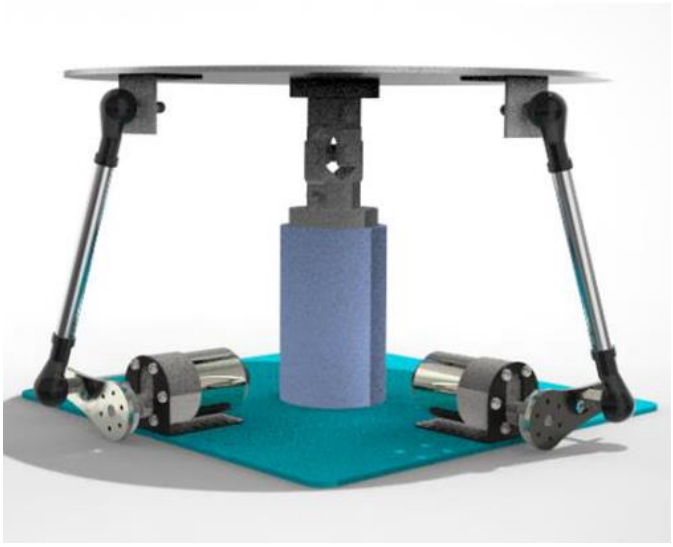


Figure 4. Test Setup

To show capabilities of Stewart platform designed, test setup will be placed at the bottom and fastened to Stewart platform. It consists of two aluminum plates, two connection rods, two servo arms, and two DC motors shown in figure at the left. DC motors create the random disturbances to show stability of the Stewart platform.

For tracking mechanism two servo motors, one LIDAR, one laser beam, and one camera is used. Servo motors are mounted on each other by using brackets. In the assembly of the tracking mechanism, LIDAR, laser beam and the camera are placed to same spot, which they can look at the same point at the same time. The overall design of this subsystem is shown at the right.

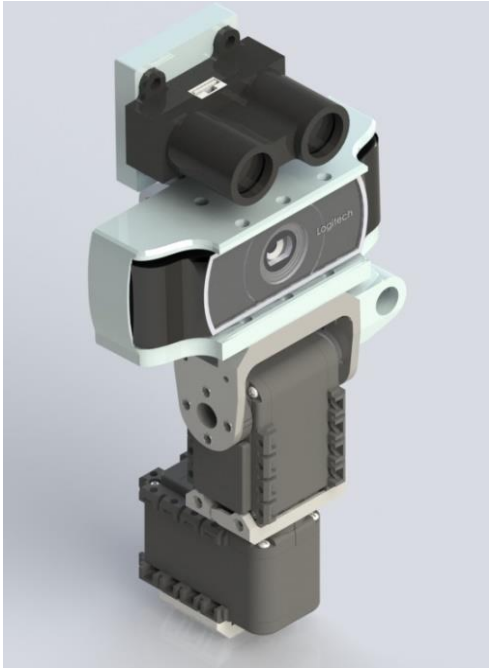


Figure 5. Tracking System

Outputs

Results:

✓ Main purpose of the design other than its technical aspects is developing a turret mechanism that was completed in Turkey with domestically developed code by Turkish engineers. Hence, Turkish Armed Forces may put this system in its inventory in the future.
✓ Three different subsystems were completely produced. In that way, stabilazing of the system, tracking and firing of the target and creation of external disturbance processes are succesfully completed.
✓ System satisfied all of the requirements defined in the problem statement and can be usable in military conditions. Moreover, additional test section was produced
✓ The team succesfully kept in the boundaries of the budget even if one more extra subsystem is unscheduledly produced.

Outcomes:

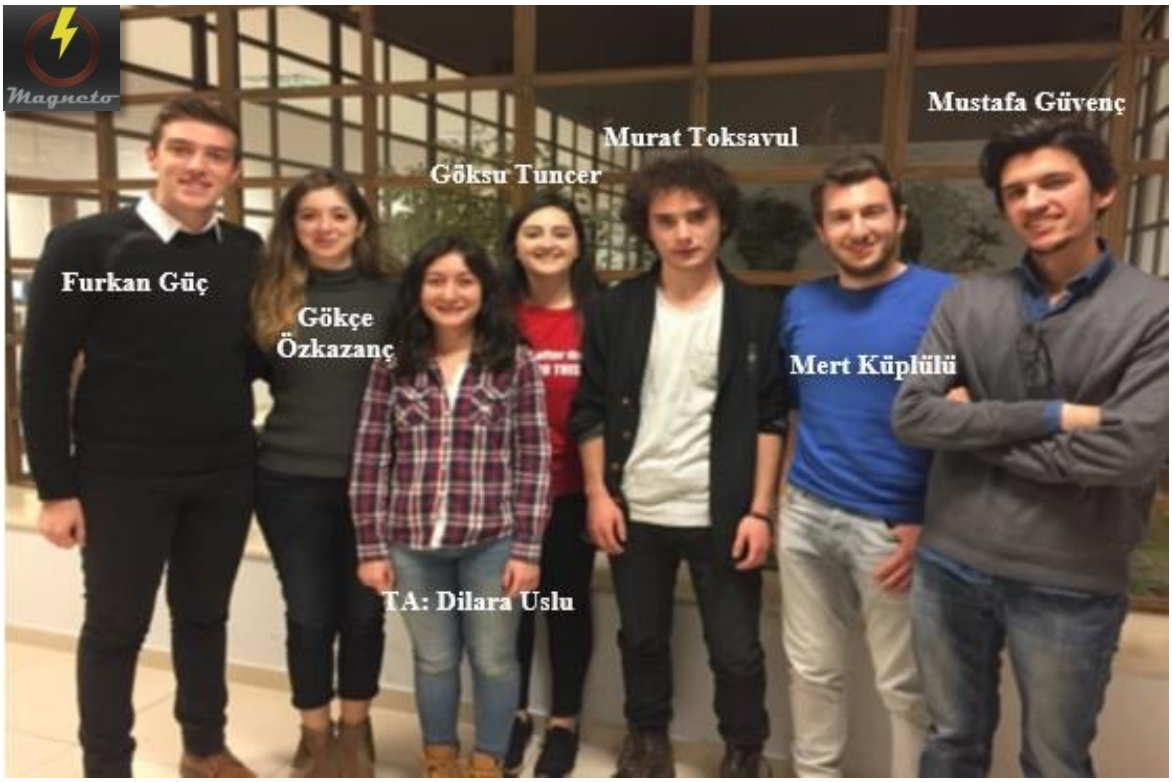
The project procedure consisted of several steps. Each steps required lots of engineering calculations, simulation and software knowledge. Throughout this project all of the pre-learned engineering procedures are used, these can be listed as follows consisting of the softwares that are used:

- Deep literature searches
- Analytical thinking
- Engineering analysis
  - -COMSOL simulations
  - -FEM analysis
- High Level CAD Drawing Ability
- Image Processing
  - •Object Detection
  - •Tracking
  - •Firing Calculations
- Mechatronic Systems
- Establishment of Control Setup
- Test Mechanisms
- Manufacturing processes

The project was financially worthied to support by
TÜBİTAK 2209-B Industrial Senior Year Project Support Program

MAGNETO (B3)

Development of Electro-Mechanical Clutch for Military Systems



Academic Supervisor: Dr. Melih Çakmakçı

Industrial Supervisor: Bülent Başaran

Teaching Assistant: Dilara Uslu

- ABSTRACT-

Main purpose of this project is to develop an electro-mechanical clutch mechanism for the military systems. Development procedure consists of literature survey, design activities, manufacturing and testing. While developing the clutch mechanism, there were several constraints to be satisfied whose main titles can be listed as; operational constraints, material constraint, safety, manufacturability, economic constraints, ergonomic and aesthetic constraints. By taking into consideration these requirements; an electromechanical clutch has been developed, manufactured and tested.

Problem Definition

In modern vehicles, torque and power is generated by the engine and this torque needs to be transmitted to the drive shaft so that the desired motion of the load can be obtained. This transmission is actuated by a clutch mechanism. In this manner, a clutch makes two shafts engage or disengage based on the availability of the power source within the vehicle [1]. This engagement or disengagement of the shafts is provided by different ways such as using friction discs or magnetic fields requiring a mechanism.

Throughout this project, a clutch will be developed for military systems. This clutch will provide a phase shift between two different drive modes: electrical motor and manual control mode. In other words, this clutch will engage the shafts when the electrical motor is in use and disengage them when manual control is required. These drive mode changes can be seen clearly from the Figure 1 given below. As a requirement, an electro-mechanical clutch will be developed which is actuated by electrical current.

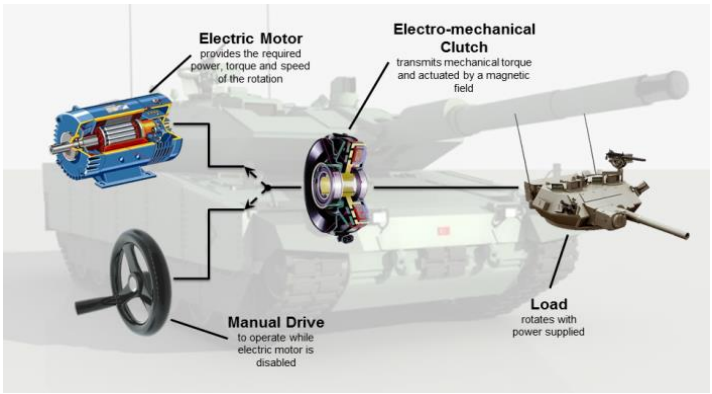


Figure 1. Use of electro-mechanical clutch for military systems

It is known that the currently available products are bought from abroad for this purpose. Yet, cost of product increases dramatically and maintenance becomes much more difficult when a product comes from a foreign country. On top of those, their export can be precluded by the international laws. Therefore researching, designing and manufacturing the clutch system in the same country where it will be used is crucially important.

In the military vehicles, the currently used clutch system is electro-mechanic clutch system that controls the rotation of the target system in different directions by both automatically and manually. In the domestic production of the military vehicle, the electro-mechanical clutch system is desired to produce with all national R&D and manufacturing techniques. In this context, the location of electro-mechanical clutch in the military system is shown in the Figure 2.

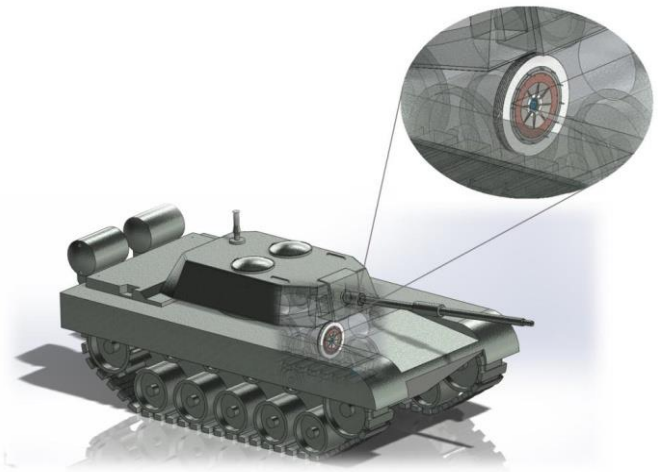


Figure 2. The location of electro-mechanical clutch in the military system[2]

Therefore the main purpose of this project is to design, analyze and manufacture an electro-mechanical clutch mechanism with using local sources, which can give the desired torque output along with the maintenance and reliability requirements also adaptable to the working conditions and standards of the military systems.

[1] "Clutch Mechanisms." Ed-Thelen. N.p., n.d. Web. 4 Nov. 2016.
[2] "GrabCAD - CAD library", Grabcad.com, 2017. Web. 21 Apr. 2017.

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:

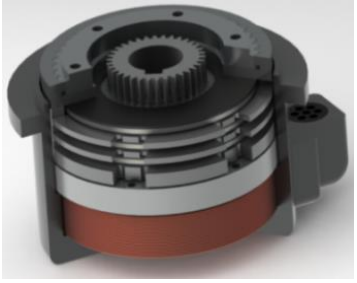
Literature survey → Virtual system → Prototype and tests → Final design

To design, analyze and manufacture an electro-mechanical clutch using **local sources**, which can give the desired **torque output,** adaptable to the standards of the **military systems**.

Up view

Down view

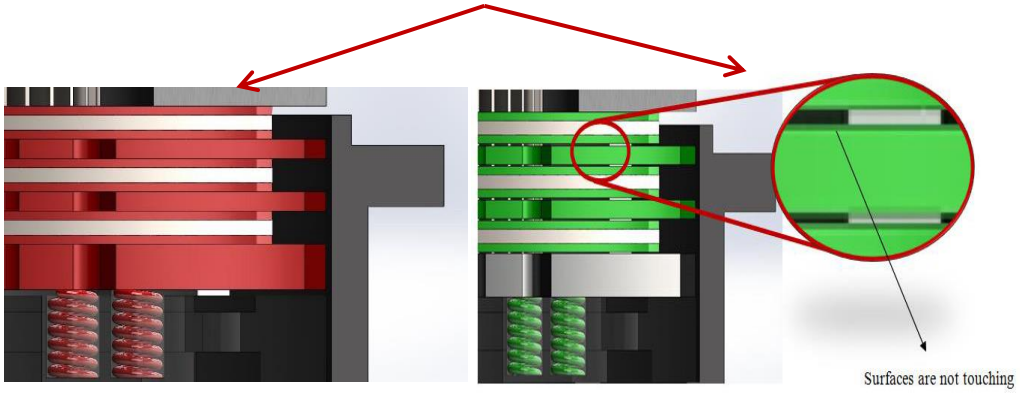
Inside view



Cross Section view

At the end of these procedures, problem given is totally satisfied. The working principle of the multi friction plate electro-mechanical clutch satisfying the needs is based on the electromagnetic effects provided by the coil and those effects are converted to mechanical transmission. The magnetic field principle is exploited in order to disengage the manual shaft drive from the rotor which is connected to drive shaft. The transmission of torque is provided by the aid of multiple discs and these discs make the clutch able to transmit high torque values. Two different working orientation of the design are demonstrated in Figures given below.

Two phases of the system: Engaged and Disengaged



MANUAL DRIVER MODE

- Electrical motor is off
- Disks and plates are touching (engaged)
- Powered manually

ELECTRICAL MOTOR MODE

- Electrical motor is on
- There is current on the system
- Coil is magnetized (pulling the plates)
- Disks and plates are not touching (disengaged)
- Powered by electrical motor

Outputs

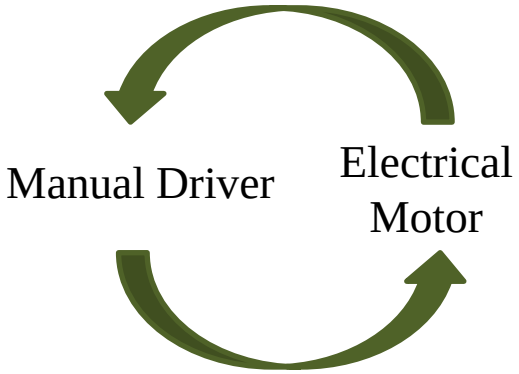
Results:

✓ Main purpose of the design other than its technical aspects is producing an expensive technology coming from abroad with more reachable sources. This project proved that a technology can be developed mainly by using sources without needing any exports. This point reduced the cost and in additional to that, technology became more improved with localized sources.

✓ All virtually fictionalized systems proved to be working even the prototypes and test mechanism.

✓ System satisfied all of the requirements defined in the problem statement and can be usable in military conditions.

✓ Phase shift between manual driver and electrical motor is done along with the required motion of the load (which is turret for this case)



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 such as the magnetism analysis and the heat 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
- Engineering analysis
  - -COMSOL simulations
  - -FEMM analysis
- CAD drawings
- Test mechanisms and procedures
- Manufacturing processes

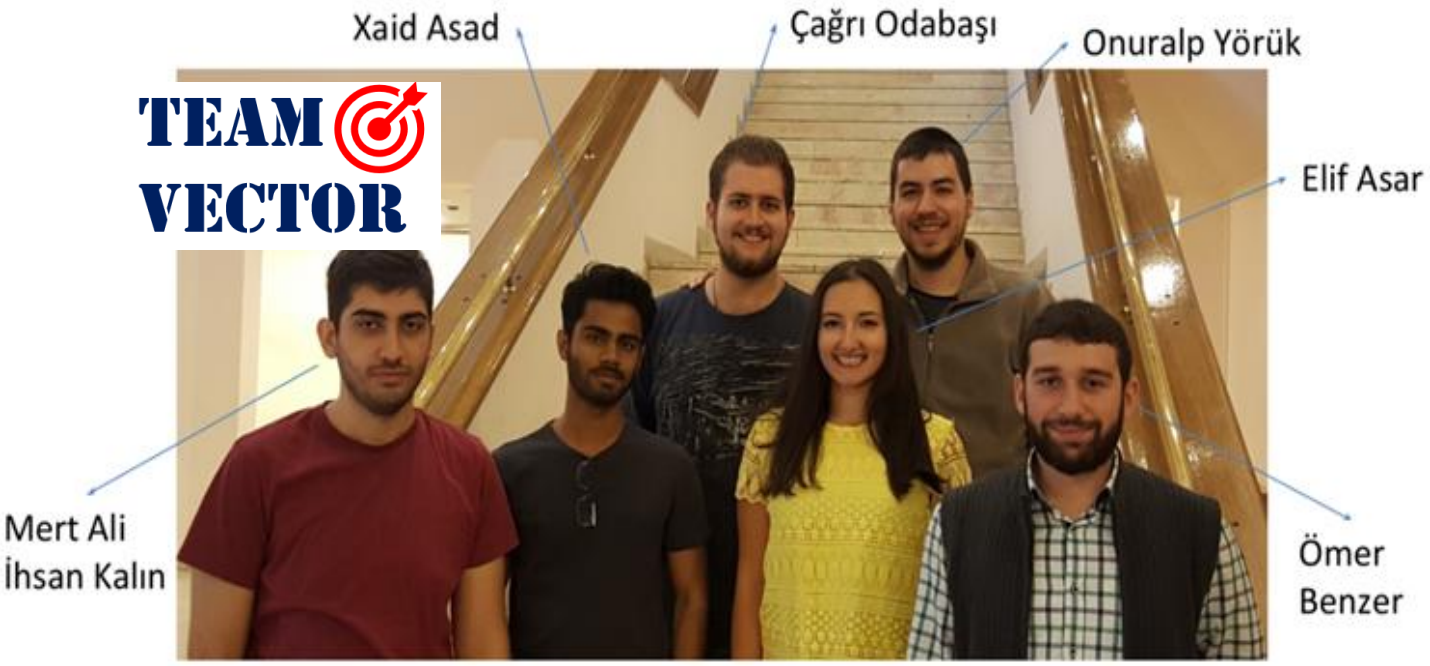
Acknowledgements:

This experiment is granted with TUBITAK 2209/B award

Besides the softwares, as an engineer certain skills are obtained such as developing a test mechanism to obtain the correct data. Also by producing our own project, familiarity with production facilities is gained in addition to learning manufacturing processes with hands on experimentation during these procedures.

TEAM VECTOR (B4)

Design of a Fuel Suction System that Works in Various Tilting Angles



Academic Supervisor: Dr. Barbaros Çetin

Industrial Supervisor: Dr. Hakan Mencek

Teaching Assistant: Cem Kurt

-ABSTRACT-

One of the fuel tanks of the Turk Tractor has an irregular shape that prevents sucking all the fuel with one suction pipe in tilting conditions. Hence, the project is aimed at designing a new suction system that will eliminate trapped fluid inside the tank in 25o tilting angles for 4 directions with 5% error. The system is based on the existing fuel tank and problem is solved by increasing suction points such that main suction line is inside a pool called reservoir fed by two additional pumps. The pumps are located in critical locations inside the tank and their ON/OFF activity is controlled by a controller unit fed by fluid level sensor located near pumps. That is because the pumps should be OFF when there is no fluid at the pump inlet in order not to increase air bubble content of the fuel that goes to tractor's motor.

Problem Definition

Primary Problem: TürkTraktör produces a wide variety of tractors that are bought and utilized by thousands of customers in many different professions. One such area of work is the field of agriculture where TürkTraktör products are put to use in order to obtain power and traction which are then utilized in the arduous tasks of tillage and hauling. However, during operation of tractors manufactured by TürkTraktör on fields with an elevation difference of up to ± 25° in β and θ directions showed in figure 1, it was observed that 10% of the fuel remains trapped in the fuel tank unable to be used. This happens because the suction system used in the fuel tank is unable to reach the fuel that remains in the tank when the tank is nearly empty during tractor operations under elevated conditions for long periods of time.

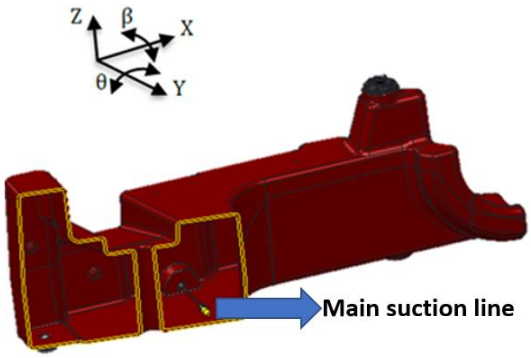


Figure 1. Existing suction system creates problem.

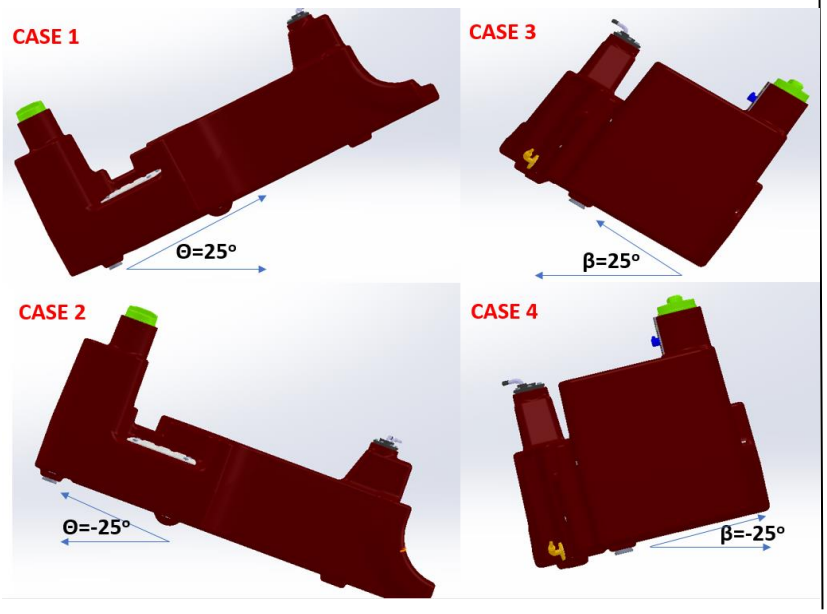


Figure 2. Tilting cases

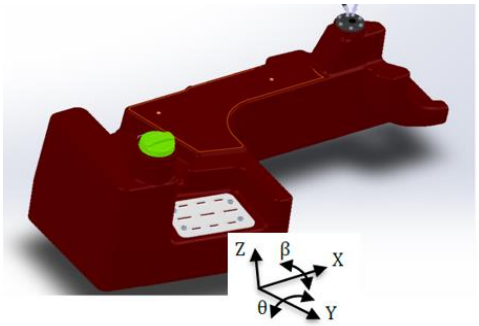


Figure 3. Irregular-shaped fuel tank

Goal and Motivation: Decreasing the amount of trapped fluid in tilting cases decreases the minimum fuel needed to sell the tractors. Hence, the tractor initial cost for fuel will be diminished. Also, quality of the tractors enhances.

Secondary Problem: If the solution contains additional suction pipes, none of the pipes can suck air because air bubbles can create motor power problems and sucking air directly can burn the pumps (see Figure 3). Therefore, if it is chosen to solve the problem by adding pipes, it is required to differentiate between air and fuel at the inlet of the pipe and close the air inlet.

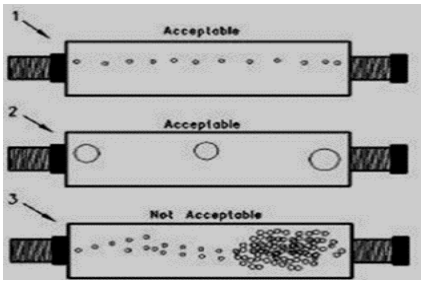


Figure 4. Excessive air bubble on the fuel line is not acceptable [1].

Requirements and Constraints: There is a need for different suction system.

- The minimum fuel that cannot be sucked is asked to be decreased at least %5 in ± 25 tilting angles in β and θ directions.
- Problem need to be solved without changing the shape of the existing fuel tank.
- If the solution contains additional suction pipes and pumps, none of the pumps can have air inlet.

[1] Accessed on 12.9.16 "http://tractorz.blogspot.com.tr"

Design

To solve tilting problem → Use additional pipes and pumps on critical locations

Fig 5. Pump-pipe assembly

To solve sucking air problem → Use level sensor to differentiate whether the pumps' inlet are in vicinity of fluid

Fig 6. Fluid level sensor

To control pumps ON/OFF activity → Use a controller unit

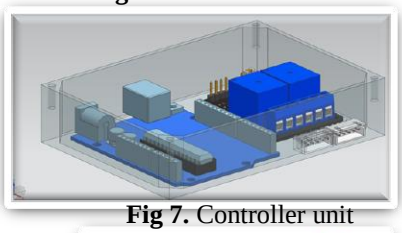


Fig 7. Controller unit

Both pumps may OFF because of the controller delay → Use reservoir to maintain feeding of main suction line

Fig 8. Reservoir

Design consist of:

- 2 pipe lines
- 2 electronic pumps
- 2 fluid level sensor
- 1 reservoir
- 1 control box

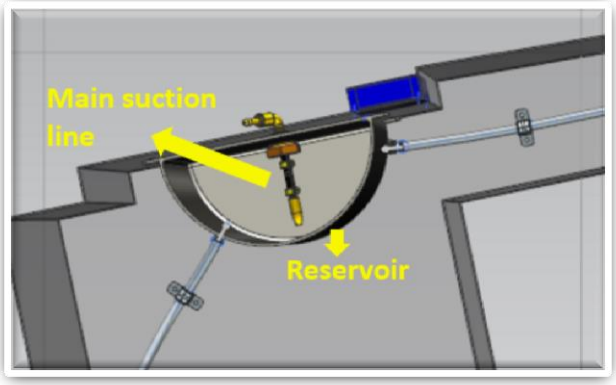


Fig 9. Main suction line inside the reservoir

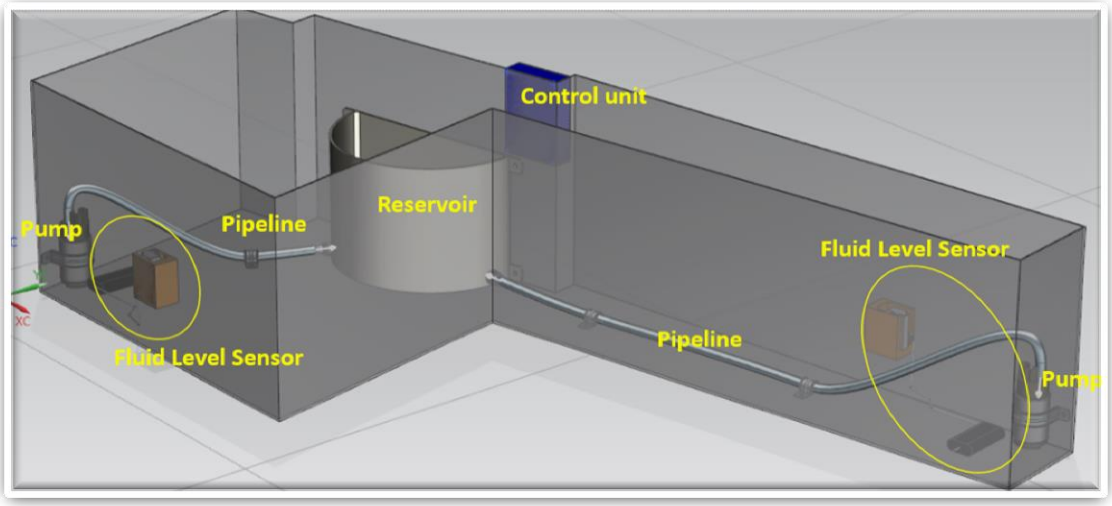


Fig 10. Model of the system

Outputs

Results:

✓ Fuel suction in tilt conditions is a major problem of vehicles. The problem gains more importance if the fuel tank has an irregular shape. Still there is no universal solution to this problem. By Team Vector's solutions, the fuel suction problem in tilt conditions is diminished.

✓ This solution can also be used in different shape of fuel tanks after deciding the critical locations and their number.

✓ Solving suction problem in tilting conditions not only increases the customer satisfaction, but also decreases necessary fuel input before selling tractors about 9 liters. Hence, considering the number of demands and fuel prices, for a tractor company that sells 40,000 products, annualy 1,000,000 TL will be saved approximately along with increased customer satisfaction.

Outcomes:

This project have been done in several steps stated as follows:

- Literature search for the same problem
- Analytical thinking
- Engineering analysis
  - -Calculation of necessary pump work to select pump
  - -Determination of critical locations inside the tank
  - -Designing a filter for fluid level sensor
- CAD drawings
- Test mechanisms and procedures
  - -Verification of critical locations for pumps and sensors
  - -Verification of pump and sensor orientations
  - -Tests for controlling ON/OFF activity of the pumps by using filtered data of sensors.
- Manufacturing processes

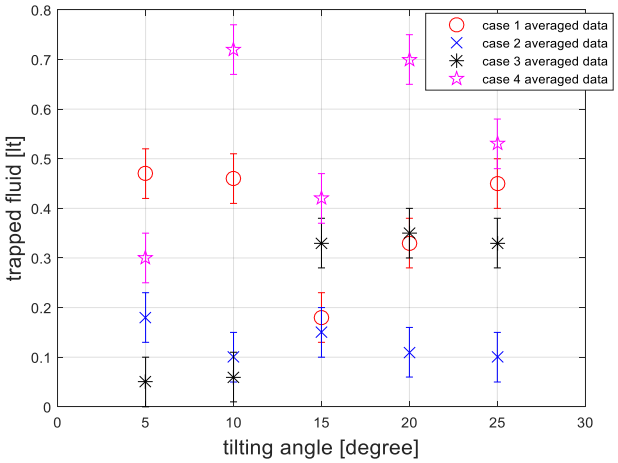


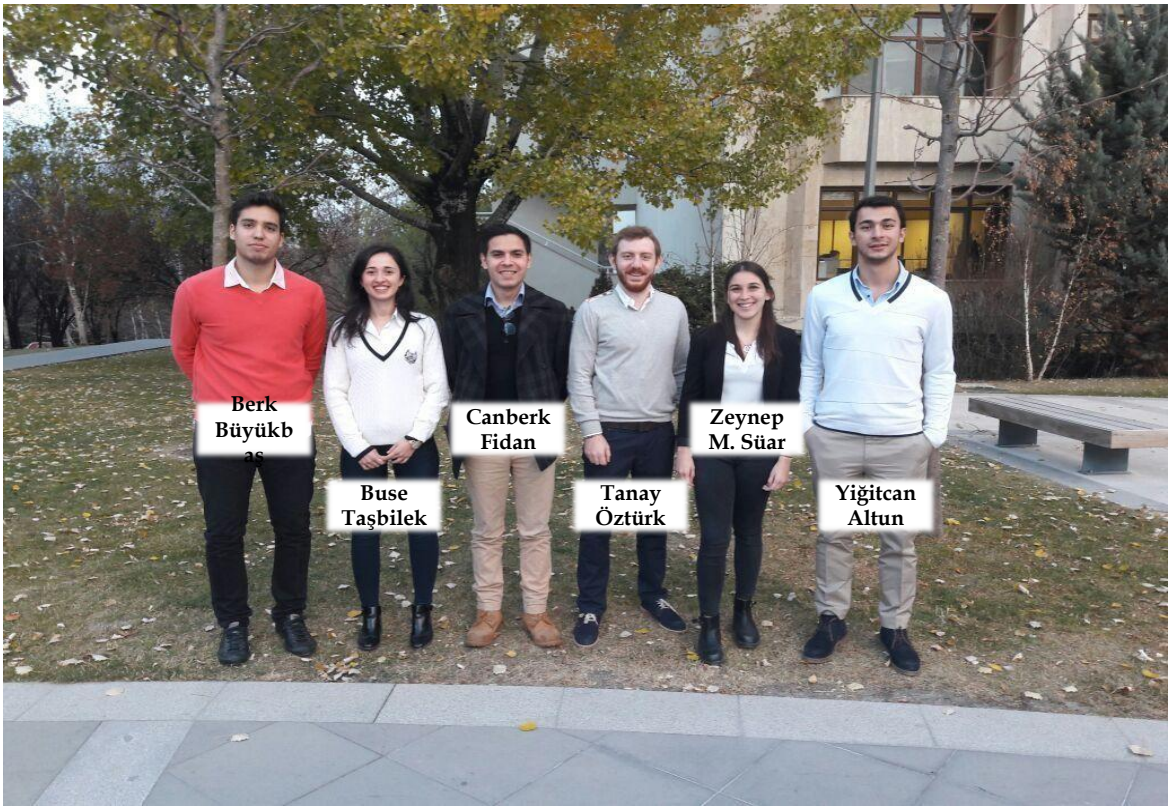
Fig 11. Complete prototype system test results.

Fig 12. Trapped fluid of case 1 with 25 degree tilting condition.

This Project is supported by Tubitak.

TEAM ROCKET (C1)

High Speed AFM Scanner Development and Control



Academic Supervisor: Dr. Mehmet Baykara

Industrial Supervisor: Dr. Ahmet Oral

Teaching Assistant: Rico Morasata

- ABSTRACT-

The objective of this project is to design a scanner and a controller for high speed atomic force microscopy (HS-AFM). Throughout the project, literature search, several design processes, manufacturing and testing steps are conducted. The designs are made according to the design constraints given by NanoMagnetics Instruments. Additional criteria are considered such as accuracy, precision, manufacturability, optical microscope implementation, cost, reliability and pluggability. Regarding those aspects, an innovative scanner and controller for HS-AFM are developed.

Problem Definition

What is AFM?

Atomic Force Microscope (AFM) is a measuring system for obtaining nanoscale images, characteristic properties and topography of a surface. It is a mechanical type of microscope that works on length scales in which optic microscopes are incapable of measuring accurately. It is used in a variety of areas such as; solid-state physics, semiconductor science and technology, molecular engineering, polymer chemistry and physics, surface chemistry, molecular biology, cell biology and medicine.

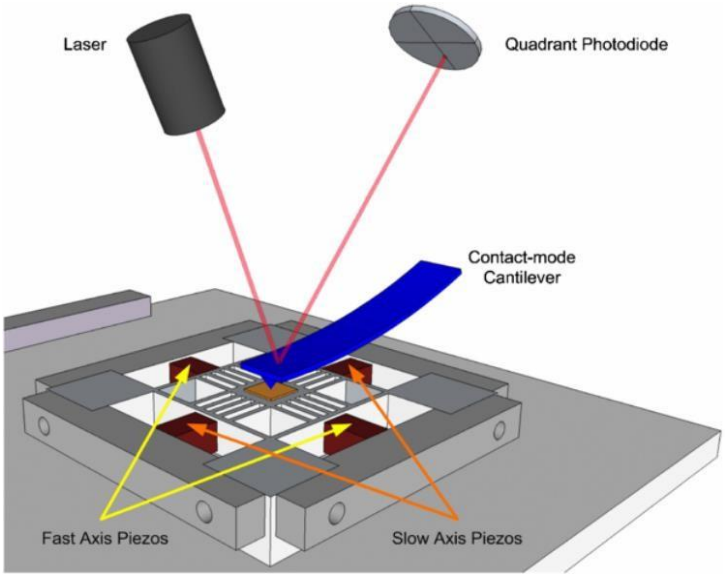


Figure 1: High speed AFM scanner scheme

P. Klapetek, L. Picco, O. Payton, A. Yacoot and M. Miles, "Error mapping of high-speed AFM systems", *Measurement Science and Technology*, 2013.

High Speed Atomic Force Microscope (HS-AFM) is a variation of AFM. The main difference is that HS-AFM obtains images in a much faster way (several images per second) than conventional AFM (only one image in a few minutes) and allows observation of dynamic processes in real time.

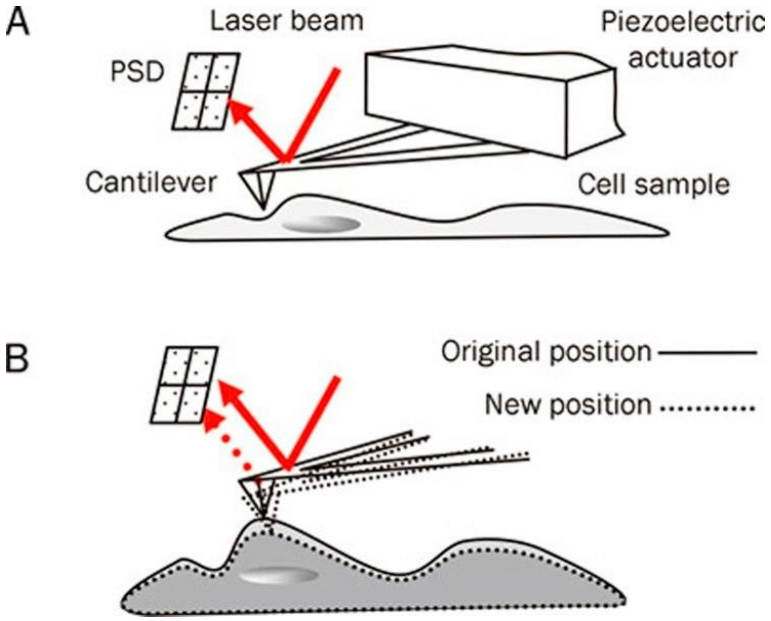


Figure 2: AFM scheme illustrating its working principle

2017. [Online]. Available: https://www.researchgate.net/figure/51175537_fig2_A-AFM-working-principle-Briefly-the-piezoelectric-actuator-drives-the-cantilever-with.

Working Principle

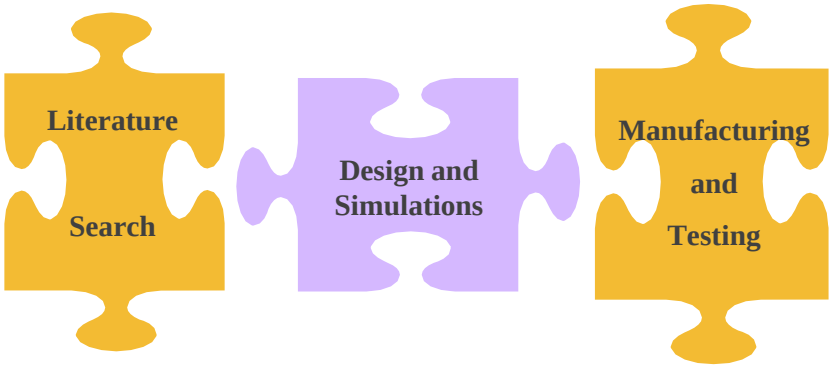
A sharp tip attached to a cantilever is used to scan the surface. A laser beam is directed to the cantilever and reflected over to a position sensitive detector, which tracks the laser spot and determined how much the cantilever deflects during scanning. As the tip touches the surface, a repulsive force between the cantilever and surface occurs. This force bends the cantilever, resulting in the deflection of the laser beam. During scanning, the height of the sample is adjusted by the feedback loop to keep the deflection constant.

Design Challenge

The problem tackled in this project is to obtain a video-like imaging rate (8 frames per second) with a 128x128 pixel resolution on a 15x15 □m area via AFM. This is a very ambitious goal and our design will be one of the first HS-AFMs that could be applicable to industrial use.

Design

The design was done considering the problem definition, cost constraints and compatibility with an existing system. After 2 months of literature search, first designs were made. After further investigations and simulation results, the current design was chosen.



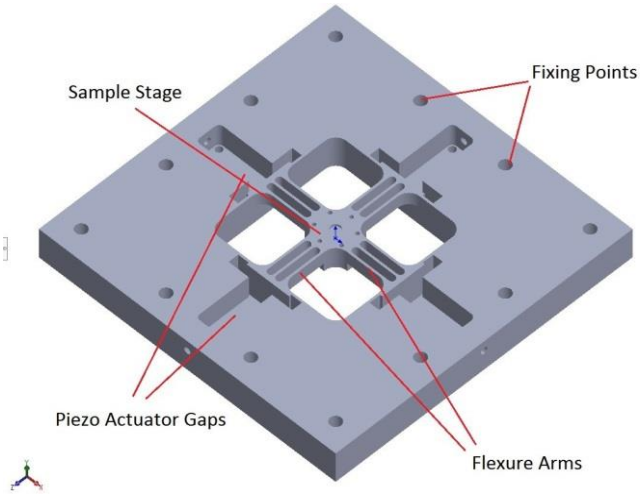


Figure 3: Designed scanner

The scanner is designed to be made from bulk titanium. The sample stage in the middle is attached to the frame with thin flexure arms. The cavities shown in the figure are for the stack piezo actuators. Stack piezo actuators will be used in this design to move the stage as the motion is too fast for any conventional motor to achieve. Piezo materials have the property of elongating and shortening in a very fast way in response to voltage.

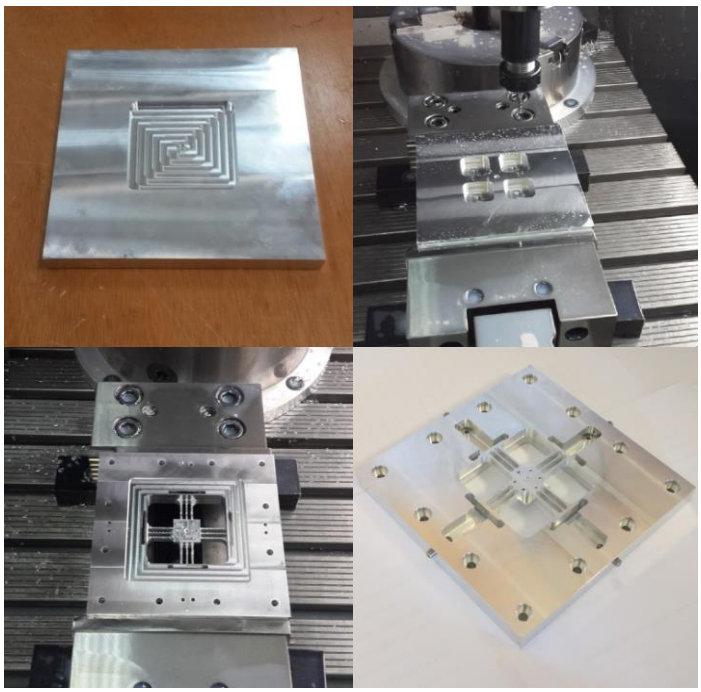


Figure 4: Manufacturing process of the scanner

An AFM head (not shown in the figure) will scan the surface while the sample stage moves below it. It is very important to achieve a symmetrical movement for the sample stage and the opposing piezo actuators.

Flexure arms convey the force applied by piezo actuators to the stage as they elongate and move the sample stage located in the middle of the scanner.

Preloading planes are placed at the back sides of lateral piezo actuators, since they require compression with a screw before application. To avoid damaging piezo actuators, preloading planes are essential. Vertical piezo actuators also require preloading and a cover for this purpose is designed.

After the design concept was chosen, many small changes according to simulation results are done.

Due to time restrictions and procurement difficulties, the manufacturing is done with a different material than the original design we have (aluminum). The constraints are partially accomplished by the manufactured product. However, with the original design material (titanium), the actual constraints set by the project definition can be met in a straightforward fashion.

Outputs

Results

- The main aim of this project is to design a scanner and a controller that would be pioneers in terms of the area it scans and how fast it scans the area, with very high resolution.
- The design has proven its capability in the simulations but some modifications were needed for real-life testing.
- The system can be used at high speeds and low speeds like a conventional AFM.
- The system will become a pioneer in terms of its industrial applicability, which is different from the ones manufactured to be used in academic works.
- The proper working of this device would allow a better insight about topics like dynamic cellular processes or oxidation of metals as these can be observed in real-time.

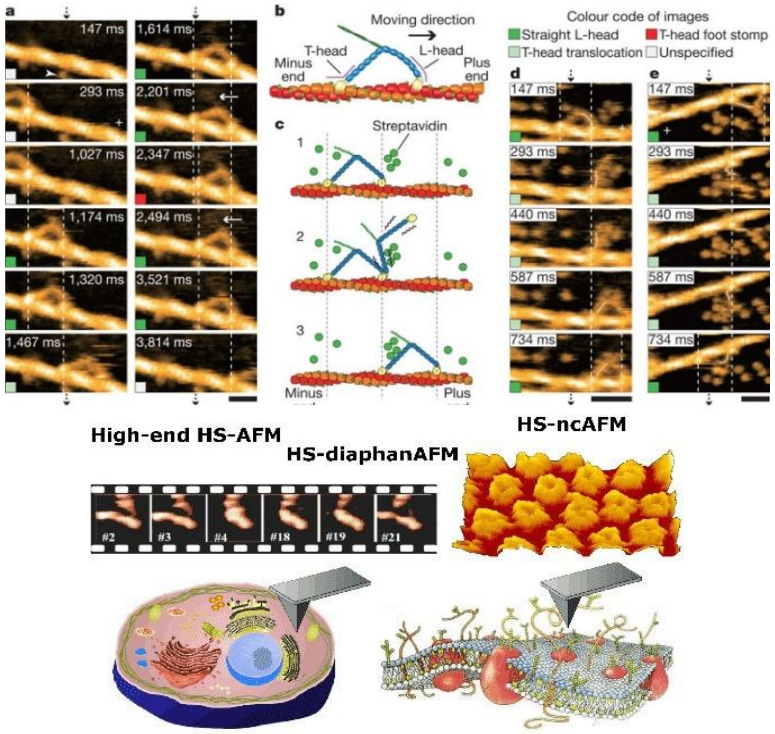


Figure 5: An example of biological application of an HS-AFM made by the group of T. Ando and images obtained by it

"Development of high-speed microscopy capable of capturing fine structures of live cells", *Hiac.or.jp*, 2017. [Online]. Available: http://www.hiac.or.jp/cluster/en/research/imaging03.html. [Accessed: 23- Apr- 2017].

Outcomes

This project consisted of several steps. In each step, it required very deep knowledge on various engineering topics. High Speed AFM is an emerging trend around the world due to the wide variety of its application areas. There are many groups working on improving the current capabilities of HS-AFM. There were many papers to read before we even started thinking about the project. In the end, we were able to contribute to HS-AFM studies worldwide with our own design.

The project required:

- Deep literature search
- Analytical thinking
- Engineering analysis
- SolidWorks drawings
- COMSOL simulations
- Test mechanisms and procedures
- Precision manufacturing

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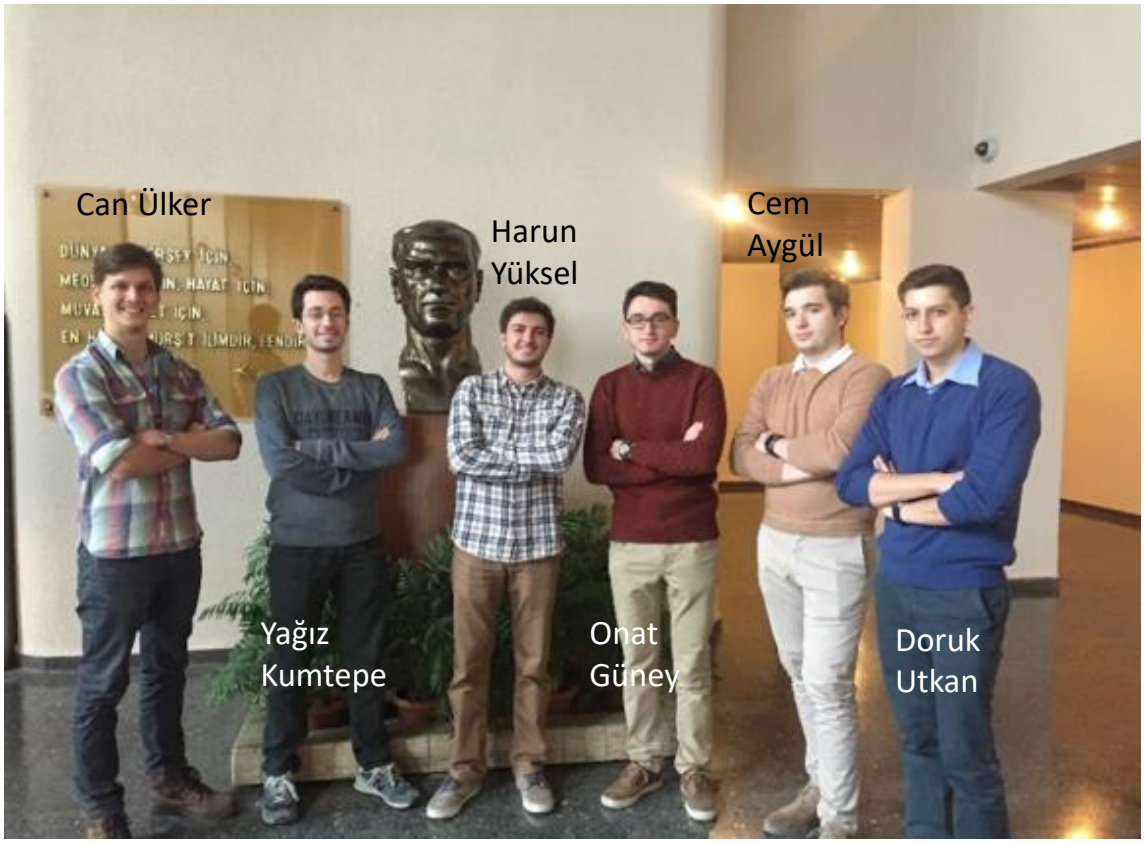
Asst. Prof. Yıldıray Yıldız
Dr. Müjdat Tohumcu
Dr. Şakir Baytaroğlu
Rico Morasata
Dr. Ümit Çelik
Bülent Polat
Şakir Duman

MAGNUM OPUS (C2)

Forward Looking Platform Production



Academic Supervisor: Dr. M. Selim Hanay

Industrial Supervisor: Esat Tuğla

Teaching Assistant: Kubilay Bahçeci

- ABSTRACT-

This project focuses on the problem of safe observation of surrounding from a military ground vehicle. The project aims to produce a forward-looking platform system and a control panel to keep the observer inside the vehicle. Primarily, constraints and requirements are determined as budget, sensor capacity, weight, dimensions, safety and user-friendliness. As the production procedure, after literature research is conducted, different concept designs are formed and evaluated under consideration of constraints. Later on, selected design is manufactured and the platform is advanced after testing.

Problem Definition

This project aims to produce a complete system that satisfies all needs of a ground military vehicle operator to lead the vehicle as efficiently as possible. Therefore, the system requires integration of multiple components and compatibility of these components.

First, in order to get a vision of surrounding of vehicle, a camera is used. This camera is capable of doing focus, optical zoom and contrast adjustments manually. The operator, directs the vehicle according to vision that is transmitted through camera, therefore this vision must be clear in spite of movement of the vehicle. Military vehicles are designed to be used in various roads including ones which can make the image blurry. To limit the vibration of camera, a shock absorber is designed and it is decided to place every component of the system above the shock absorber.

Figure 1. Military Vechile with a Multiple Sensor Platfrom [1]

The final product is aimed to supply information as much as possible. Therefore, additional sensors are used. A laser range finder (Fig. 2) is used in order to define the exact distance between the target and the vehicle. This component is essential to designate the location of the target and to adjust other vehicle features accordingly. Additionally, a laser designator is used, this component is vital for the locations where there are multiple possible targets close to each other.

By the help of designator, operator can identify the target that the range finder measures the distance.

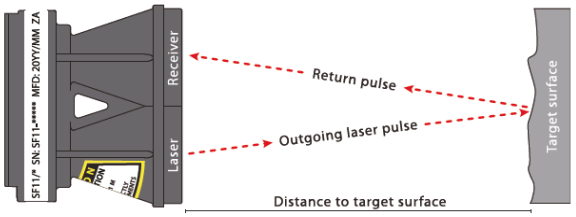


Figure 2. Laser Range Finder [2]

The camera and other sensors are required to scan a large area. For example, as the vehicle moves in a direction, the operator should be able to detect suspicious targets in other directions. Therefore, the sensors are placed on a platform that they can all rotate in azimuthally and elevational. In order to accomplish this task a Pan and Tilt mechanism is used as shown in Fig. 3.

Figure 3. Pan and Tilt Mechanism

As a result, the final system is able to get clear image from outside of a tank. This image is transmitted to a monitor inside the tank. The target is designated by a laser pointer and distance of the target from the vehicle is informed to the operator. The system can scan a large area and operator can control all features of the system by a control panel.

Design

The proposed final design is capable of vibration isolation and visual targeting with pan and tilt motion. The whole system will be integrated with a control panel and monitor to be implemented on an armored vehicle. The operator will be able to control the system from the inside of the vehicle while the vehicle is in motion. There are three main components to control; camera zooming and focusing, boresighting and pan and tilt control.

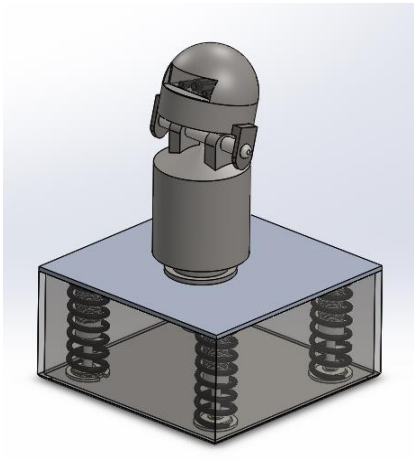


Figure 4. Final Design

Boresight

Boresight is the process of alignment of optical or mechanical axis with referencing one of the axis. Our design aims to accomplish to point the sensors exes at the same point for different distances. This idea is illustrated at the figure below.

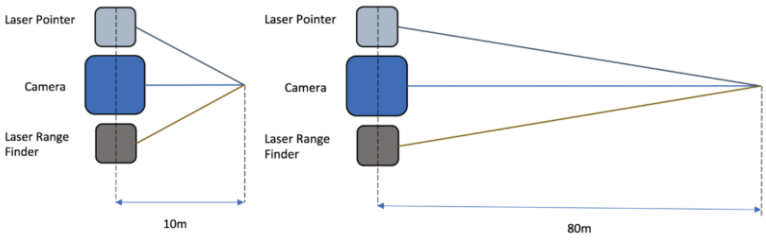


Figure 5. Boresight of Three Sensors

In order to rotate axes of the sensors accurately a four bar mechanism is used.

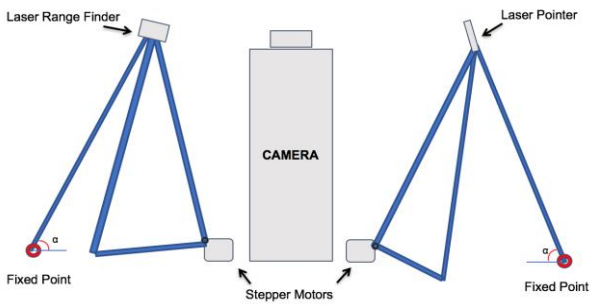


Figure 6. Boresight of Three Sensors

Camera

Zoom and focus are originally manual in the camera that is used in the project. There are automatized by using timing belts and stepper motors and their control is done by the help of a microprocessor.

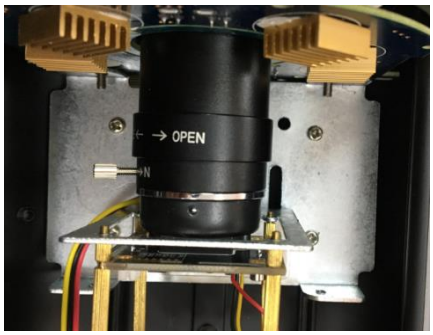


Figure 7. Camera's Zoom and Focus Adjustments

Shell

The camera and the sensors should be together in a modular manner. The vehicle may operate under rain, wind, snow or bullet fire. Thereby, the need to preserve the components arises. A shell structure is manufactured for these purposes.

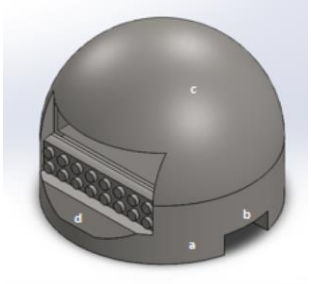


Figure 8 Shell Structure

Outputs

Results:

✓ Clear image is obtained from the camera.

✓ With only one control unit an operator can get many information that are vital for the military vehicles' action decision.

✓ System provides safety for the operator since the operator has no need to get out from the vehicle.

✓ The detections of the objects are easily done. Operator can identify the target by zooming, get information about the distance of the target and designate the target.

✓ A very large area can be scanned and possible dangers can be detected beforehand.

Outcomes:

➢ There are many steps followed in this project. For design stage, Matlab calculations are used and a Simlulink model of the system is prepared in or to simulate and find the best values for vibration isolation.

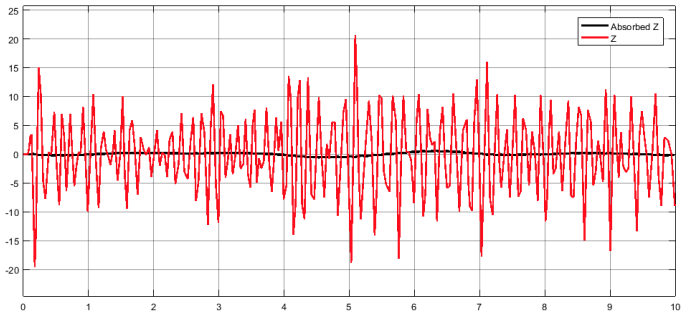


Figure 9 Simulink Output

✓ Computer aided drawings are frequently used.

✓ Different designs are formed and their evaluations are made.

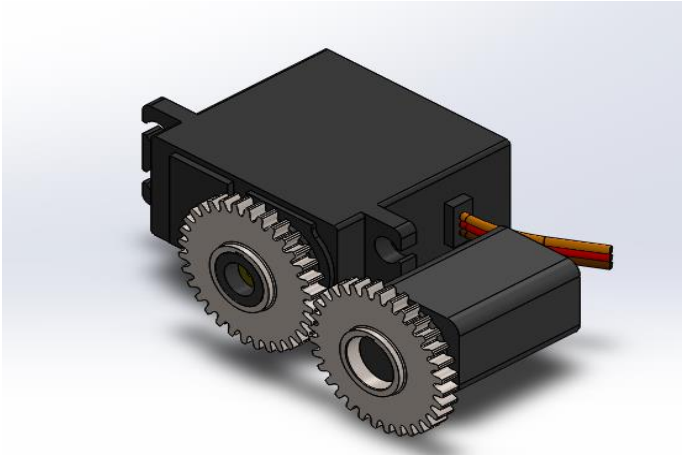


Figure 10 Different Designs are Considered

✓ Tests are conducted, after data collection and evaluation, design upgrades are done.

✓ Different manufacturing methods have been used for different parts.

✓ Arduino system is used as microcontroller. The system is tried to be mechanically and electrically work compatible. A computer language is used for this process.

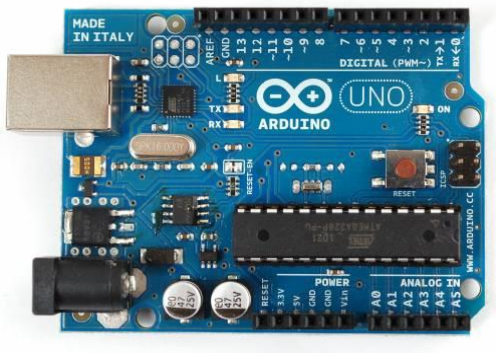


Figure 11 Arduino Platform

References

[1] "TacFLIR," TacFLIR. [Online]. Available: http://www.fematek.com/tr/firmalar/flir

[2] Long range laser range finder.. Retrieved December 10, 2016, from https://www.sick.com/tr/tr/product-portfolio/distance-sensors/long-range-distancesensors/dmt/c/g168313

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BIGMECH (C3)

Payload Carrier Autonomous Military Robot

Academic Supervisor: Dr. Selim Hanay

Industrial Supervisor: Nagehan Demirci

Teaching Assistant: Levent Dilaveroğlu

- ABSTRACT-

The main purpose of this project is to design and prototype an autonomous robot that will carry loads to given GPS coordinates. The propulsion system of the robot includes 4 wheels, two brushless motors and belt transmission. There is no steering mechanism; instead the robot uses differential steering. Arduino Mega is used as the main controller and two 12S LiPo batteries are used as power supply. Additionally, GPS Module, Gyroscope, Accelerometer, Magnetometer, Bluetooth Module are used as the electronic components of the robot. Before the operation of the robot, user gives target location to the robot via Android application developed by BigMech. Distance to target location and the required heading for shortest path are calculated. Then the robot moves along shortest path until the distance to target location is approximate zero.

Problem Definition

With each day, autonomous machines are increasing their dominance in various technological areas and especially in Military Technologies. Autonomous robots are being designed in order to replace the personal of Turkish Armed Forces in dangerous missions.

Therefore, a need for a vehicle which needs to transfer payloads between several locations and operate in all terrain has risen.

Figure 1: Husky UGV

Figure 2: Gladiator Tactical UGV

Throughout this project our team designed an autonomous robot that will carry loads to given GPS coordinates in all terrain. Below there is the constraints and the requirements for the project.

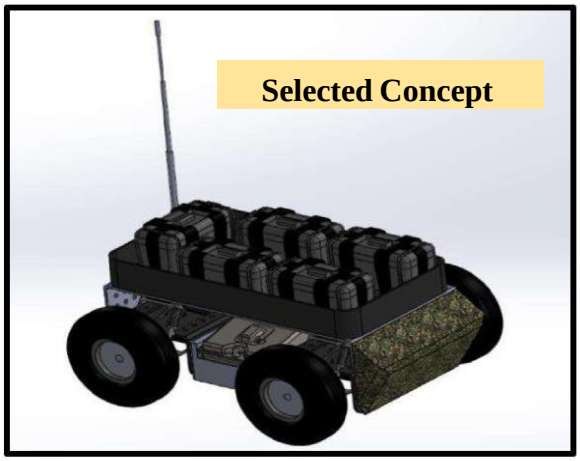
Constraints & Requirements
The total dimensions of the robot shall be less than [1x1x0.5] m.
The total weight of the robot shall be less than [25] kg.
The GPS tracking accuracy shall be at least [5] m.
The robot shall move autonomously at least [500] m.
The robot shall move on an inclined terrain with a minimum inclination angle of without damaging payload.
The robot shall move with a velocity of [5-10] m/s.
The robot shall carry at least [5] kg of payload.
The payload compartment shall be disassembled and reassembled (Modularity should be implemented).
The robot shall be operable on rough terrain without causing damage to itself or payload.
The robot shall be man-portable. It shall have functional handles for carriage.

For this project, the propulsion mechanism is implemented from an electric mountain board which is bought from abroad. The chassis and the rest of product was designed manufactured by BigMech team.

BigMech Logo

GPS guidance algorithm is completely developed by our team. In order to communicate with the vehicle an android application is developed as a human- machine interface.

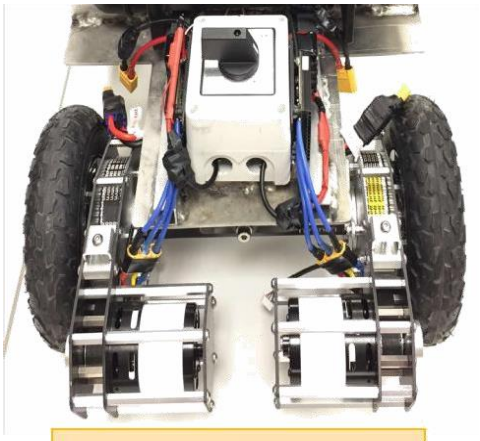
Design



Selected Concept

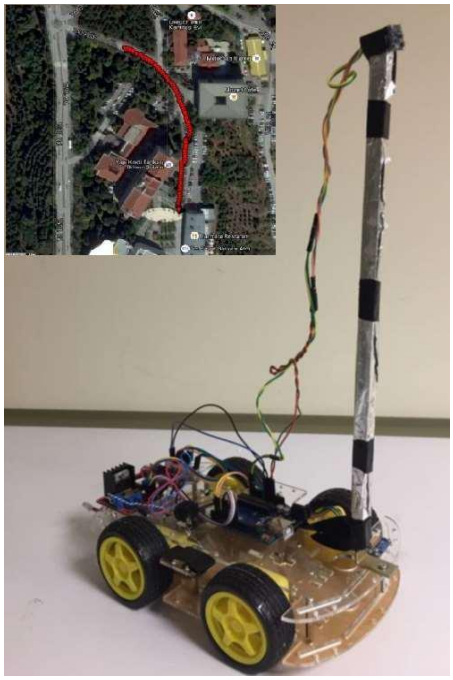
To design and prototype an autonomous robot that will carry loads to given GPS coordinates.

For the problem described, a skid-steered and on-body payload carrying vehicle with electric motors, Arduino microcontroller and Li-Po batteries are chosen as can be seen in the figure on the left.

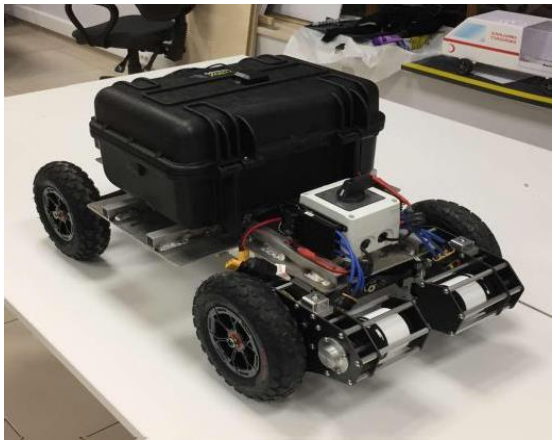


Propulsion Mechanism

The trials conducted with the prototype (see the figure on the right) helped the algorithm development. The system has a magnetometer which feeds the heading angle data to the microcontroller (Arduino), a GPS module to get the current location and azimuth angle and finally a Bluetooth module to initiate/control the system. The target is found and reached by minimizing the difference between heading and azimuth angles together with the overall distance between current location and the destination point.



Prototype of the System with GPS Trial



Side View

Top View

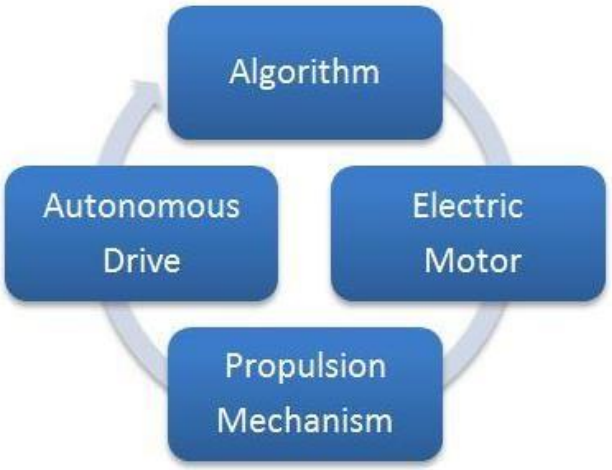
Following a systematical approach, a final product that satisfies both mechanical requirements and necessary autonomy is built by the team.

The final assembly of the system contains a chassis with both lateral and longitudinal supports, a propulsion mechanism with two Li-Po batteries, four wheels, a cargo box and an electronic box. The propulsion mechanism is basically the wheels that are connected to a gear-belt mechanism in order to increase the torque of the system. There is a switch that turns on and off the system.

Outputs

Results:

- Main motivation of the project is to produce a technology of autonomous military transportation. This project proved that different kinds of payloads, even military personnel, may be transported to desired location autonomously.
- The robot satisfied all of the requirements & constraints defined in the problem statement.
- In the first period of the project, a prototype of the final product was made in order for developing software. In the second period, production of the robot was completed and software was implemented to the system.
- Human-Machine Interface (Android Application) was developed in order to maximize ease of use
- Sufficient amount of field tests of the robot were conducted and functionality was proved.



Outcomes:

This project includes many stages and steps, which require many engineering tools and calculations as well as software development. Throughout the project, there are many calculations are made, according to acquired engineering procedures and practices. These procedures include:

- Detailed Literature Research
- Engineering Analysis
  - Structural Analysis Design via CAD Tools
  - Development of Android and Arduino Software
  - Kinematic and Dynamic Analysis of Skid Steering
- Manufacturing Processes

Final Design

NEMESIS (C4)

Designing a Rotational Shock Absorber for Military Systems

Academic Supervisor: Dr. Ömer Aka Anlağan

Industrial Supervisor: Arda Kutlu

Teaching Assistant: Cem Kurt

-ABSTRACT-

Main aim of this project is to design an rotational shock absorber that damps shocks in a radar system. The progress of the design includes several steps such as literature search, developing the design, manufacturing and testing. In the design part of the project, manufacturability, safety and functional constraints such as damping method, energy absorbance ratio, military standards and size are considered. A design that satisfies these requirements is finalized, manufactured and tested.

Problem Definition

ASELSAN utilizes mechatronic rotation systems in their radar system in order to position and rotate radar head on demand. When the mechatronic system that controls the radar head's motion fails and activates related rotor with full voltage, this results with rotational shocks. At that point, the shaft uncontrollably rotates with its highest torque possible and damages the overall system. Aselsan have solved this problem by conventional linear shock absorbers. However, any linear shock absorber in this application tends to fail quicker than the ones in conventional applications. Therefore, the main purpose of this project is to design a shock absorber that is suitable for this rotational shock.

Figure 1 -The place of shock absorber where it is used in the radar system [1]

This problem is crucially important, because the life cycle of the radar system is drastically depend on success of the damping. When the lower part moves to upward, it would collide with upper part after restricted degree. Therefore, severe damage in upper part of radar system is high likely. In order to prevent the damage, a shock absorber is embedded and absorption of shock energy which cause potential failure is succeeded.

Thus, the shock is lightened and does not affect life cycle of radar system's upper part. Same damping scenario is valid for the downward movement of lower part to machine chassis. In other words, the main function of shock absorber is to protect of upper part and chassis of radar system.

The requirements of the project can be listed as follows:

Requirements and Constraints	
Energy absorbance	75 % absorbance capacity
Angle	between -45 degree and 90 degree.
Strength	must withstand 5-30 kN force.
Motion	angular
Damping Method	hydro-spring or hydropneumatic
Size	scalable
Reset	repositionable

Table 1: Main requirements and constraints

In addition to these constraints, the safety of the design is vital in terms of military concerns. Since this is a military application, the safety quality of the design will be according to military standards. The working environment of the system can vary in extreme conditions so the design must satisfy extreme military standards like temperature range -20 to 60'C, pressure range 1 bar to 3 bar, any humidity condition and resistance to any chemicals.

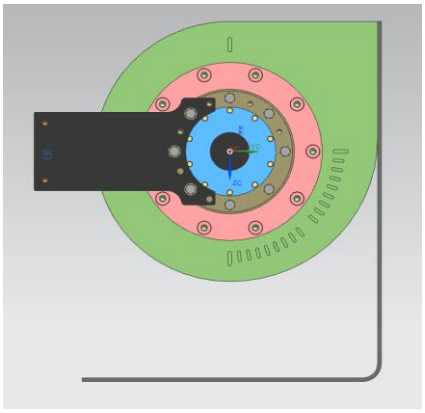
[1]http://www.aselsan.com.tr/tr-tr/cozumlerimiz/hava-ve-fuze-savunma-sistemleri/kundagi-motorlu-ve-parcacikli-muhimmat/korkut-kundagi-motorlu-namlulu-alcak-irtifa-hava-savunma-silah-sistemi [April, 2016]

Design

In order to solve the problem that is defined in previous section, following system is designed. The system consists of one torsional spring for reposition and aligned along to the main shaft and a hydraulic system for suspension of the shock energy. The designed system is shown in Figures placed below.
The design process can be simply expressed in terms of a flow chart as follows:

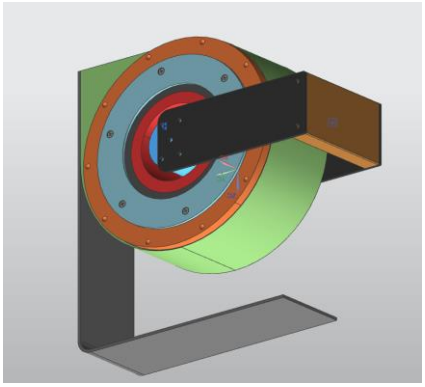
Literature search → Virtual system → Prototype and tests → Final design

To design, analyze and manufacture a rotational shock absorber which can satisfy **suspension characteristics,** adjustable to the standards of the **military systems**.



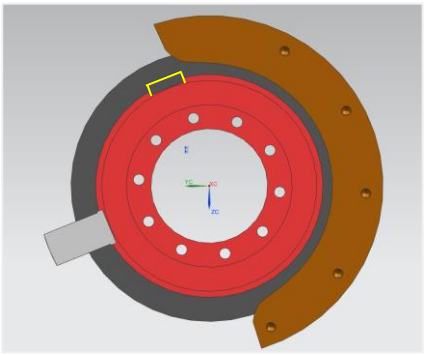
Side view

The working principle of the system is fluid friction thanks to fluid flow through a narrow orifice. When the rotational shock occurs, which is obtained by releasing of the rod in the setup, the working fluid is forced to flow by the shaft feature and the small feature is for decreasing the flow area to create fluid friction. As the fluid flows through orifice area that is provided by the base and the small feature, the majority of the shock energy is dissipated. Whereas, the minority of the energy is stored by torsional spring in order to reposition the system afterward.



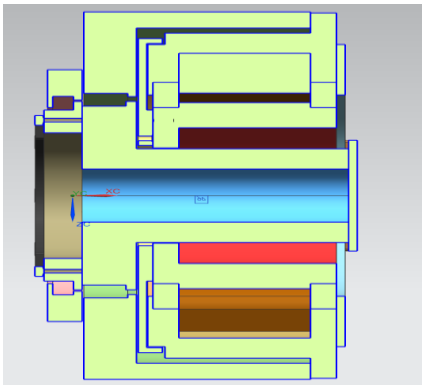
Down view

The innovative and essential part of this design is that orifice area changes with respect to angle of the shaft in order to get a smooth damping trend. Orifice area is at its peak value at the beginning and decreases dramatically. As a result, velocity of the shaft declines accordingly.



Inside view of hydraulic part

Inside view of manufactured hydraulic part



Cross Section view

In terms of manufacturing, the process is critically vital because of unconventional shapes of parts and not monolithic production. The design requires delicate manufacturing in terms of sensitivity and tolerances in order to achieve desired orifice area trend. In addition, some required parts are purchased which are bearings, spring, and oil, O-rings, oil seal and test mechanism part

Outputs

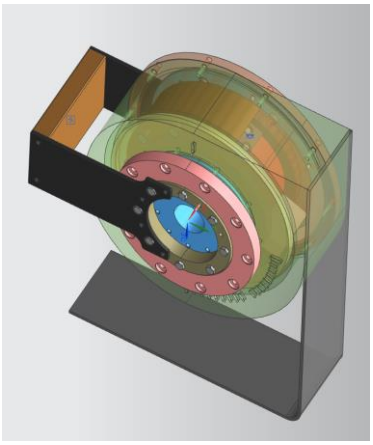
Results:

✓This aim of the design is not only satisfying technical requirements but also applying creativity to generate an unique solution and executing it with sustainable and reachable local sources. Thanks to unconventional design of hydraulic suspension part, this system is distinguished in terms of adjustability. Also, the design can be tailored in a way that is suitable for cases with different damping trend requirements.

✓The prototype and test mechanism give satisfactory results that are already approximated by virtual modelling and analytical calculations of the system.

✓The requirements defined in problem statement are fulfilled with regards to military standards.

✓Aimed energy absorbance ratio which is % 75 is satisfied and repositioning of the main shaft is achieved.



3D view

Our Outcomes:

The final state of the project achieved through many steps that involve critical thinking and analytical calculations. The flow characteristics in the hydraulic part is modeled and orifice area and drag force calculations are conducted. The geometry of suspension part and required orifice area are optimized iteratively. In addition, mechanical strength of the system is simulated. The sub-steps of the process can be summarized as follows:

- Intense Literature Search
- Critical Thinking
- Engineering Analysis
- NX Drawings
- Test Mechanisms and procedures
- Manufacturing

This project helps us to develop a wide perspective for design processes in addition to engineering analysis. Thinking out-of-box and carrying out a detailed design which is formed by various analysis enable us to improve our way of thinking and progressing. Furthermore, manufacturing the system is an enhancing process since refining the system according to manufacturing constraints develops an understanding for implementation of a design.

The project is funded by TÜBİTAK 2209-B Industrial Senior Year Project Support Program

SENIORS (D1)

Automatic Inflatable Flotation Bags System for Amphibious Vehicles

Academic Supervisor: Dr. Ömer Anlağan

Industrial Supervisor: Erkal Özbayramoğlu

Teaching Asistant: Kubilay Kaan Bahçeci

- ABSTRACT-

Most of the armored vehicles that FNSS produces are amphibious which means vehicles could be driven inside the water and on the earth. After the production stage of the amphibious vehicles, these vehicles are tested. The aim of this project can be named as following, while amphibious vehicles are testing out near the places such as lakes, pools or rivers, some problems may occur such as sinking or leaking. As a result of these problems, the design aims to survive the driver of the vehicle and the amphibious vehicle by inflating the flotations bags automatically. In the project, a prototype will be used which is downscaled according to the real dimensions of vehicles.

Problem Definition

Amphibious vehicles which have ability to operate both on land and on water, are used for commercial and military issues. FNSS designs, develops, produces and supports tailored, reliable and cost-effective land combat system solutions. To satisfy amphibious vehicle standards, several tests are conducted.

Amphibious vehicle which is manufactured for rough water, will be tested in compelling conditions. During the tests amphibious vehicle can sink or systems on vehicle can be affected from the water. As a result of this, human life and amphibious vehicle is imperiled. To aviod undesirable situations such as sinking, a safety design is reauired to balance amphibious vehicle when it is unbalanced or starts to sinking.

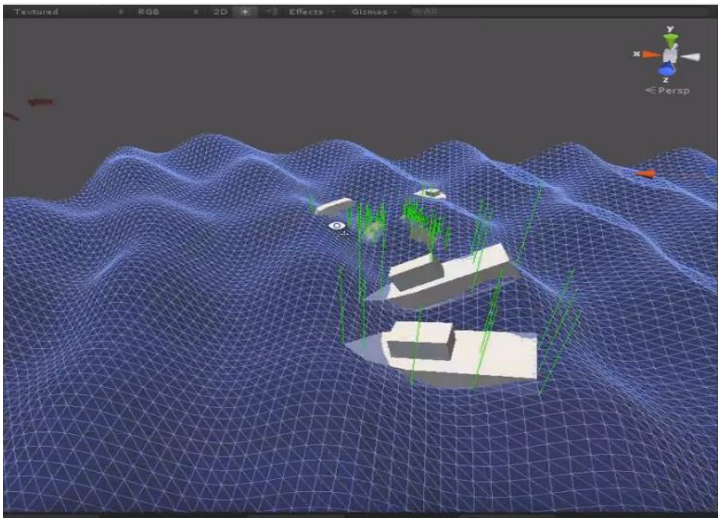


***Figure 1**: Unbalanced vehicle on water simulated in Unity 3D[1]*

FNSS is expected a safety design to use during the test operations which is a precaution for an emergency such as sinking. If amphibious vehicle becomes unbalanced or start to sink, FNNS expectations from our design as followings:

- A safety design used only in tests
- The design should be activated automatically
- The design should protect operator and vehicle
- The design should be balanced the vehicle when the vehicle out of control
- The design should not affect capability of the vehicle motion
- The design should create extra water buoyancy when it is activated
- In first application; the design should be feasible for prototype of the vehicle

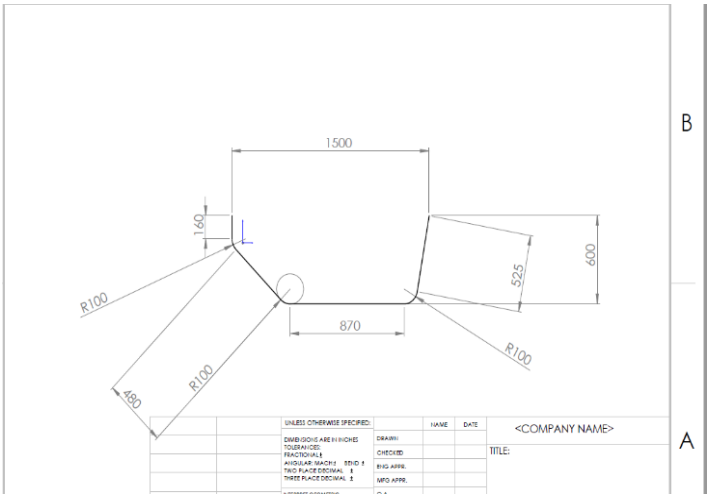


***Figure 2:** Size of Prototype*

The main purpose of the project is related to survive the prototype with inflatable flotation bags in steady state water level and prevent the possible risks against external factors during the test process. In order to overcome the sinking problem during the test process, inflatable flotation bags are preferred because they provide the extra volume which is necessary to take precautions for sinking. Therefore, the main requirement of the project can be determined as inflatable flotation bags.

[1] ‘’Unity3D - Making Objects Float in an Ocean, and Making Ocean Waves’’ https://www.youtube.com/watch?v=y_Q47rA_wmA

Design

The aim of this project is surviving the amphibious vehicle during the test processes in steady-state water level and preventing some dangerous situation related to the driver. According to the research have been done up to this point, balloon system is chosen as a solution for this problem. The main aspect for choosing balloon and boat system could be described in some ways; while the amphibious vehicle is exposed to different types of tests in order to prevent sinking it is needed some extra volume inside or outside the vehicle. Moreover, when some new materials added to the amphibious vehicle all the physics that are measured at the standard conditions might have changed. So, it can be said that while adding extra materials it must affect the vehicle motion as low as possible. As a result of these requirements, inflatable floatation bags (pillow type) are chosen for the procet.

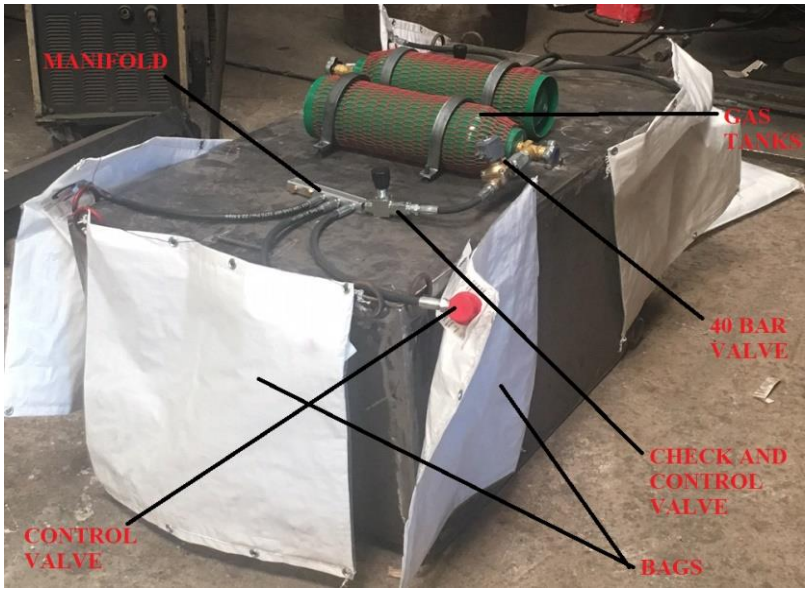


Figure 3: *Preview of Design*

SUBSYSTEMS

- PILLOW TYPE AIR BAGS
- FLOTATION BAGS
- PRESSURIZED GAS TANKS
- INCLINE SENSORS
- WATER LEVEL SENSORS
- VALVES
- MICROCONTROLLER
- BATTERY

All subsystems and the importance of these materials are described above and the critical usage of these systems or materials are understood deeply. After all of these, the project or system could be thought as a whole. For giving detail information, the general type of system could be summarized in this way; in test stage when the amphibious vehicle takes any signal from sensors, valves will be activated automatically, required inflatable floatation bags will start inflating. As a result of this whole procedure, the amphibious vehicle is balanced and stabilized above the water level.

The concept will be based of the buoyancy force which acts on inflatable floatation bags and also the number and volume of bags are calculated by the volume of the amphibious vehicle that stays under the water level, and the volume of the compressed gas tubes will also be affected by the total volume of bags. Moreover, sensors will be programmed by Arduino which is one of the most beneficial hardware program for engineering applications.

Outputs

Results:

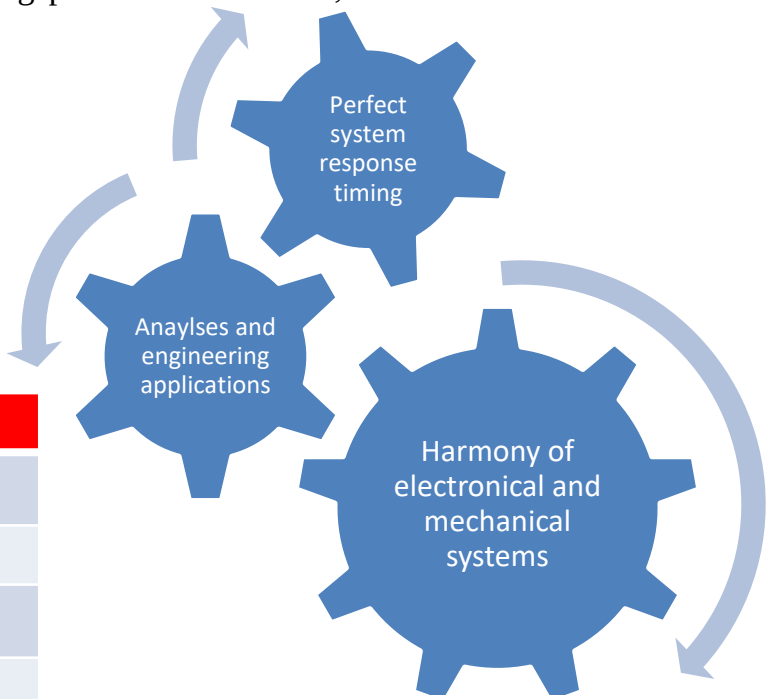
✓ For inflatable flotations bags, we searched so many different companies which were all useful for us. However, their shipping times and some cargo prices hinder us to order these products. As a result of this situation, a company which is in Istanbul is founded and the bags are ordered from this company which is Dunnage Company.
✓ For pressurized gas tanks, we find a company in Manisa and these tanks are ordered from that company. Also some small changes occurred as this stage, this was related to the pressure of the air which stays inside the tank and the total capacity (volume) of the tank. This change is occurred in order to prevent fill the gas tank every time after testing. In addition to all of these, sensors are ordered from Alfa Industry.
✓ Solenoid valves are also purchased and assembled into the main part of the prototype.
✓ The prototype is produced in Ostim, ATEŞ Makina Industry.

Outcomes:

Finally, it can be concluded as, all these experiences helped us to improve the quality of the system. The final decisions increased the quality level of the project. All of the materials are desired ones and we are now looking forward to combine all these component and write the code of the system to reach the final step of the project.

In the 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
  - ✓ Unity 3D simulations
  - ✓ SolidWorks Drawings
  - ✓ MatLab Analyses
- ❖ Test mechanisms and procedures
- ❖ Manufacturing processes



Subsystems	Number of products
Pillow Type Bags	6
Pressurized Gas Tanks	2
Sensors (Incline + Water Level)	2 + 4
Valves	2+6
Microcontroller	1
Battery	1
Gas	2x5 liters compressed gas

SENIORS

MOTORHEADS (D2)

Compressed Air Engine

İlhami Ilgaz Aydoğdu – Yiğit Oskay – Cem Aydoğan - Süleyman Doğan Öner – Utku Hatipoğlu
Mert Yusuf Çam – Dündar Dedekargınoğlu

Academic Supervisor: Dr. Barbaros Çetin

Industrial Supervisor: Serdar Güryuva

Teaching Assistant: Süleyman Doğan Öner

- ABSTRACT-

The objective of the project is developing a compressed air engine which can be used as the engine of a small vehicle such as shuttle and vehicles that are used indoor. Development process consist of designing, conducting computational analysis, manufacturing and testing. Design of the engine is made by considering power, speed, range requirements and volume, weight, manufacturability, safety constraints. According to these requirements and constraints, a compressed air engine is developed, manufactured and tested.

Problem Definition

A piston compressed air engine generates rotational movement by using compressed air as source of power instead of gasoline in internal combustion engines. Similar to other piston engines, mechanical work and rotational movement is obtained with the compressed air engine from the input power source. Torque and rotational movement output of the engine is used to rotate the wheels of the vehicle that the engine is mounted.

Today's automobiles generally have internal combustion engines which release exhaust gas to environment such as NO_x and CO_2 . To protect the environment, non-combustion engines should be used whenever possible. Compressed air engines can be used as alternatives for this problem as their exhaust gas is only air; therefore they make no harmful gas emission. One of the possible usage of these systems is light vehicles such as shuttles and vehicles that are used indoor as they do not require power and torque as much as commercial automobiles.

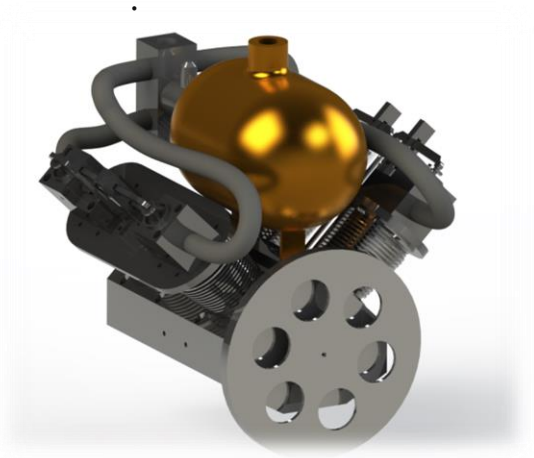


Figure 1. Designed **c**ompressed air engine

Compressed air engine offers a low cost solution for research and development, production and maintenance because of the simplicity compared to internal combustion engines and electric motors. In addition, manufacturing the engine in Turkey also decreases the manufacturing cost.

Also, there is no research and development project and manufacturing of compressed air engines in Turkey. This project can play a leading role to fill this missing scientific field in Turkey.

In order to be suitable for using as the engine of a small vehicle; the engine is designed to have enough load carrying capacity with its power output. The maximum speed and range of the vehicle which the engine is mounted is considered. Volume and weight is minimized for packaging concerns and it is paid attention to safety of the system. Whole system is designed to be manufacturable with local manufacturing concerns.

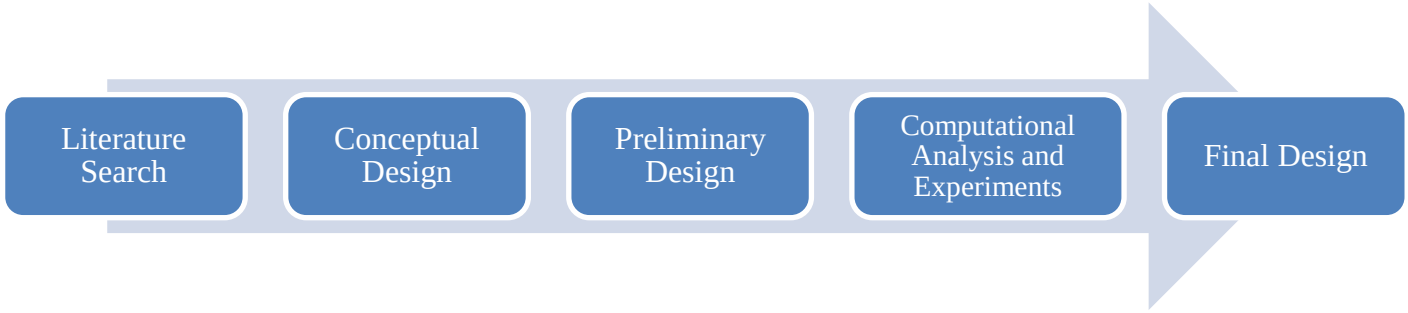
Figure 2. Usage of compressed air engine in a small vehicle [1]

Therefore the objective of this project is to design, conduct computational analysis, manufacture and test a compressed air engine with local manufacturing facilities, which satisfies the desired power, speed, range requirements with volume, weight, manufacturability, safety constraints and also suitable to be used as the engine of a small vehicle such as shuttle and vehicles that are used indoor.

[1] "AIRPod 2.0 Compressed Air-Powered Car," MDI AIRPod , 2017. [Online]. Available: http://zeropollutionmotors.us/.

Design

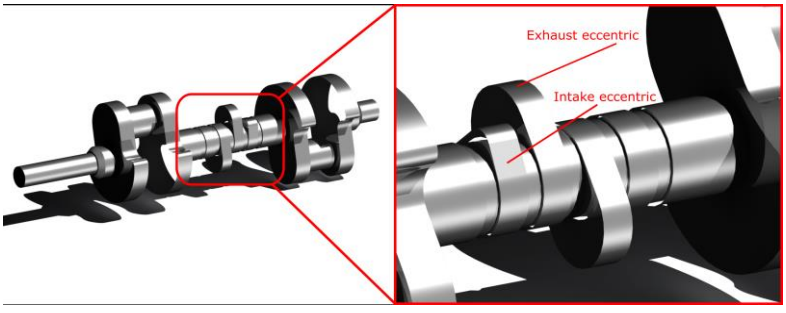
For the aforementioned problem, a solution is developed with compressed air engine. Compressed air engine will be available to use in indoor operations, will produce with zero harmful gas and will be manufactured in local facilities. The design process can be seen below,



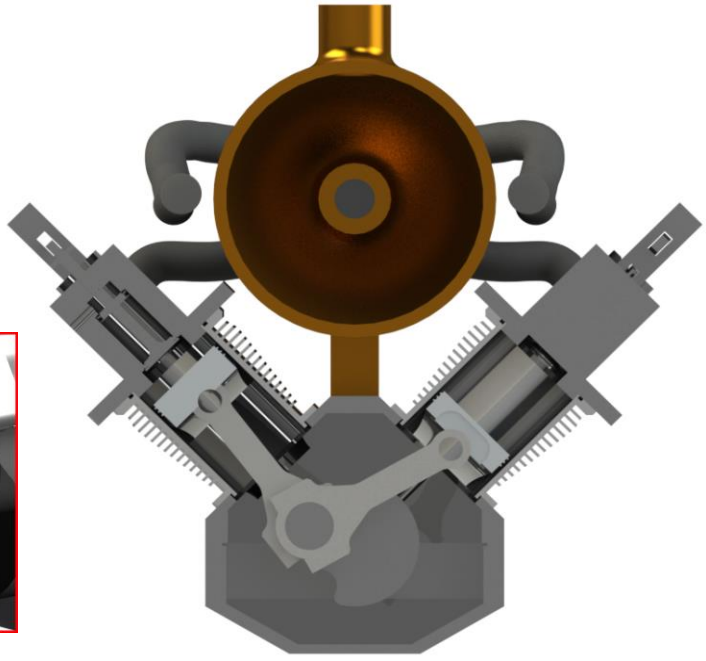
Piston – crankshaft assembly

Compressed air engine generates rotational movement by using compressed air as source of power. Compressed air is supplied to the engine via compressed air tank and distributed by valve mechanisms. Pistons are pushed down with high pressure air; linear moving pistons rotate the crankshaft since they are connected via connecting rods. Rotational movement obtained from the crankshaft is used to rotate the wheels of the vehicle.

The main difference between internal combustion engine and compressed air engine is the source of high pressure which is compressed air in this case instead of burning fuel in internal combustion engines.



Cam mechanism



Cross section view

Outputs

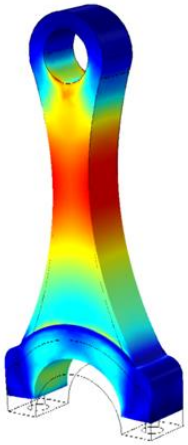
Results:

✓ The compressed air engine satisfies all the previously mentioned requirements.
✓ All parts of the compressed air engine are produced with local facilities. No parts have been supplied from abroad during production. Since the fuel of the engine is air it can be obtained locally, unlike gasoline.
✓ The compressed air engine produces zero harmful gas, therefore it is suitable for indoor applications.
✓ The compressed air engine produces the required power and torque.

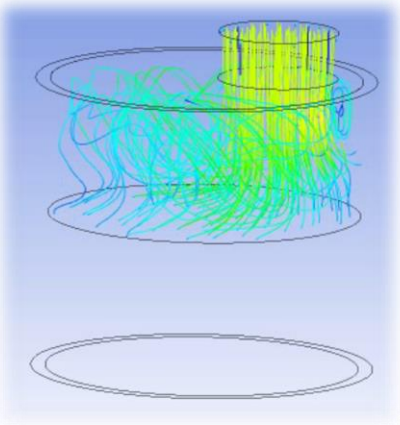
Outcomes:

In each step of the project, problems are solved with engineering approach. After the design step, an extensive engineering analysis is applied to optimize the design and get output parameters of the engine. The engineering analysis does not only contain calculations, but also usage of computer programs for modelling and analysis for thermodynamic, fluid and static analysis. The steps of the project are listed as below:

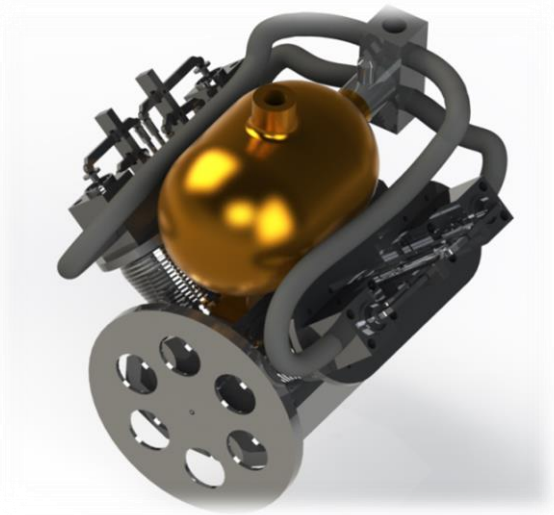
- Design matrix
- Design with CAD program
- Engineering Analysis
    - 1D Thermodynamic Analysis
        - Mathematical Modelling with MATLAB
    - 3D CFD Analysis
        - Fluid Analysis with ANSYS Fluent
    - Static Analysis
        - Load analysis with COMSOL
- Manufacturing and Modifications
- Tests and Developments



Connecting rod load analysis



Piston CFD analysis



The project is supported by Tübitak 2209-B Industrial Senior Year Project Support Program

xDESIGN (D3)

Design of Zero-Leak Check Valve, Fitting and Plug-Plug Core

Academic Supervisor: Dr. Ömer Aka Anlağan

Industrial Supervisor: Salih Okatan

Teaching Assistant: Anıl Alan

- ABSTRACT-

Main purpose of this project is to design and manufacture aerospace grade zero-leak check valve, fitting and plug-plug core to be used in electro-hydraulic actuators for aerospace and defense products by ROKETSAN. Development procedure consists of literature survey, analysis, design activities, manufacturing and testing. While developing the aforementioned components, there were several constraints to be satisfied whose main titles can be listed as; temperature constraints, pressure constraint, safety, manufacturability, economic constraints, and most importantly leakage constraint. By taking into consideration these requirements; check valve, fitting and plug-plug cores have been developed, manufactured and tested.

Problem Definition

The problem in this project is the leakage in hydraulics aerospace grade components. The leakage problem associated with the aerospace type components arises from not manufacturing as precisely as they are required to be because such components have very small dimensions and highly sensitive and precise tolerances. Therefore, they should be manufactured with precision machining. Because if they are not, surfaces of such parts may be defective, there may be cracks on the surface, or even they may not match with the other part. This is a very important aspect of our problem because once these components are mounted on the product and sent to mission, there is no return of it, and these must work mutually and without an error within the product, so that the product can succeed.

Components are restricted to a gate check valve as in Figure 1, fitting as in Figure 2, and plug-plug core as in Figure 3. These components that are in the scope of this project are sub-components of electro-hydraulic actuation systems. To briefly summarize their working principle; function of a check valve is to prevent flow in one direction and allow flow in the other direction, the function of fitting is to change direction flow to various angles and the function of plug-plug core is to cover the drilled holes, in order to complete the hydraulic network.

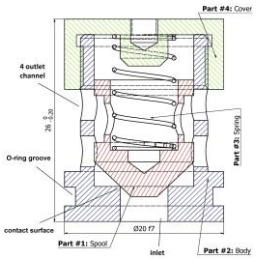


Figure 1: Check Valve

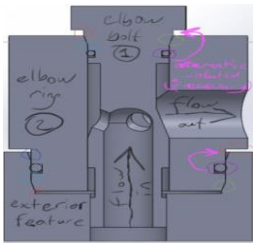


Figure 2: Elbow Fitting

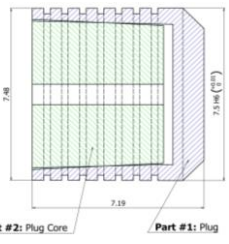


Figure 3: Plug-Plug Core

Acquiring these components are problematic; ROKETSAN can either purchase from foreign companies; but in this case end-user agreements becomes a problem or they can buy these zero-leak components from Turkey, but there are some drawbacks; such as the precision machining industry being very limited in Turkey due to being more expensive, requiring more time and labor, having a limited area of use and having highly priced CNC benches and materials rather than normal CNC machining.

The system requirements are mainly as follows;

- Withstand 210 bars
- Withstand a temperature range of -54/+200°C
- The nominal flow rate of the fluid is 15 liter/minute
- Expected pressure drop inside of the check valve and between ports of fitting is approximately %5-6
- No leakage in the system.
- The fluid flowing inside the components is MIL-PRF-5606H

Most important aspect of this project is the surface roughness of the components because it determines whether there will occur leakage or not since it plays an important role in determining how a real object interacts with its environment. Surface roughness is basically deviations in the direction of the normal of a surface from its ideal nominal form as in Figure 4. No real surface is totally smooth. In our components, the surface roughness is decreased up to 0.2 μm by using former related tests, special machining aspects, and cutting tools.

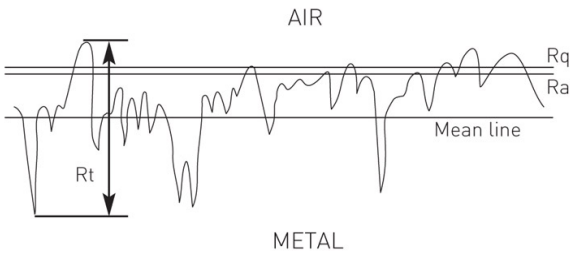


Figure 4: Surface Roughness

Therefore, the main purpose of this project is to design, analyze and manufacture gate check valve, fitting and plug-plug core with using local sources, which can give the desired non-leakage with the maintenance and reliability requirements also adaptable to the working conditions and standards of the aerospace systems.

Design

For the problem definition given in previous pages a solution is produced. This solution will consist of both precise manufacturing which allows the contact surfaces on the assembly have perfect fit to each other and use of O-rings as a seal method. As well as the components, also holes, where components will fit in, are designed considering the solution.

To design, analyze and manufacture **zero-leak** hydraulics components (check valve, fittings and plug-plug core) satisfying **aerospace grade** to be used in electro-hydraulic actuators with system requirements

Literature Survey → Feasibility Study → Engineering Analysis → Final design

At the end of these procedures, the problem is solved by mainly reducing possible leak sites. For the check valve, perfect fit on the critical contact surfaces are met due to low surface roughness by precise manufacturing and high pressure on sharp contact edges. For the elbow fitting, the possibility of a leak is eliminated by the use of primary seal which is O-ring (elastomeric) and the secondly metal to metal seal. For the plug-plug core, design is made for achieving zero-leak property without using O-rings and threads for sealing the drilled holes. Manufactured parts are as follows;

Figure 5: Design of Check Valve

Figure 6: Design of Elbow Fitting

Figure 7: Design of Plug-Plug Core

- Precise manufacturing of every component
- Satisfying extreme pressure and temperature requirements
- O-ring seal at aerospace grade
- During backflow (flow from outlet to inlet channel) leak is prevented through the inlet channel thanks to the sharp edge design and precise manufacturing.

- Direction of the outlet channel can be oriented after the assembly
- Primary seal is O-ring (elastomeric)
- Metal to metal interface in front of O-ring that works as a second seal.

- Achieving zero-leak property without using O-rings and threads
- Plug and plug core has shrink fit to each other and the assembly also has shrink fit to the drilled hole.

Outputs

Results:

✓ Main purpose of the design other than its technical aspects is producing components which are highly needed in aerospace industry with local resources. This project proved that zero-leak property components which will be used in aerospace industry can be developed mainly by using sources without needing any exports.

✓ By this project dependency to foreign countries can end and strategic advantages can be gained in terms of economy and military.

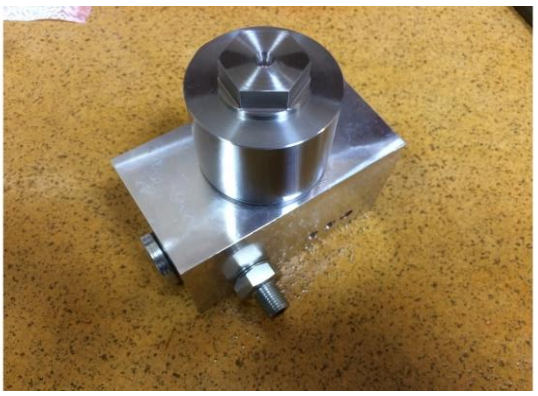


Figure 8: Test Fixture With All Components Mounted

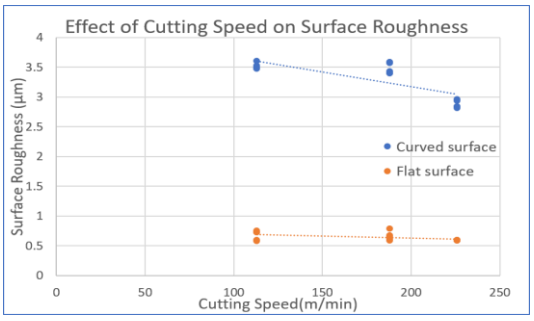
✓ It is shown that leakage can be reduced to zero while satisfying the aerospace grade and system requirements.

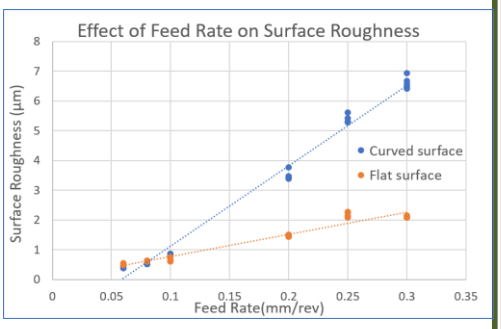
✓After the studies on design and manufacturing, components are verified on a test fixture whether they satisfy the intended properties.

Outcomes:

This project procedure consisted of several steps. In each step, engineering analyses are done. Yet analyses are not the only engineering approach that is being followed, experiments are done in order to precise manufacture the components. In addition, test fixture and procedure are prepared in order to verify the components. 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:

- Literature searches
- Analytical thinking
- Engineering analysis
  - Fluid Flow Analysis (ANSYS Fluent)
  - Stress/Strain Analysis & Material Selection (ANSYS)
  - Fluid Power Analysis (HOPSAN)
- Experiments
  - Optimal Cutting Condition Test
- CAD drawings
- Manufacturing processes
- Test fixture and procedure





Evaluating the optimal cutting conditions by experiments in order to get adequate surface roughness for the components manufactured in this project

Besides the software, as an engineer certain skills are obtained such that experimental results are very important in terms of manufacturing. For precise manufacturing, there are many parameters that can affect surface roughness and relations between them can be determined mainly by experiments. Then **optimal cutting conditions** can be determined due to the **experimental results**. While manufacturing, tolerances and surface qualities on the technical drawings were never engaged at the first trial. Matching the theoretical and the practical requires a lot of tryouts because there still exist many unknown and inevitable incidences such as machine vibration and chatter or non-homogenous material.

NOTES