



MACHINE MODIFICATION DESIGN

Thesis

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Degree Programme in Industrial Management
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Abstract The project was done in a medium-sized company known as Itä-Suomen Balanssi located in the city of Varkaus. The goal of the project was to upgrade the old mechanical equipment to fit the current demand and this was done by acquiring enough information about the equipment, the use of the equipment, by determining shortcomings of the equipment and solutions, for determining the shape of the individual part to be used, having the detailed dimensions of each part and then using the inventor program to prepare the drawing. As a result of this project, it can be said that modifying the old equipment reduces costs to the minimum in the sense that sixty-five percent of the new equipment price is cut-off, saves time and the familiarity of the equipment is constant. In this project, it is seen that equipment modification made life simple when thinking about future development because machine redundancy will be reduced.		
Keywords Heavy duty equipment, Light equipment, Computer aided design, Modeling, 3D Scanners, Tolerance.		
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1. INTRODUCTION

1.1 Background of the study

There is an increase in technological methods in all daily activities. This is done to improve the efficiency, quality and cost reduction of a particular product. Many manufacturers try to be up-to-date in their products' improvement without thinking the effects on their customers. Although it is good for customers to have the latest version of particular products but if the interest of their valued current customers is to be put into consideration there should be a stand-by solution to their previous products improvement to suit the latest version to some extent if not one hundred percent.

This has been one of the major problems of companies nowadays because their equipment and machines are very expensive and the manufacturers should not expect the customers to buy the new products anytime they are released. This was the reason to examine equipment modification. This was carried out in a medium-sized company Itä-Suomen Balanssi Oy.

1.2 Itä-Suomen Balanssi Oy

Itä-Suomen Balanssi Oy (ISB) is a company located in Varkaus in Eastern Finland. Their major business area is building, renovation, cleaning, care and maintenance. It is a Finnish company established in 2006 and their staff has decades of experience and solid skill. ISB offers a good quality and knowledgeable service and they are time-minded.

ISB also deal with home or business premises cleaning, renovation of the building or additional need in the masonry walls, stairs and wet areas for painting renovation, cleaning of the offices and homes' yard service areas and making of garden and household chores.

The staff of ISB includes experienced carpenters, metal and construction work. The foremen, regarded as seniors, guide the work and are involved in any activity that is going within the younger ones. [5]

1.2.1 Area of Specializations

The company has different areas of specialization which include the following.

ISB Renovation: It deals with home and business premises renovation and value restoration and all other things that have something to do with maintenance such as: toilet and bathroom renovations and tiling, unimpeded flow of the solutions, walls/floor corrections, furniture installation, furniture customization, repairs to structures, roofing and roof installation, sweeping, hats chimney and sheet metal construction products. [5]

Gardening and Landscaping: This is making your home and the nearby courtyard's environment comfortable to suit your taste and this includes plantations, places to barbecue, garden furniture and flagpoles, tiling, landscape management and clearing activities, external site management, storm water systems maintenance and cleaning, tree and shrub cuttings, sowing of grass and grass-cutting, composting, other yard work and landscaping. [5]

Building work: This deals with construction like garages, warehouses, outdoor saunas, patios and terraces, wind cabinets, flagpoles and sliding. [5]

1.2.2 Equipment/machines used by the company

Equipment used in the company is of two types: Light and Heavy duty equipment. Light equipment includes a drilling machine, a circular saw machine, a cutting machine, welding machines, mowers, grinders and sweepers.

Heavy duty equipment includes a tractor, vans and buses, a backhoe, pale-loader, a trailers and tippers. [5]

1.2.3 Problems facing the company in terms of equipment

Due to technological advancement, some of the old tractors' attachments (e.g. backhoe for digging trenches) are not suitable for the newly bought tractor this causes a big problem for the company because it means that they have to buy new attachments again for the newly bought tractor. The suitability has nothing to do with strength and efficiency but coupling, fixing and assembling them together is the major problem.

1.2.4 Suggested solutions

As it is known in any company that to be a good manager you have to be money conscious and minimize your cost to the lowest with a very high efficiency. This is explained better by using the graph in figure 1.

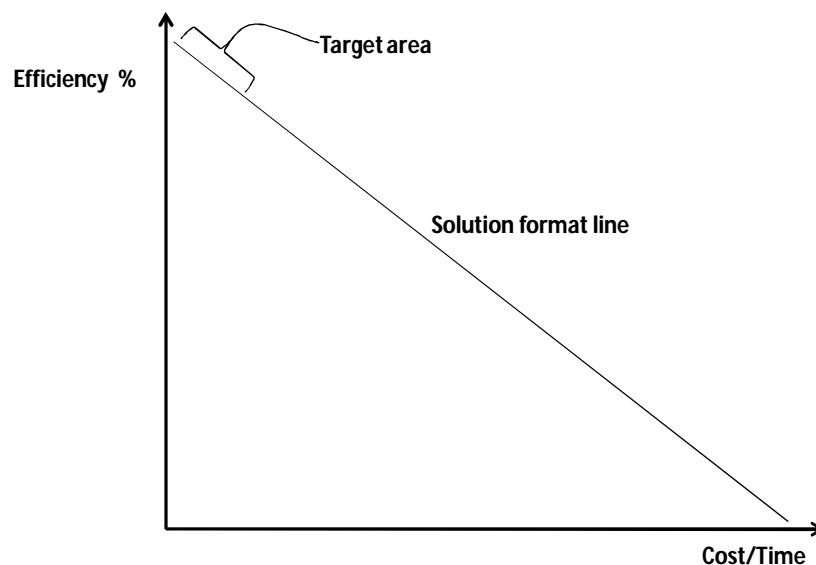


Figure 1. Solution format line graph.

As it is seen in the above diagram, there are two things to put into consideration when you are thinking about a solution to this problem.

1. Cost
2. Efficiency

The cost of the suitable solution must be low with very high efficiency as it is shown in the graph as **target area**.

There are various types of suggested solutions and their short comings which are:

1. Buying a new attachment for the new tractor (High cost)
2. Managing the old one with help of some supports (Low efficiency and cost)
3. Buying a suitable old tractor for the attachment or new attachment for the newly bought tractor(High cost)
4. Redesigning of the coupling area/parts for easy fittings (High efficiency, low cost and less time)

By carefully checking the figure 1 graph, it will be seen that the target area can be found in the fourth option which makes it the most suitable option to choose.

2. BASIC CONCEPTS AND TERMS

2.1 Design for manufacture and assembly

In order to have a good design, the designer needs to start with what is called a design brief which can be gathered within the company itself and from the existing or potential customers who wish to satisfy market demand by developing a new product. A design brief is just what your clients really need from you.

It includes:

- Client's requirements
- Functional requirements
- Maximum permissible project and product costs based upon the perceived market
- Market details
- Quality requirements

After the design brief has been evaluated, the key design features will be known and concerned with:

- Aesthetic requirements
- Contextual requirements
- Performance requirements
- Production parameters and constraints such as availability of labour, materials, technology and health and safety requirements.

Alternatively, while proposing design feasibility studies are also needed to be carried out in order to give a realistic presentation to the client. The final design will be planned in accordance to associated quality specifications requirements given by national and international standards organizations, safety and environmental legislation and legally binding notes of guidance for the category of product concerned. Although it may be a bit costly at the end but those requirements have to be met. [1]

2.2 Philosophy of design for manufacture and assembly

As it is known that design is the first thing to have in mind when thinking about manufacturing a new product and can have a great effect on cost of the product so the philosophy of design for manufacture and assembly looks into cost reduction by manufacturability improvement with ease of assembly of a particular product. [1]

2.3 The implementation of design for manufacture and assembly

Naturally, the manufacturing engineers usually have one problem or the other in doing their job because they do not participate in the designing stage which made the designers' work to be termed as over-the-wall approach. To overcome this, a team has to be built called Concurrent Engineering Teams and they will give some criteria for manufacturability and assembly for proposed design. [1]

The criteria are:

- Functionality
- Manufacturing issues
- Handling and Assembly

2.4 Functionality

A component consists of different parts. The functional part is the one that really has critical assignment that leads to the performance of the component. The non-functional part does not have major work in component existence but it has to do with maintenance, covers, inspection and aesthetical value and it must be reduced to the minimum to have low production cost. [1]

2.5 Manufacturing issues

Manufacturing issues is a topic that has to do with the manufacturing process and materials. The complexity of the manufacturing process, type and quality of the materials to be used has a great effect on production cost of the product. In addition, amount to be produced affects materials' volume cost but design process and method does not go along with the number of products to get, cost spent on design is fixed. To reduce cost on manufacturing issues, some certain points have to be clarified which are [1, 2]:

- **Complexity:** Component's shape has a great effect on the manufacturing method. Different types of shape have a distinct suitable method of making them and how the structure looks like also gives the best idea of the method to be used e.g. simple cylindrical shape can be manufactured by turning but if it has a thin wall, a bit complex other method has to be looked into because of strength and accuracy.
- **Material suitability:** Material suitability is one of those things to be kept in mind when deciding on the type of materials to be used for a particular product because some materials are really good for some processes while some are bad due to their physical and chemical properties e.g. copper, zinc, lead and some aluminium alloys are easier to work with by impact extrusion process than steel and steel alloys are easier to hot forge than aluminium alloys.
- **Wall thickness:** A certain wall thickness of a particular product has a suitable manufacturing process e.g. sand casting (greater than 3mm thick), die-casting ($0.6\text{mm} \leq 3\text{mm}$) and sheet metal pressings and impact extrusion ($>0.6\text{mm}$).
- **Tolerance and surface finish:** The equipment with high tolerance will be costly because of increase in processing time and tools handling regulations which make it easier to be handled with care.

- **Process cost:** A component to be manufactured has to pass different processes and stages and each process can't be completed without the financial aspect. Money spent on each process is known as process cost and the addition of different process costs make the production cost.
- **Waste:** Some processes are regarded as waste because of the materials disposed of as scrap while manufacturing them and some consume really long time to complete the process. It is the task of production economics to assess both situations and balance it and come up with the best choice to be used.
- **Treatment:** Surface treatment cost varies depending on the type of materials used. Some materials are costly but they do not need any other surface treatment while some are not expensive but they require additional surface treatment for quality improvement. The product designer in consultation with customer can decide how the balance will be made.

2.6 Handling and assembly

When thinking about handling and assembly of a component it should also be considered how redesigning of a product can lead to reduction in parts quantity as it is known that for smaller parts less time is to be spent on handling and assembly of the product. [1]

- **Handling:** Poor design of a component will result to difficulties in manual or mechanical handling of the product. An example of this is a fragile and delicate product or a product with unnecessary weight which makes it too heavy to be suitable for what it is meant for or to serve its purpose.
- **Assembly:** It is also good to check how a component can be coupled to another to test and assess its functions. Difficulties in handling and obstructions are also signs of poor design.

The features of good design include the following:

- Orientating one about how the product can be positioned correctly at the first attempt.
- There should be no resistance to insertion.
- Assessing the product must not be restricted by any means
- There should be no additional joining process such as bolting, soldering or adhesive bonding.

To achieve all these criteria, all the components:

- Should be symmetrical, if possible and this also helps in manufacturing
- Have polar geometry mark.
- Have important directions.
- Should be tangle proof.
- Should have consistency in the dimensions used for feeding, orientation and location
- Should be self-locating.
- Should have a datum surface

If volume of production and cost are to be kept in mind, it is important that assembly:

- Should have location points
- Will be designed to start from top
- Should be designed to avoid unnecessary turning over of the product
- Should be designed to allow series of subassemblies for intermediate checks
- Should incorporate standardized parts e.g. fasteners in order to facilitate assembly and correct selection.

- Should reduce complications and eliminate components that are not important. [1,2]

2.7 Computer aided design and manufacture (CAD/CAM)

This chapter deals with the use of computer hardware and graphics software to make design drawings. Nowadays CAD tools make the designer to produce a realistic image of a product to be manufactured with accuracy. It is a system that automatically produces finished products by using computer controlled production machines.

Both CAD and CAM work together. A digital model will be generated in CAD which will be used as input in CAM software package after the physical shape of the product has been known before composing a proper set of fabrication instructions to a production machine.

The CAD/CAM operators are very useful in every area of design with an architectural design background and creative talent because every design starts from a rough sketch and own thinking. A CAD/CAM operator must be able to read and write with a college level of algebra, trigonometry, and manual drafting practices, the window operating system, 2D and 3D manual sketches. [1]

2.8 3D Scanners

3D scanners capture physical measurements of a real object by scanning it and transfer the data into a viewable 3D format on the computer. As it is known, CAD is based on ideal mathematics by giving the features of the model from the imagination to reality but a 3D scanner works on a physical real-world object to form its imagination, that is, in the opposite direction. The reverse engineering Process starts from scanning the object, re-bridging the data and sending to CAD model for manufacturing. It is fastest way to put an object onto the computer with physically accurate three dimensional measurements. The 3D scanner is represented with a scale digital model or a 3D graphical rendering. When the object is scanned, all its features like length, width, height, volume, surface area, location and size will be processed as given data to produce the drawing of the object in a 3D mode.

The coordinates are measured in data capture application but to get the information correctly, you have to avoid some errors which include: improper datum schemes, probe compensation and environmental effects like temperature and rigidity of the table. [4]

Types of 3D scanner:

- 3D Laser scanning
- White light scanning
- Photogrammetry
- Machine vision
- Coordinate measuring machines
- Destructive slicing
- 3D CT or MRI scanning
- Theodolite
- Trackers

Advantages:

- Physical object measurements can be done quickly
- It shortens the design work time
- It makes components' assembling easier
- The inheritance of manufactured parts made easy
- It limits the difference between as-designed and as-built

3. PROCESS DESCRIPTION AND STEP

3.1 Preliminaries

The needed tools were gathered and machines and other equipment to be used were checked well. Due to the nature of the study which caused some measurements to be done manually some other tools were also constructed for determination of perpendicularity of an object.

3.2 Project plan

The project plan was done without including the time schedules and it goes thus:

- Assessing and studying the old equipment
- New tractor assessment
- Comparing and contrasting the two
- Identifying the problems
- Knowing the source of the problem
- Checking out for people's opinion about the problem
- Suggested solutions and their assessment and comparison
- Choosing of the most suitable, reasonable, cost effective and with high efficiency
- Gathering information needed for the project like measuring, checking shapes etc.
- Drawing the rough sketch and its compatibility with the old equipment
- Designing
- Modeling
- Re-designing
- Testing of the re-designed parts
- Finishing the process

3.3 Assessment and comparison between the old equipment and the new tractor

Information about the workability of the former tractor attachment was gathered and some critical points like joints, coupling areas, turning areas, valves, gear, both dead and live loads etc. were noticed and some questions were asked and answered like how does it work, means of connection, area of connection etc. In this way, more information about how the machine was being operated before was gathered.

The new tractor information guide was studied to know both the physical and structural properties of the tractor and the structural members' properties were also checked to know the maximum loading capability of those members e.g. chassis, axle etc.

By comparing all the information received or gathered from both the old equipment (tractor attachment) and the new tractor, it was discovered that both of them are capable to work together but there will be more efforts to be put in the coupling area to aid the assembling system so that the tractor can take it conveniently and everything will be balanced both structurally and physically. Figures 2 and 3. show the parts that are to be coupled together.

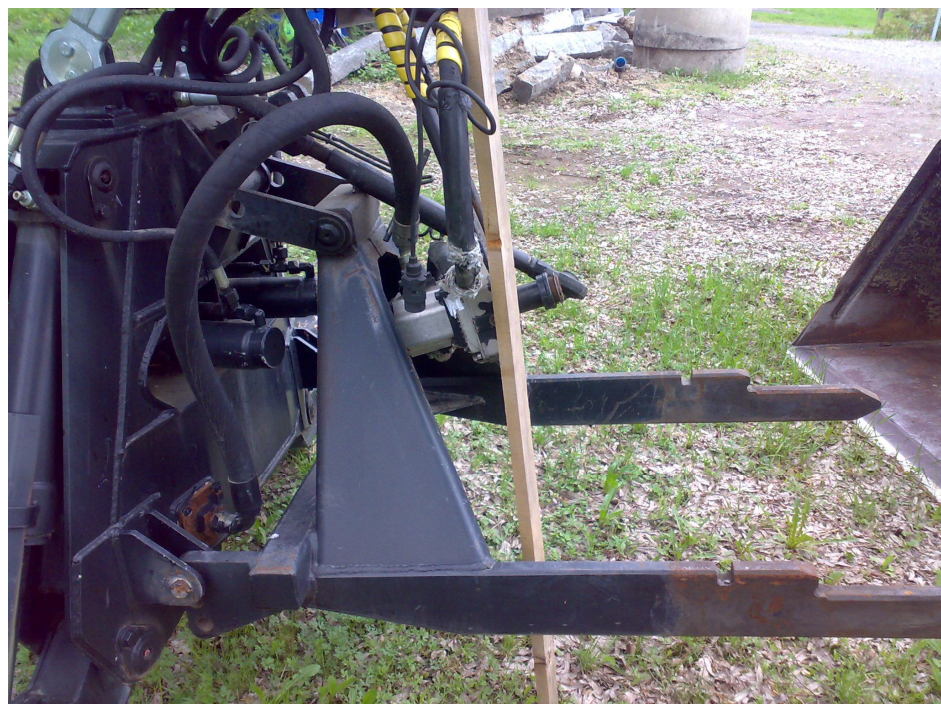


Figure 2. Picture showing the coupling area of the old equipment.



Figure 3. Picture showing the coupling area of the tractor.

3.4 Problems encountered and their identification

It was discovered that the cylinders and other structural members used in the new tractor's coupling chamber did not have enough strength to hold the old equipment while working. Physically, it was seen that there should be an additional support for the stability of the system if they are to be used together. Details can also be seen in figure 4.



Figure 4. Picture showing the structural parts used for the connection.

3.5 Cause of the problem

After checking the mechanism well, it was seen that the all the forces coming from the equipment while at use which make it to be in form of cantilever were transferred to the main tractor through the same mechanism that is responsible for automation, feeding of hydraulic oil and the gearbox for the hydraulic control of the system which lead to low efficiency and parts' to the fact that the parts wear out easily.

Suggested solutions gathered are:

- Buying the new one
- Welding and repairing the damaged part
- Re-designing of the joint/coupling area

The assessment of the suggested solutions and gathered opinions:

- Buying the new suitable equipment is good in terms of efficiency and time but too costly in terms of money to be incurred and wasting of old resources (formal equipment).
- Welding and repairing the damaged part gives low efficiency, an unreliable system, is time consuming but saves money when thinking about short time effect.
- Re-designing the product also gives a permanent solution to the problems, reasonable cost, and high efficiency without wasting of resources (formal equipment).

Comparison:

As it is known that there are two things to be put into consideration and they are cost and efficiency. After checking all the options available, it was discovered that re-designing gives what is really wanted because there is cost reduction with high efficiency.

3.6 Gathering information needed for the project

Steps taken in this area are:

Preliminaries

- Looking out for the same type of machine and seeing how it is coupled together to give a brief idea of what is really needed for the work. This was accomplished by discovering the same kind of equipment in Varkaus main cemetery located at savontie and enlightened the idea.
- The manual of the new tractor was carefully studied in order to know the features of the chassis and axle like their dimensions, shapes, spaces available etc
- Taking some real measurements of the area and parts needed for the equipment and thinking how the placement will be done conveniently. In order to get an accurate number, a tool was constructed which gives perpendicular distance and enhances accuracy.

Rough sketch

The gathered information and ideas were put into rough sketch for criticism and assessment where some short-comings were found and corrected. With this the final shape was and concluded.

Designing

Different parts to be designed were listed and basic information and the shape of each part were listed as criteria under each part before the work continued. More information about these parts will be given in chapter four.

Modeling

The models of some critical parts like the one to be attached to axle member were done by using wood to test if the part will fix in well or not. This later led to making some corrections and amendments in order to get them fixed well to the new tractor.

Redesigning and testing

After checking the compatibility of the models made, some corrections were made which means that the part will be redesigned, models will be done and checked again. The process continued until the suitable and accurate one was done.

Finishing the process

The surfaces of the parts agreed to be painted with a black glossy paint to prevent rusting and matched colour of the new tractor's chassis colour.

4. DESIGN STAGE

4.1 Equipment modification design

The distance required for the attachment to fit well to the tractor was really mastered to minimize any kind of difficulties that may arise during assembling.

Due to the nature and source of the problem, the best place and structural member that is capable of taking the load is the axle of the tractor which is shown in figure 5. So all the designed parts were done by considering the characteristics and features of the axle.



Figure 5. Showing the axle's features.

4.2 Components and assemblies

List of different parts designed that will be fixed to the tractor axle and how they will be assembled for the work.

The upper part (figure 6.) helps to attach (without dropping or falling) the whole component well to the axle without having any effect on the axle with help of another component coming under it that will be bolted together. Details will be found in drawing 4 in appendix.

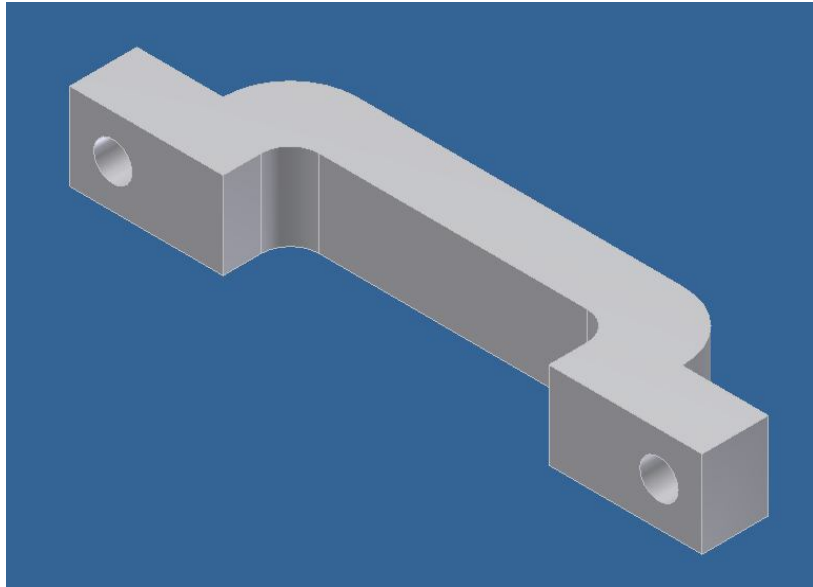


Figure 6. Upper part.

The down part holds (by welding) the plate that is responsible for the holding of another member responsible for the cantilever load. It positions the whole member at the accurate place. Details will be found in drawing 1 in appendix.

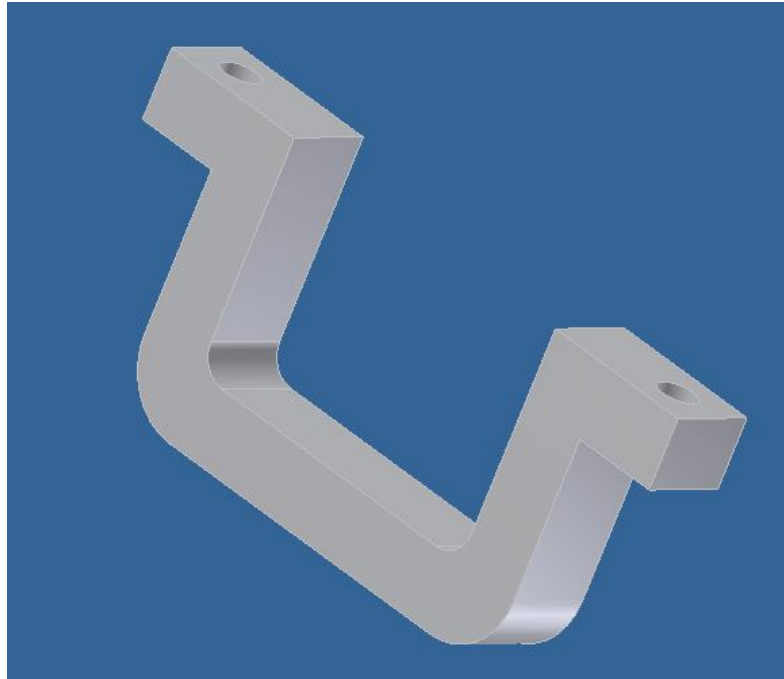


Figure 7. Down part.

The front plate (figure 8.) serves as an intermediary to transfer the load (tension force) from the attachment to the axle. It is a tension member. Details will be found in drawing 3 in appendix.

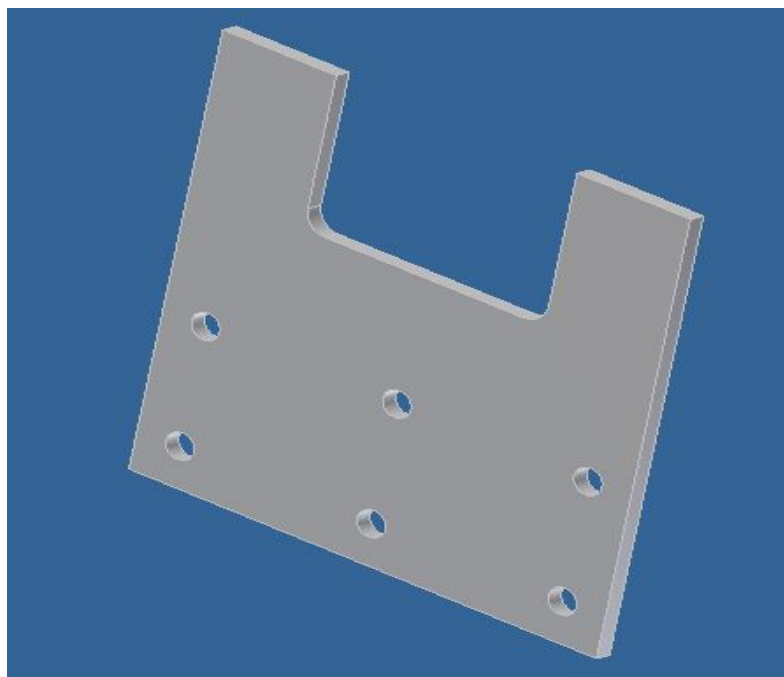


Figure 8. Front plate.

Assembly 1 (figure 9.) shows how all the three parts will be joined together before the one that will act as chassis will be bolted to it which also has another support towards the end part.

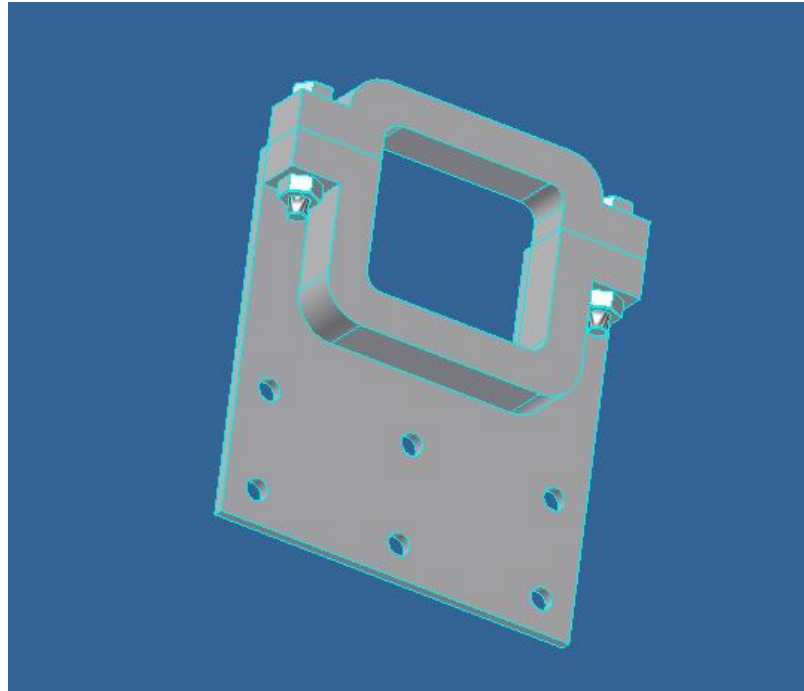


Figure 9.

Back plate (Figure 10) will also act as a support at the rear end to counter the tension force that will act on front support. It will act as a compression member. Details will be found in drawing 2 in appendix.

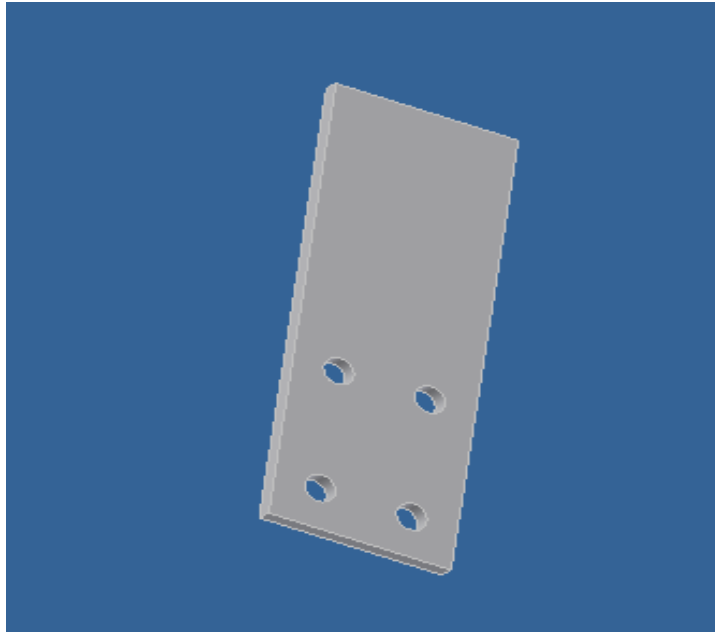


Figure 10. Back plate.

The chassis member (figure 11.) will be bolted to both front and rear plate to carry the load of the equipment. This current picture shows how the old one will be reshaped into this format.

The old one's shape has to be changed to this shape for the on-coming equipment to fit in properly to facilitate the assembling process. Details will be found in drawing 5 in appendix.

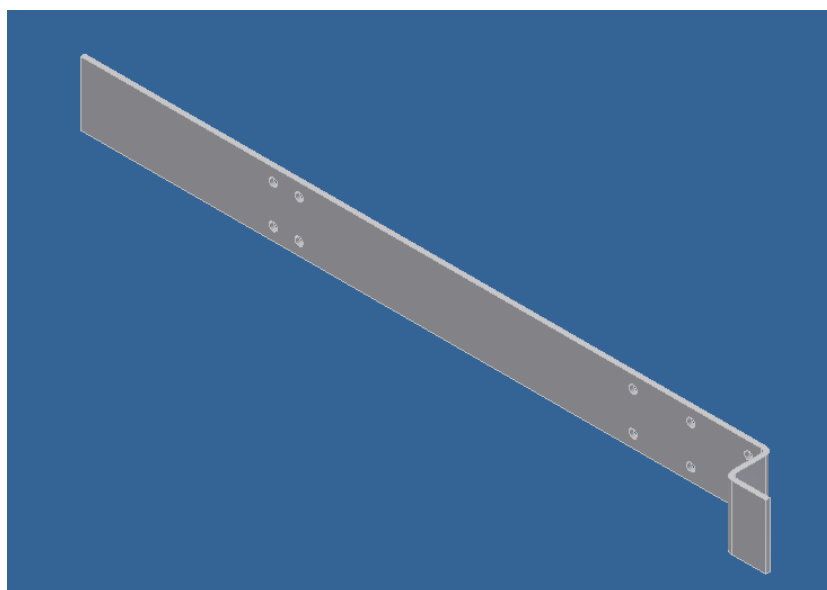


Figure 11. Chassis member.

At this juncture, the full assembly of the whole part can be seen in figure 12. This picture gives a full diagrammatical description of the whole system.

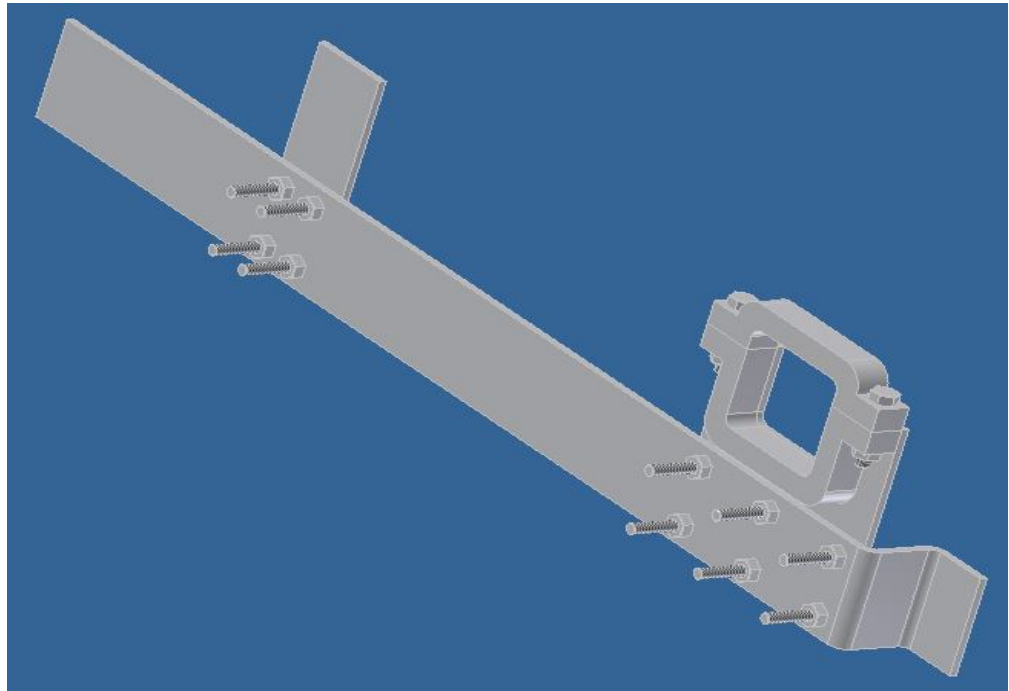


Figure 12. Full assembly.

The same method is also applicable to the second part but there is also a fuel tank which makes the shapes of the component parts to be different.

The pictures of the second part of the system are shown in figures 13-15. The difference in shapes is caused by the presence of the fuel tank and the shape of chassis which has to be taken into consideration. Details will be found in drawings 7, 8 and 6 respectively in appendix.

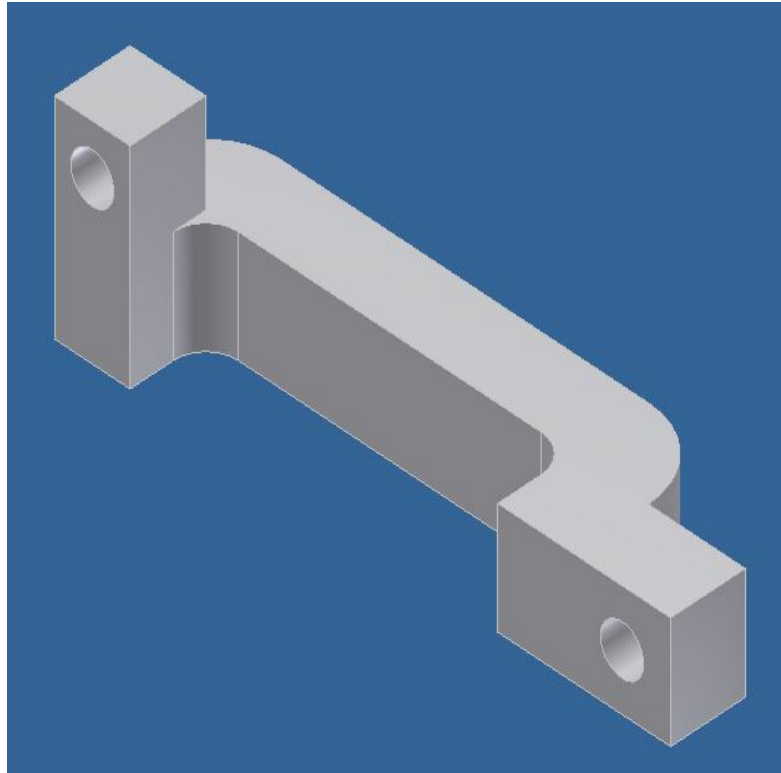


Figure 13. Upper tank with tank.

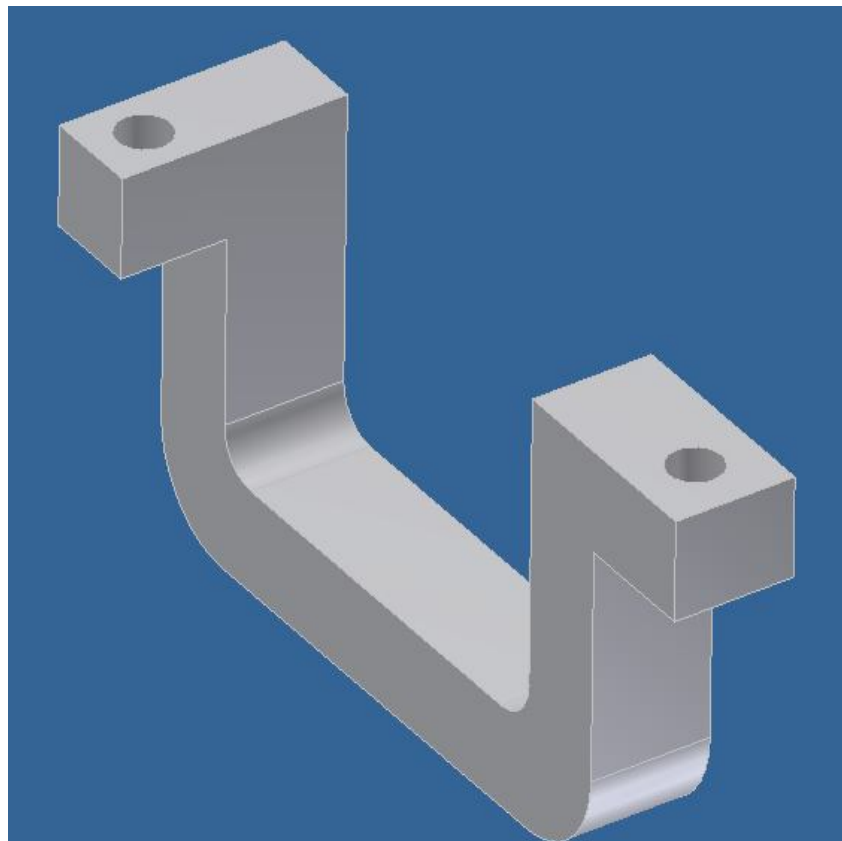


Figure 14. Lower part with tank.

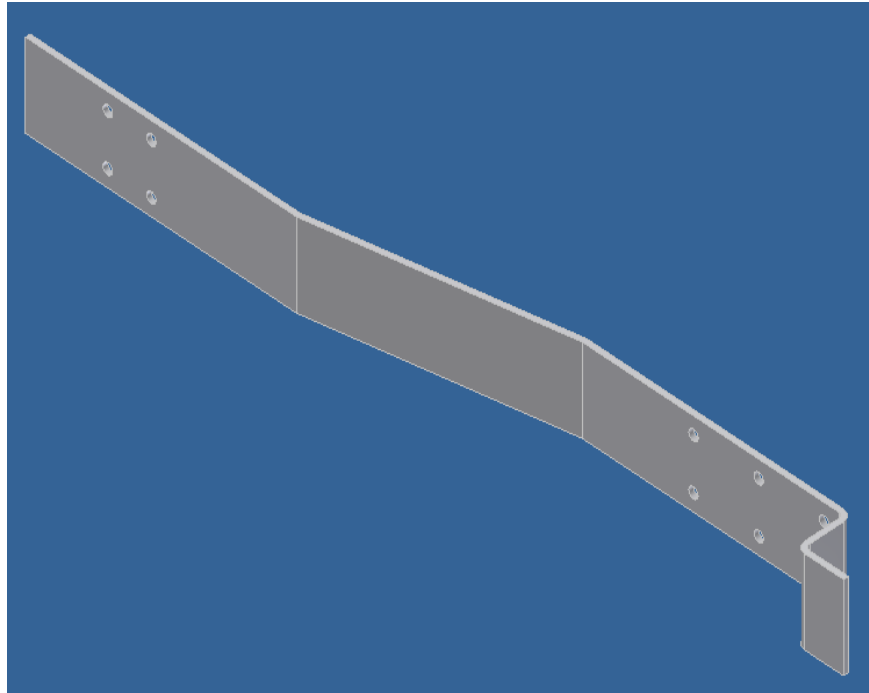


Figure 15. Chassis member with tank.

5. CONCLUSION

As the target point was discussed in chapter one, using a simple graph to analyse how the efficiency of the equipment and cost/time taken for the process made it easier and served as guide. Before the abandoned equipment can be set back to life, those stages mentioned were followed and mastered. Putting all the components together and comparing and contrasting all the solutions available made the project went well. The pre-determined target area which was found to be a place with high efficiency and minimum cost served as guide to follow. Also, by modifying the old equipment to suit current use falls within the target area which made it to be the chosen one. The price of new equipment ranges from fifteen thousands to twenty-five thousands Euros depending on the maker and the model number but this modification system takes off up to sixty-five percent of the price which makes it affordable for a good manager. In addition, it was seen that this project really improved my skills and gave me confidence to tackle any type of other designing work to some extends.

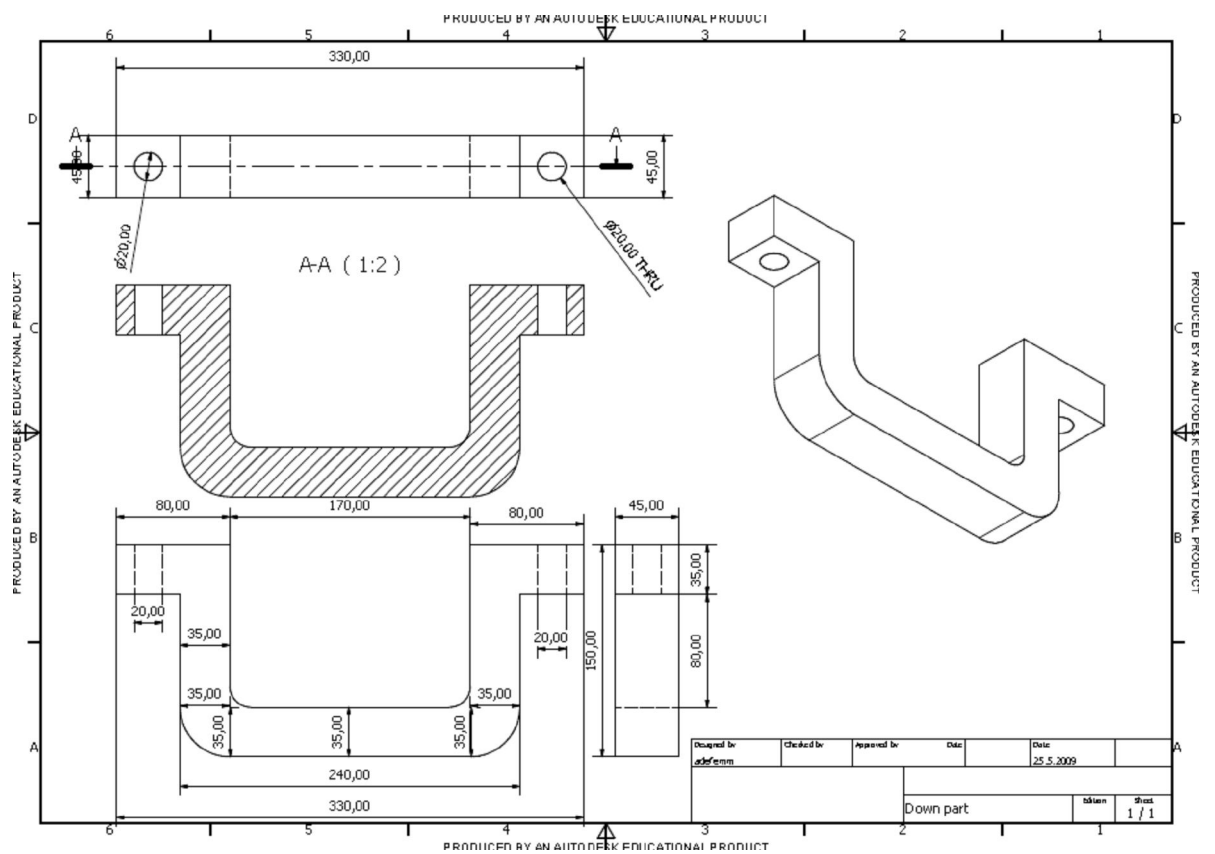
References

1. Timings, R. L. and S. P. Wilkinson.
Manufacturing technology Vol. 2, Second edition, 2000.
2. Timings, R. L.
Manufacturing technology Vol.1, First edition, 1990
3. Brown, James.
Advanced machining technology, First edition, 1998
4. <http://www.3dscanco.com/about/3d-scanning/>

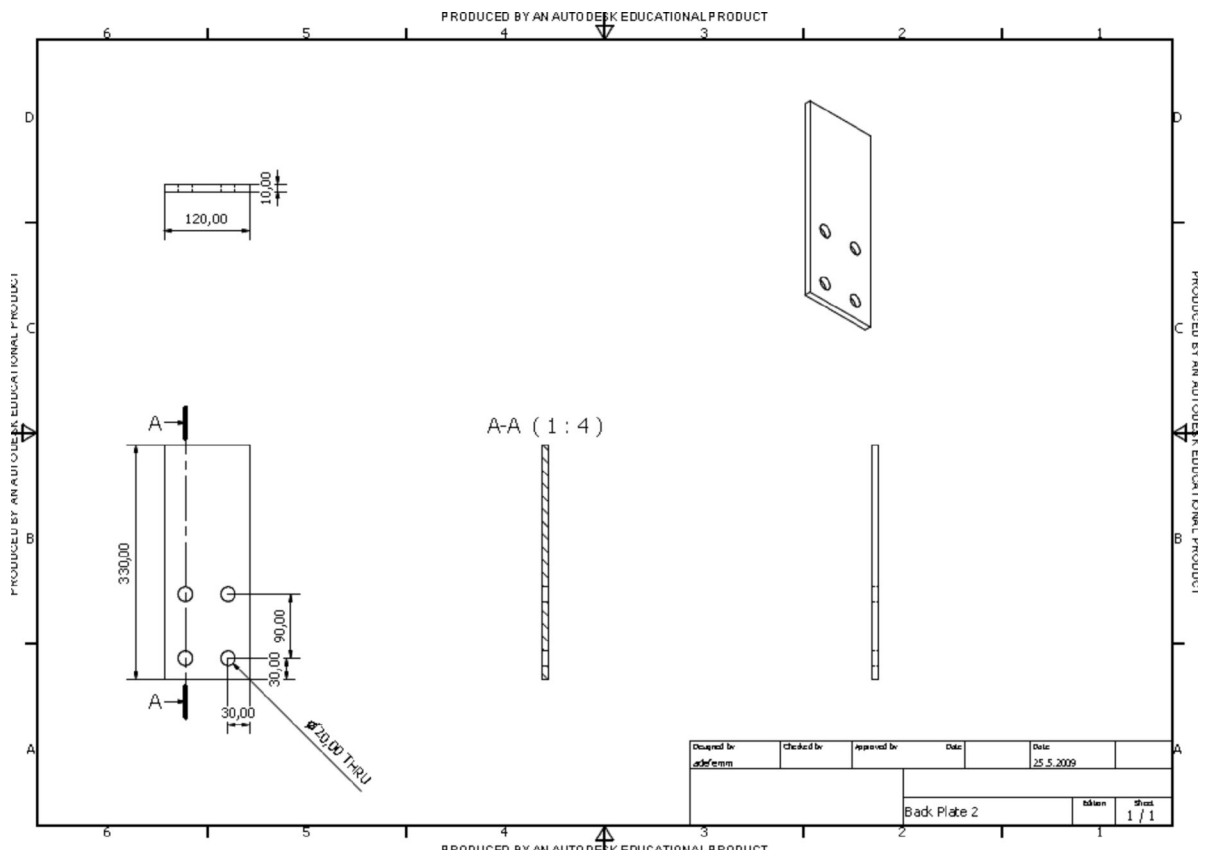
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5. www.isbalanssi.com

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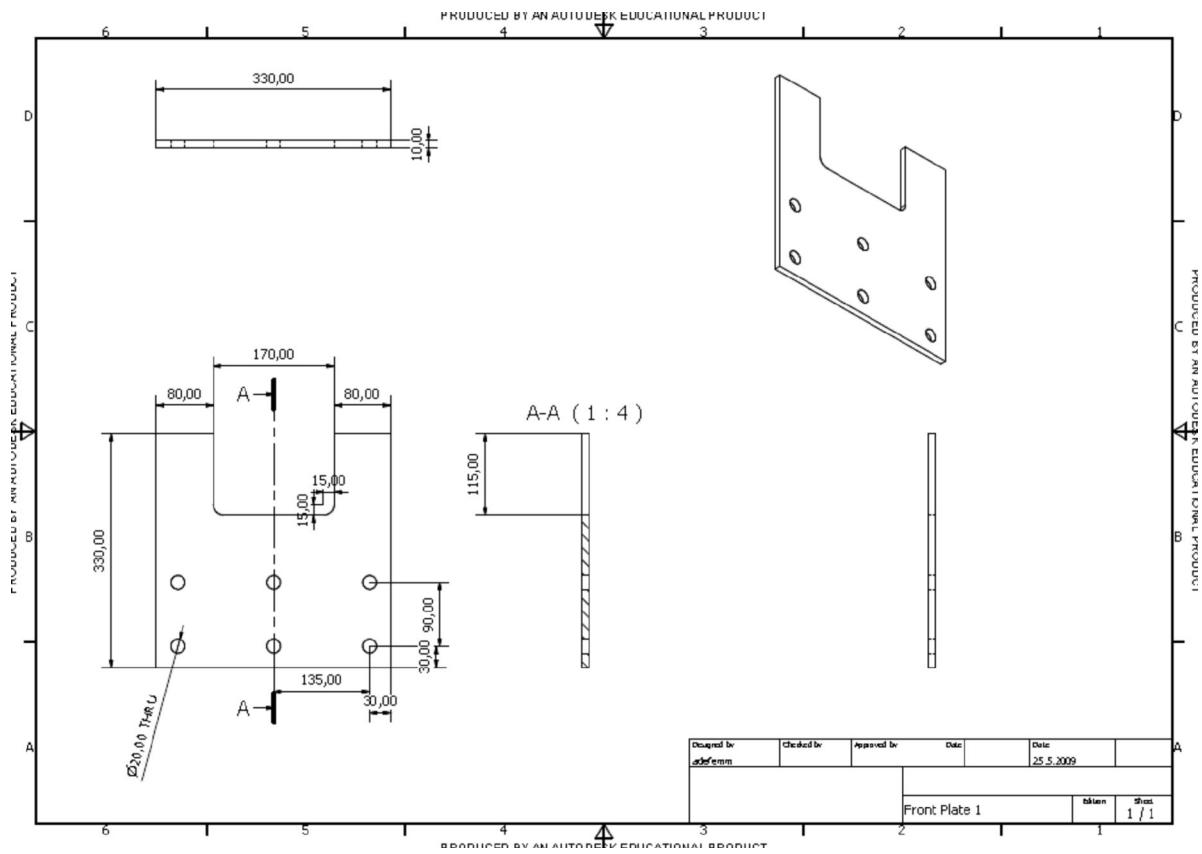
APPENDIX



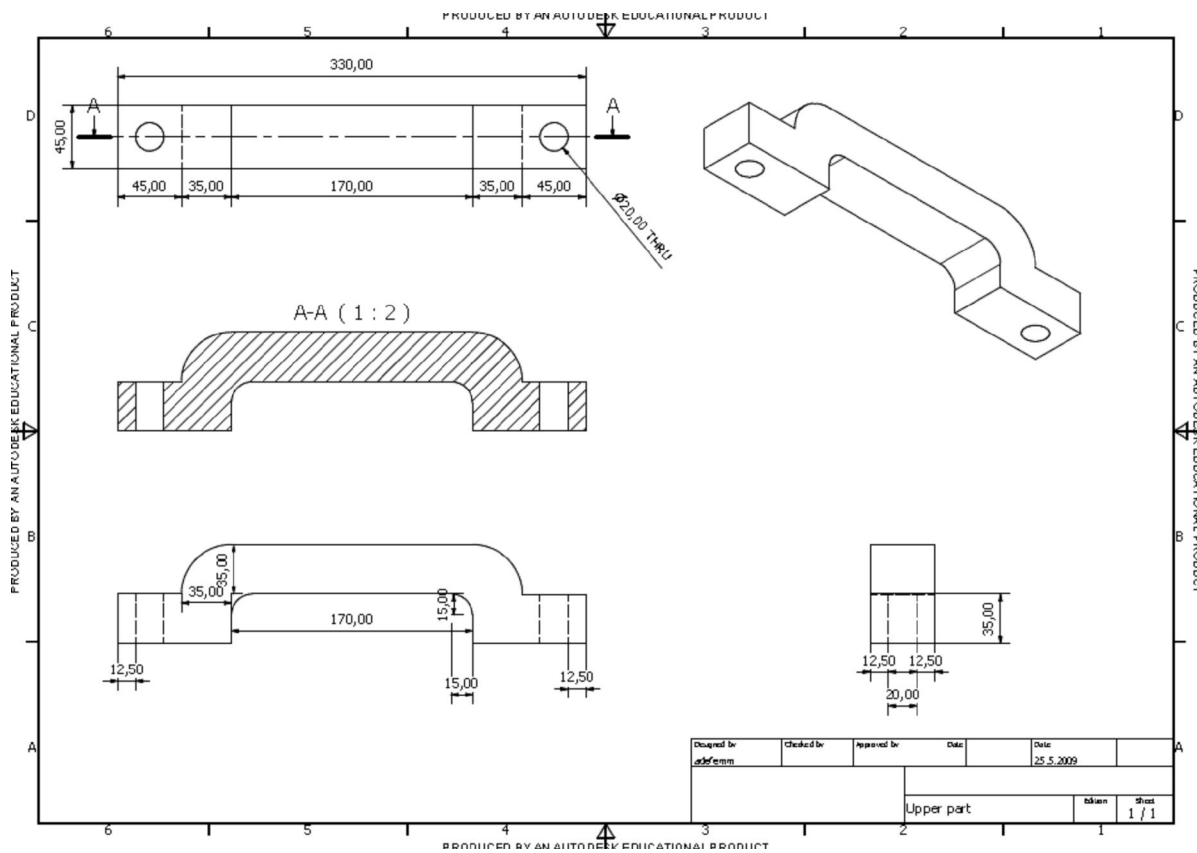
Drawing 1.



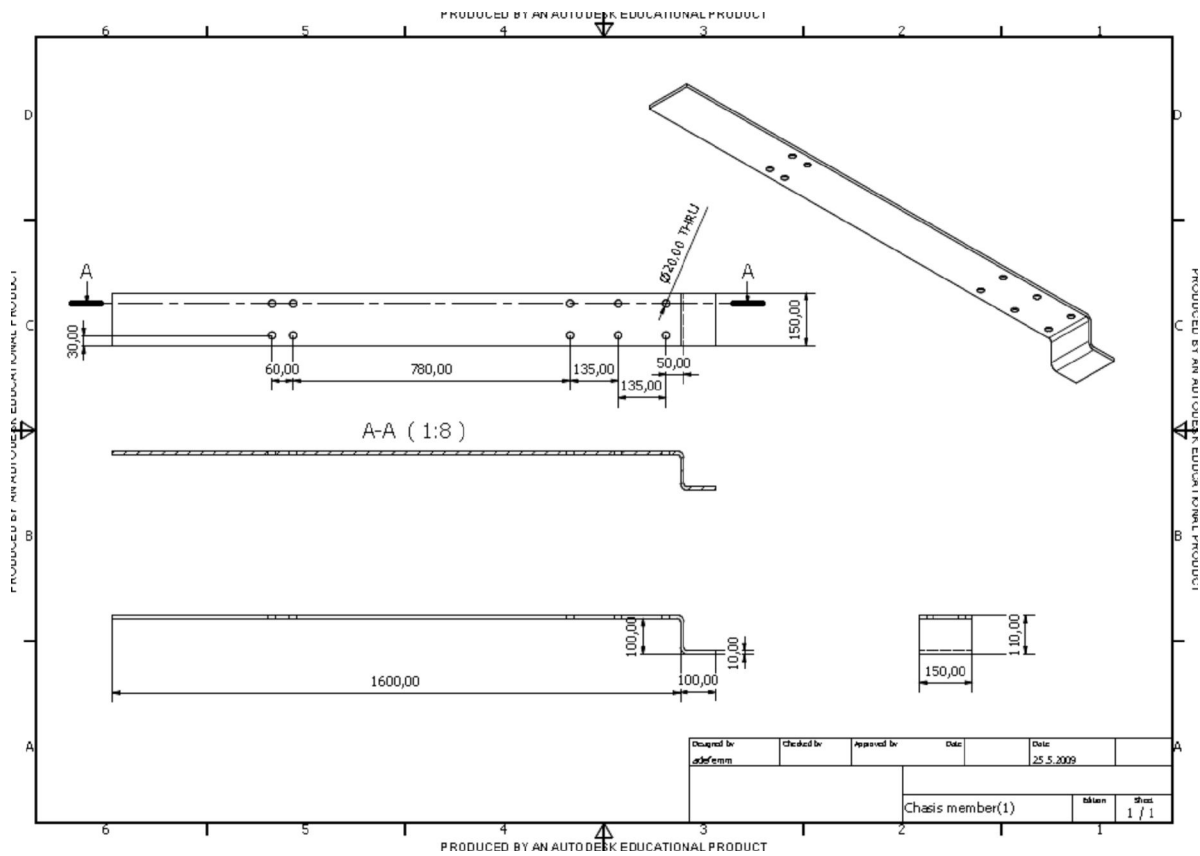
Drawing 2.



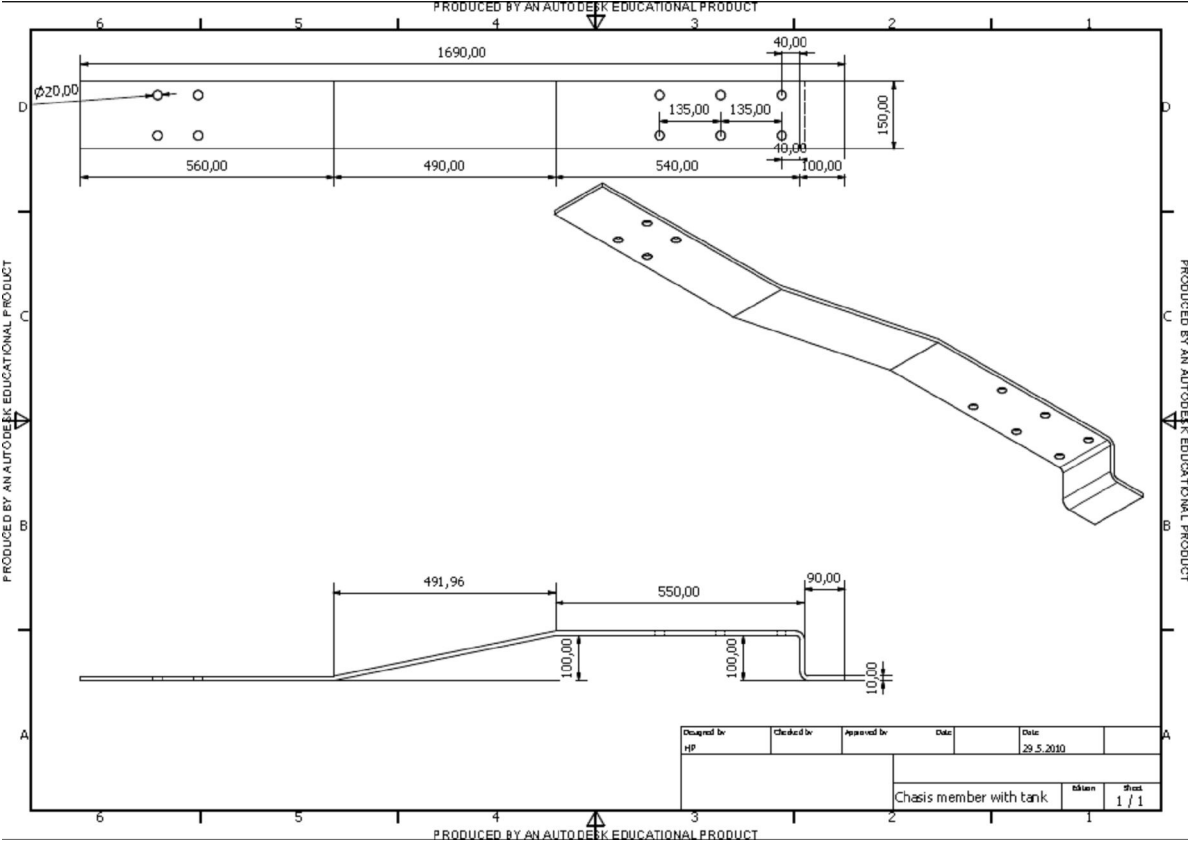
Drawing 3.



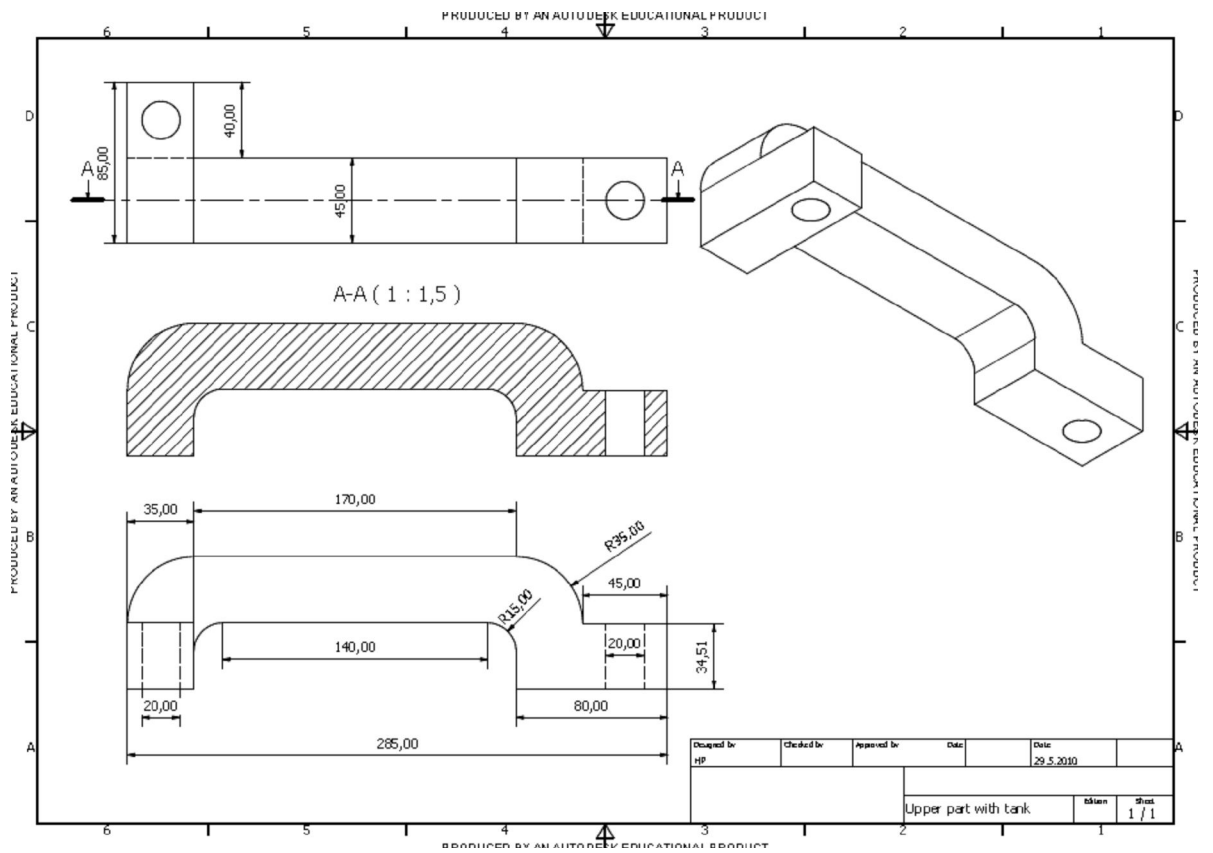
Drawing 4.



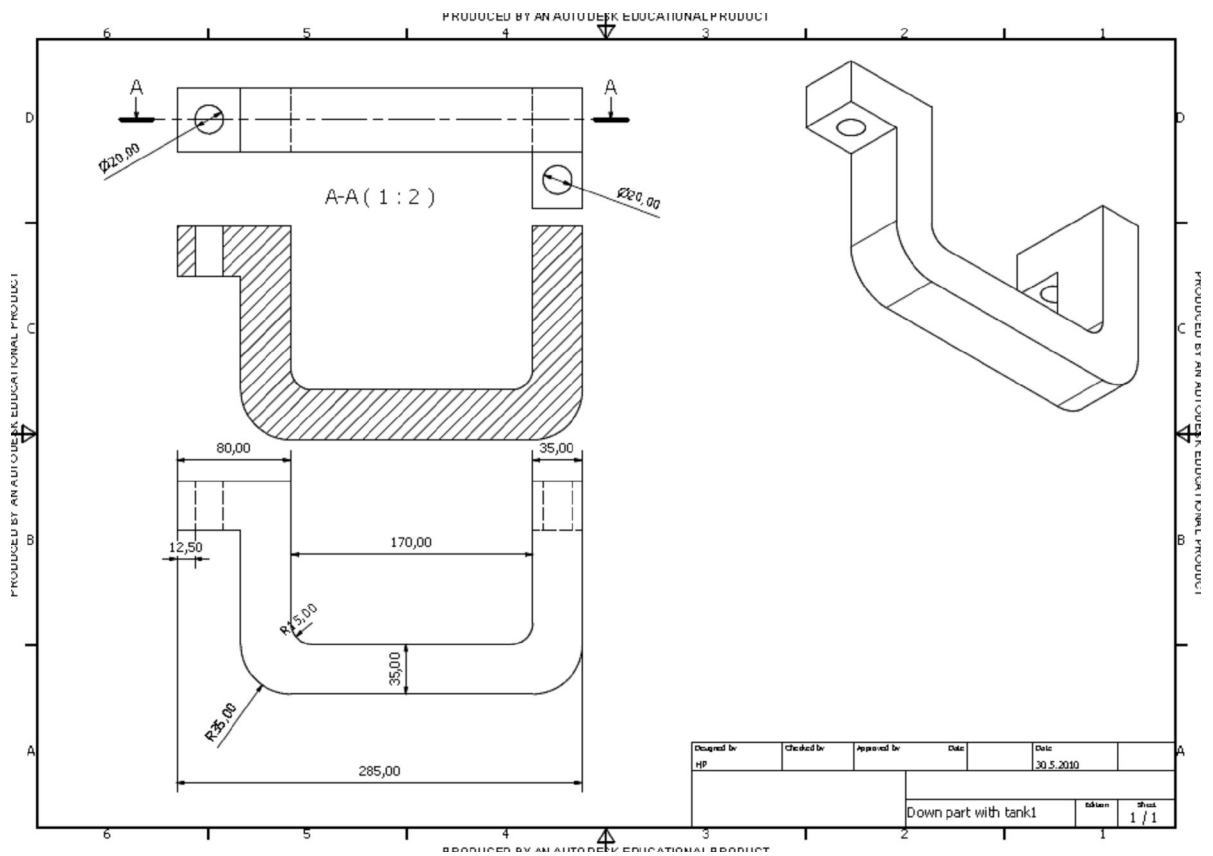
Drawing 5.



Drawing 6.



Drawing 7.



Drawing 8.