UNIVERSITY OF TWENTE.

Flexible welding table Design for Sheet metal parts

Pan Oston®

HEART OF STEEL / SENSE OF DESIGN

Pan oston , Raalte , The netherlands

Student: Gaurav Shetty Anagally

Student number: S2160927

Company: Pan oston

Supervisor: Heico Booyink

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Summary

This report contains the work that was carried out in order to design a new automated welding table for the company ‘pan oston’ located in Raalte, The Netherlands. This internship was a part of a bigger project that was being carried out at the company, which is the upgradation of the current system of welding that is currently labour intensive and time consuming into a fully automated welding cell for sheet metal plates where a single piece flow is envisioned. Also in order to design a new automated welding table a welding cell is to be simulated with handling and welding robot with its accurate dimensions and positions. Also lot of varieties of products has to be studied in order to understand the complexities involved. In order to make the new welding table design it is needed to get rid of the product-specific fixtures and so that parts shall be placed, positioned and welded in a flexible welding table concept based on the different requirements, parts specifications etc.

The end product is one which shows a welding table where it is possible for most of the products to be welded automatically with the new flow line. And this report also describes the material selection criteria, the kind of equipment that needs to be fitted in order to make this table workable. Also some suggestions are made in the end on how to test these concepts and also how to adapt in the future to achieve more productivity.

1. Introduction

This section gives all the information that is necessary to explore in order to understand the background and see how the work can be done in an effective and efficient way.

1.1. Introduction about the company 'pan oston'

Fig 1. The company 'Pan oston'

In 1969 a metal company by the name 'Halton' was started in Finland which would serve as a basis for the current pan oston company. In the year 2005 the company 'pan oston' becomes independent company thus becoming 100 percent Dutch owned company. And today Pan oston is located in Raalte, The Netherlands that specialises in designing and manufacturing checkouts, self-service and kiosk solutions for the European market with a special focus on Netherlands and Germany. The operations of the company can be classified in four steps which are : consultancy, Design , Production and service. As a specialist in making checkouts, self-service kiosks the company always keeps an eye for new trends and is continuously in contact with the customers to meet the demands. The production department works with many press brakes, laser cutters, welding robot to produce required sheet metal. And these outputs are frequently checked quality and reliability in order to guarantee the required product quality to the customers. And as these products are used in public spaces there is always a chance that if they malfunction they need to be fixed as soon as possible, for this purpose there is a service team within the company itself with national coverage to solve these issues as soon as they are reported.

At Pan oston many products are welded using the robotic welder which is shown in the figure 2. The welding tables (other one is not visible in the fig, its on the opposite side) are serviced by a single robot. Currently parts are brought in manually into the welding cell and are fixed to a specific fixture/mould depending on the product family and clamped to be welded by the robot.

Figure 2. current welding cell

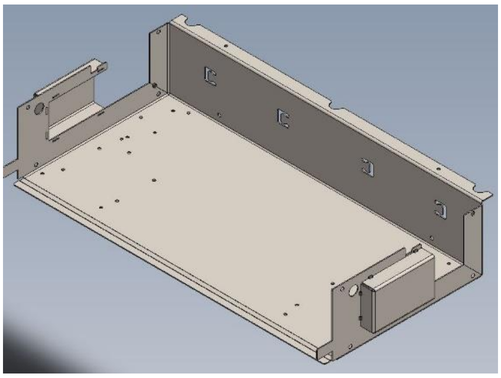
1.2. Customer needs

The company Pan oston needs a single welding table that can hold multiple family of products. And this table needs to be an automated one as setting up the table for each product will be a time consuming exercise leading to a downtime which has to be converted into productive work. Also the table must hold parts properly in place as the products are sheet metal and are prone to deformation quite easily during part handling and clamping.

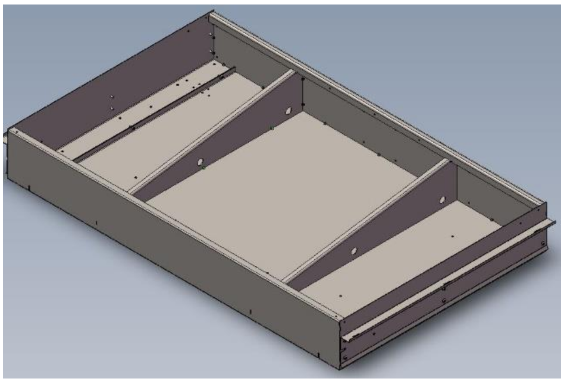
1.3. Target specification

The table is designed by keeping in mind the maximum dimension of available products. Upon investigation it is found out that the maximum length of any part is 2090 mm, and maximum width is 1183 mm. Thus the table should hold the products of these dimensions as their maximum limits. And as the products vary a lot in their shapes and weight some of the very diverse family of products in terms of number of components, shape, welding steps, weight etc. have been inspected closely to include as many products as possible into the new system. Some of the main family of products and their information have been shown below.

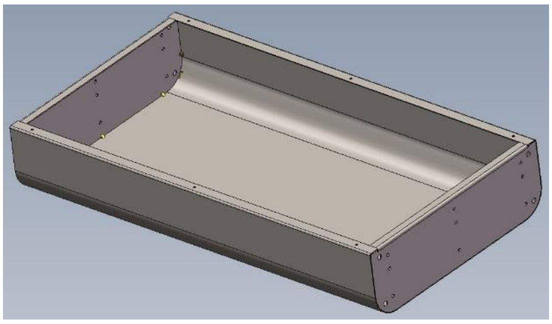
- This family has multiple products with similar shape that has 3 or 4 components welded in the same order and technique. And the maximum weight of these product is just under 11 kgs.



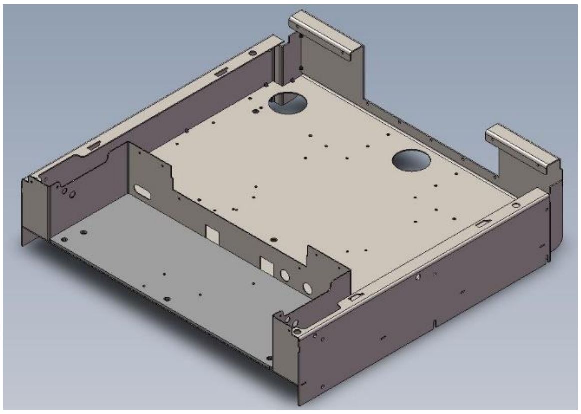
- This family of products has many components (9 -11) and these products follow a similar path of movement and welding and clamping and the maximum weight of this product is just under 18 kgs.



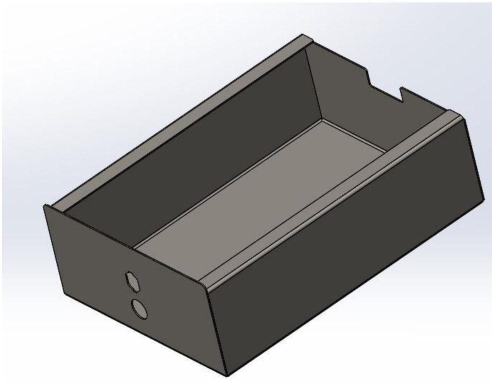
- This family of products just contain 3 components and all follow a simple and straight forward path of positioning and welding. And the maximum weight of this product is below 6 kgs.



- This group of products have 5 or 6 parts and the they are clamped down to a fixture and restricted from all the 4 corners to properly hold down the product. And the maximum weight is under 8 kgs.



- This family of products are the easiest to weld and clamp as they have perpendicular corners and only the inner corners need to be welded. And the maximum weight of this product is under 3 kgs.



1.4. Constraints and limitations

The concepts described in the report still have some restrictions when it comes its flexibility, for example products with curvature cannot be welded in this table. The reason that products with curvatures in it cannot be welded is because the products having a curvature needs more force and supports to be properly placed on the welding platform. And these shapes need to be held accurately at multiple positions which the new system of handling robot in combination of the new welding table cannot be achieved.

Current setup

The current flow is that each fixture/mould takes 30-40 mins to be set up as the existing fixture on the table is to be lifted using a forklift and then the new fixture is brought to be table using the same forklift and then the new fixture is fixed to the table manually.

Problem definition

Before defining the project objectives it is necessary to define the problem at the moment. The problem is that each fixture/mould takes 30-40 mins to be set up as the existing fixture on the table is to be lifted using a forklift and then the new fixture is brought to be table using the same forklift and then the new fixture is fixed to the table manually.

1.5. Project objective

The project objective is to design a new welding table that will reduce the manual work and time being lost in the setting up of different fixtures depending on the product. And the position of the handling robot, welding table, and welding robot has to be simulated properly for the optimal use of the space resulting in a better workflow.

1.6. Welding cell Layout

In order to plan the cell layout ABB robot studio software was used to look for optimal position of all the components. As shown in the picture of the layout the Handling robot(reach 2.85m) is placed at a distance of 1500 mm from welding table(Centre to centre), and for the welding robot(reach 1.85) it has to be mobile as it cannot reach all the position on the table from a single point. Hence it should be mounted as shown and must be movable along the width of the table from 1100mm-1600mm(centre to centre) at the height of 1600 mm.

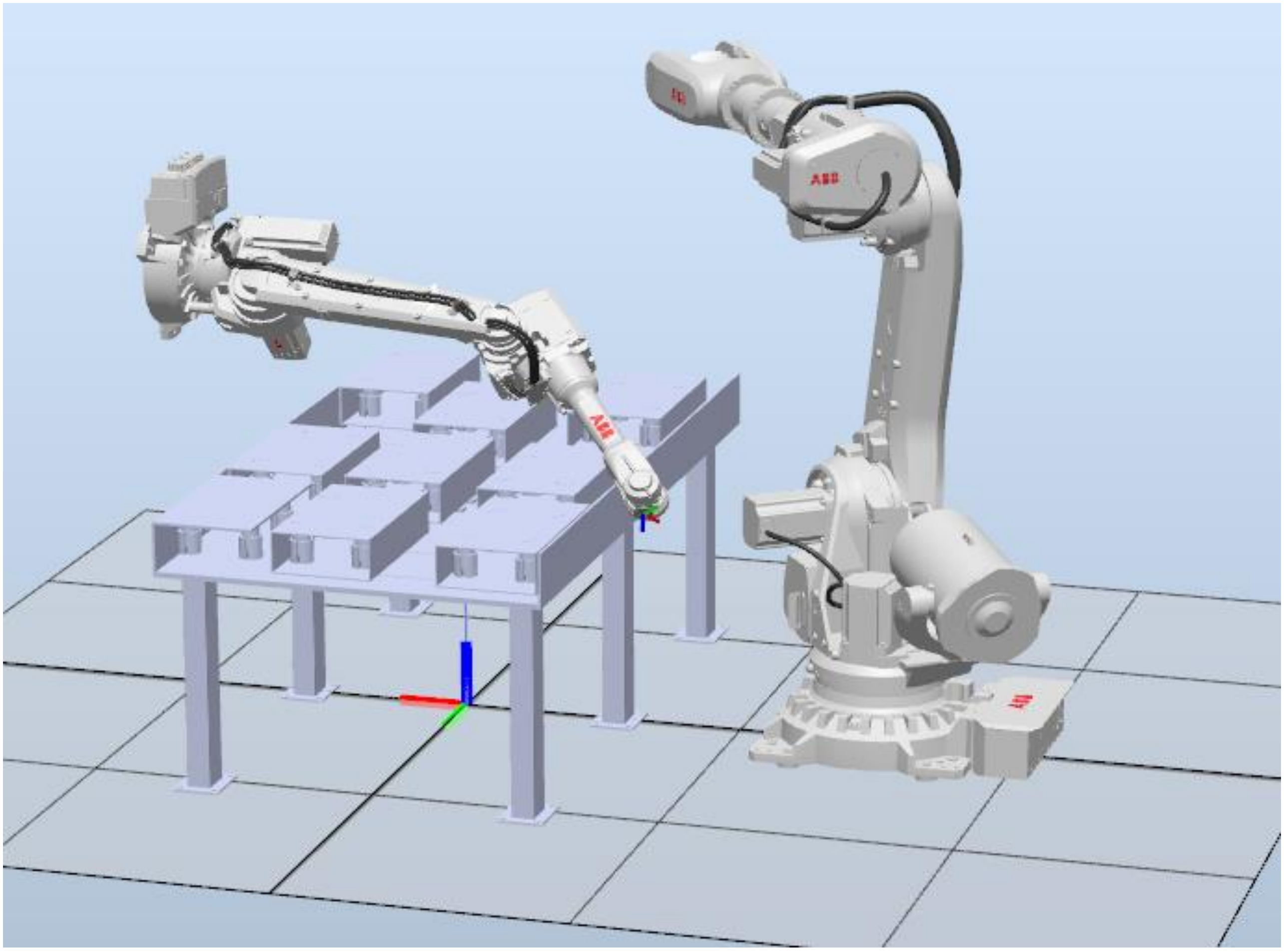


Figure 3. Proposed welding cell layout

2. Welding table concept design

A welding table was designed by looking at customer needs, limitations etc. which is explained in detail in the below sections.

2.1. Types of welding table

The new proposed table can be one of the two kinds which are, either a fixed table or table with movable platform on which welding can be carried out such as a tilting welding table. As shown in the image below both the tilting welding table was considered to decide whether they would be feasible or not. This Welding table comes with height adjustment through hydraulic lift and turning function as well as movable clamping bridge for ergonomic welding of the components. This concept is considered as it can minimize the movement of the welding robot possibly easing up the process.

Fig 4. Tilting welding table

To convert any table with movable base a lot of programming and additional hardware is required. And along with that the sequencing of the movement in height and angular moment is required. And after discussing this concept with the company supervisors at Pan oston we came across many potential challenges such as these tables are constantly change their position and this may result in the platform not being able to come back to its exact accurate position which may lead to big problems and also the general maintenance of this kind of table was not preferred in the industry. So it was decided that the best way to go forward is with a table where the welding platform as a whole is not mobile i.e, it may contain movable parts in them but the entire structure should not move/tilt/rotate.

2.2. Welding table design

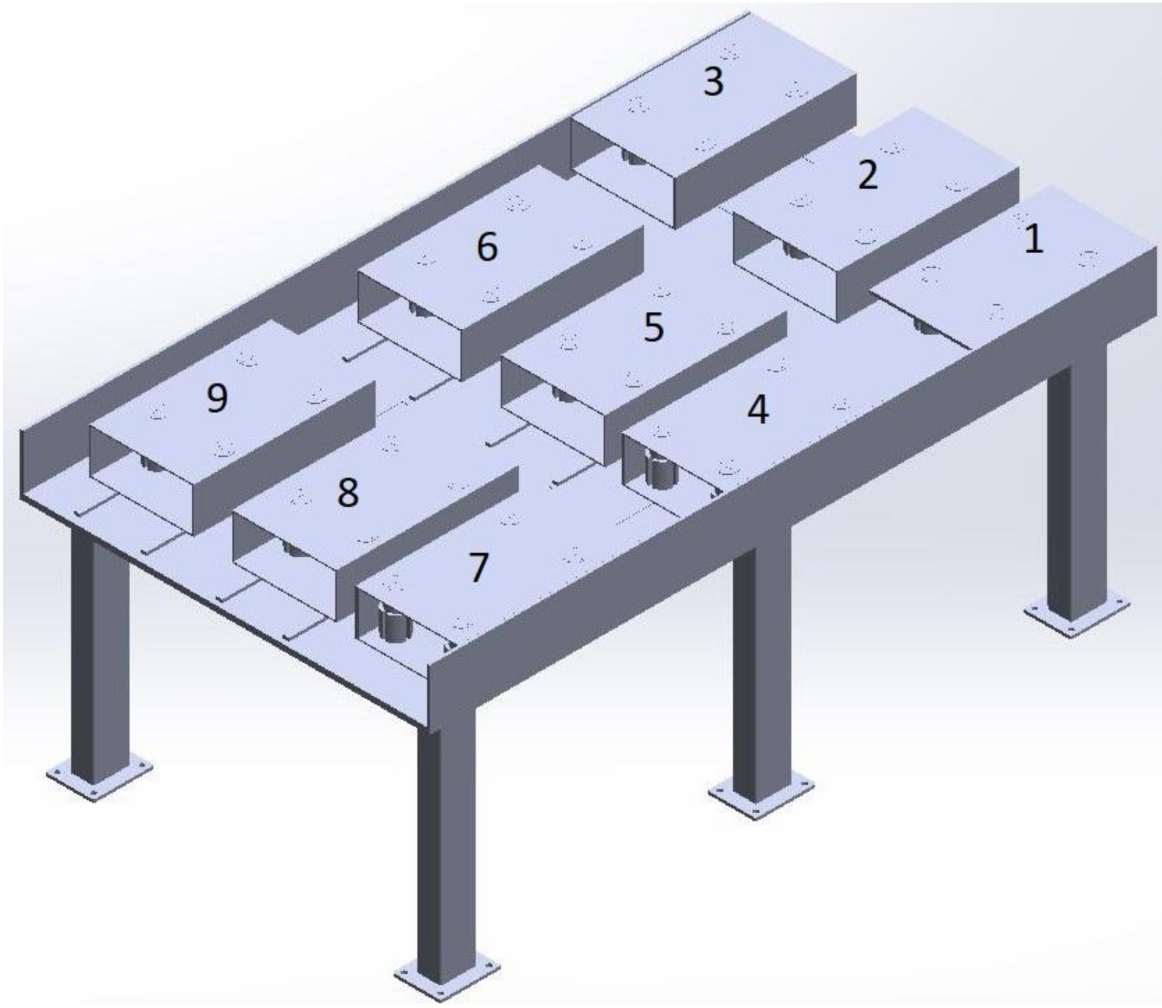
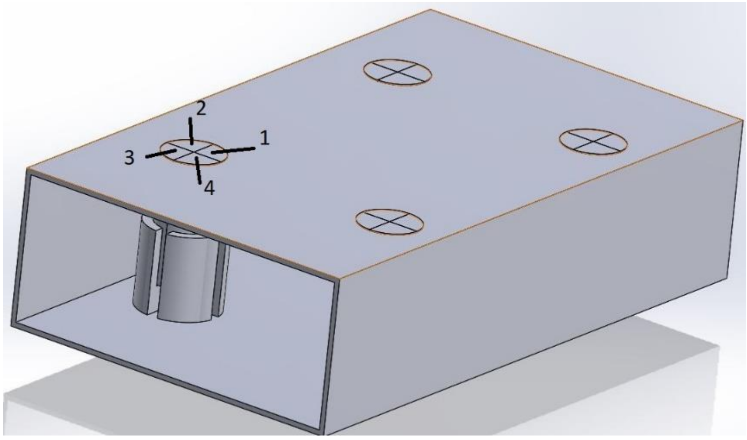


Fig 5. Initial welding table design

2.3. Features

As shown in the figure above the table is made up of 9 modules. The module numbered 1 is fixed meaning it is the reference for incoming products. Then the modules numbered 2 & 3 are movable in X direction, and the modules numbered 4 & 7 are movable in Y direction. Whereas the modules 5,6,8 & 9 are movable in both X & Y direction. Also each module has 16 pins of one quarter of a circle which are arranged in four circle as shown.



2.4. System parts

In this table the idea was to have maximum flexibility with respect to the dimensions of the products and accordingly it was designed. The modules designed were to be moved using pneumatic actuators controlled by a software in X,Y or X&Y direction depending on the module. Similarly the 16 pins in each of the module were to be controlled independently to be moved in Z axis flexible to be rotated along any angle to accommodate various products to properly hold the part in position using three quarters of a circle depending on the part while at the same time giving necessary elevation if need be. And this concept was presented to two different companies and the following feedback was received.

Eriks and Aventics(Emerson)

Meeting with company officials of both the companies and discussing the welding table concept and the methods to achieve the required results was done in order to look for the practicality of the concept. Both the companies had a similar view on this concept, which is:

- This concept is complex
- It would be very expensive to build it
- Sparks and dust may cause problems due to the open slots
- But with all issues, it is achievable and can be built

But a simpler design was required with less complexities and upon brainstorming again for a new concept which would be less expensive and easy to make the following design was made.

2.5. Welding table design(updated)

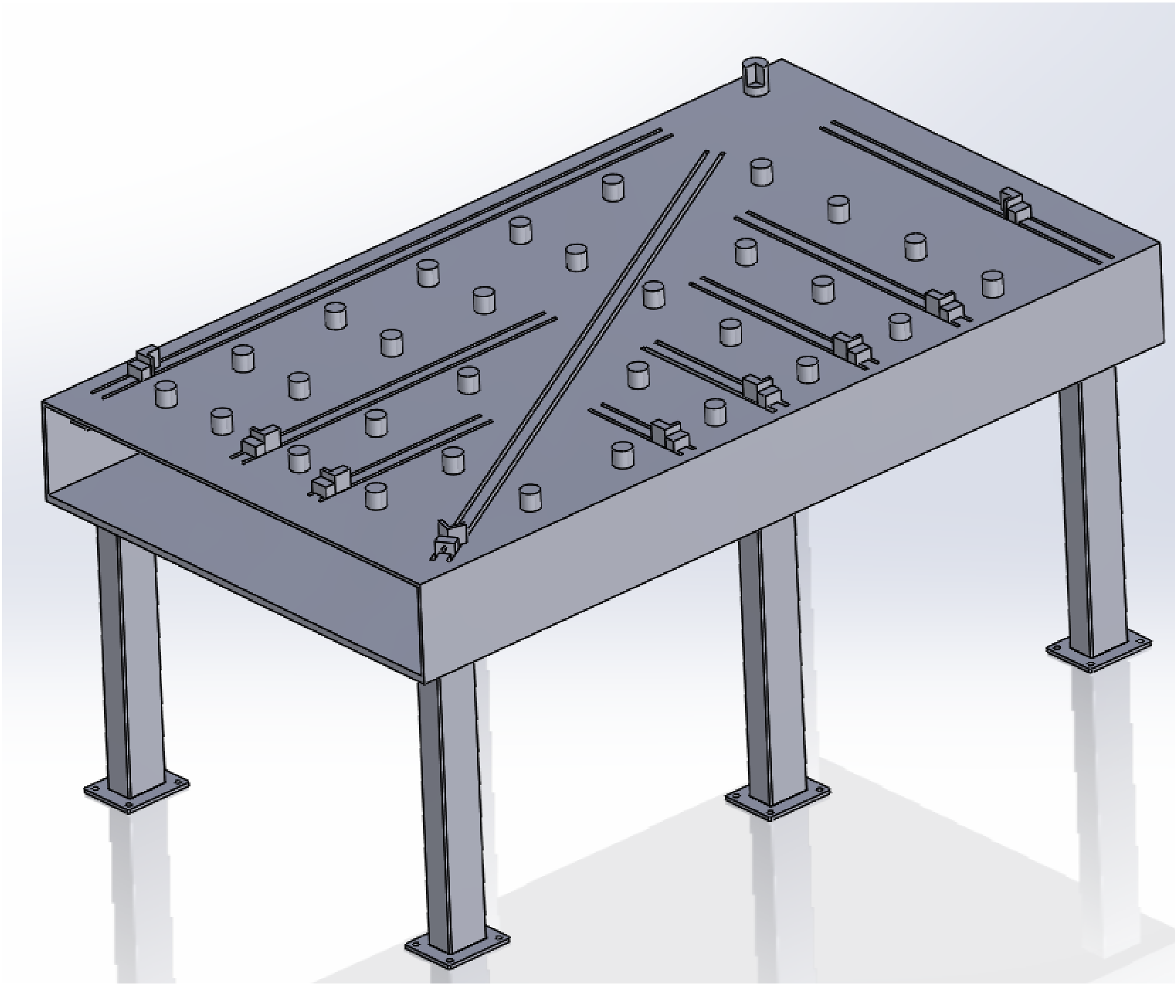


Fig 6. Welding table design(updated)

This welding table is similar to the initial welding table concept in terms of its size. But its functioning is different which is explained in the next sections.

2.6. Features(updated)

This new concept is simpler than the first concept as it doesn’t include modules that need to be mobile in different axis to be functional. Instead this table includes tracks for rodless cylinders as shown and holes for pins to be moved along z axis for giving necessary height for the parts and also giving extra force for the parts to be held properly aligned.

2.7. System parts(updated)

This table includes multiple pins/extrusions that are connected to its own profile cylinders that is moved along Z axis as and when needed, also these pins can also be divided into foue equal parts so that it can act as four separate pins effectively giving more flexibility if needed in the future. The table also includes tracks in X and Y direction, also one in diagonal direction for the movement of rodless cylinders which can hold the parts in the corners and can also maintain them in proper straight line when needed.

2.8. Material selection

Robotic welding can vastly improve the productivity and for that to happen a proper material has to be chosen for the welding table to have a smooth operation and some of the most common materials are weighed against required properties as shown. And for our products Mild steel can be chosen.

	Mild steel	Tool steel	Aluminum 6061	Stainless steel	Copper/copper alloys
Material cost	Low	Medium	Medium	High	High
Wear resistance	Medium	High	Low	Medium	Low/medium
Electrical conductivity	Low	Low	Medium	Low	High
Thermal conductivity	Low	Low	High	Low	High
Thermal expansion	Low	Low	High	Medium	Medium

3. Welding table concept functionalities

The way the table will function is explained in this section.

3.1. Operation

The operation of the table is an automated one as this assignment is a part of a bigger project that wants to achieve industry 4.0 in welding operation of the company.

The rodless cylinders move along the tracks shown in the figure and they clamp the parts at the corners or just hold the part in proper alignment depending on the product. And these Products from Aventics(Emerson) company have the following specifications.

- Piston diameter: 16-40 mm
- Double acting with magnetic piston
- Ball rail guide
- Cushioning pneumatically adjustable
- Easy2combine capable with connection kit

Rodless cylinder, series RTC CG

The Profile cylinders used for vertical movement of pins have the following specifications.

- Piston diameter: 32-125 mm
- Double acting with magnetic piston
- Piston rod with external thread

Profile cylinder, PRA series

And the variant that needs to be chosen will be based on the force that will be exerted by the handling robot once the gripper mechanism is finalized.

3.2. Maintenance

In pneumatic systems, regular maintenance of all the components is of utmost importance so as to ensure that the system works at its complete potential. If not properly taken care of, frequent damages and breakdowns are bound to happen, and this will in turn reduce the life of the equipment and will incur additional costs. Some of the points to be kept in mind are:

- Leakage: Any air leakage from the pneumatics is easy to detect as it makes a noise, and in that case it can be repaired by tightening the fittings, joints etc.
- Do not drill the elements of the system for new openings.
- If you are dismantling the cylinders or valves, do take care of its sealing materials. Even while assembling them again, ensure that they are properly placed.
- As these systems are automated they can be checked by simulations on a fixed time interval for their accuracy.

3.3. Safety

As pneumatic actuators are used the safety of the component and also other surrounding components has to be maintained properly.

- To provide safe speed control of a cylinder or actuator, flow controls should be added to these devices if the stroke is greater than two inches. These flow controls should be meter out. The use of adjustable cushions, or even external shocks, should be used to dampen the shock at the end of stroke.
- Appropriate range for the operating conditions, for example pressure, flow rate and temperature ranges should be taken into account according to the guidelines.
- Oversizing/safety factor; the safety factors are stated in standards or are based on experience with safety-related applications.

3.4. Programming

Conventional method: The programming part can be done by anyone who has experience with microcontrollers and its programming in order to get the necessary sequences by the handling robot and the pins, rodless cylinders correct. This is done by placing each part on the table and the necessary components are programmed accordingly and stored in for the future use.

Offline programming: Off-line programming (OLP) is a robot programming method where the robot program is created independent from the actual robot cell. The robot program is then uploaded to the real industrial robot for execution. This includes Importing the CAD files of the parts into softwares like ‘Siemens process simulate’ or ‘ABB robotstudio’. The parts imported must be marked properly at edges and points, then the trajectory of robot motion and optimal sequence of the path process are generated. This includes creation of individual paths for respective target point.

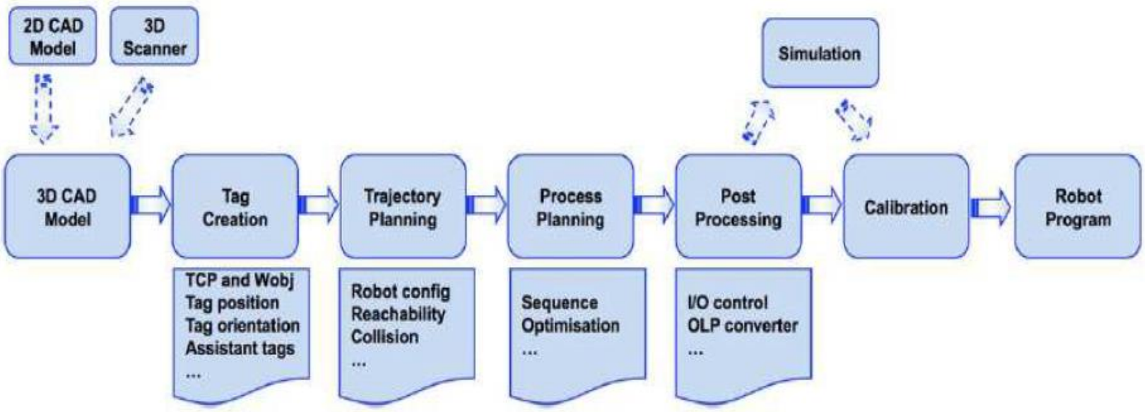


Fig 7. Key steps of offline programming

3.5. Overall cost

The estimated cost of the table is as follows. This is the estimated cost of the hardware and doesn't include the programming part. And these values are obtained from the company website of Aventics(Emerson).

Rodless cylinder: 2100 mm stroke: 3300 Euro

1800 mm stroke: 2000 Euro

2X1000 mm stroke: 3500 Euro

800 mm stroke: 1650 mm

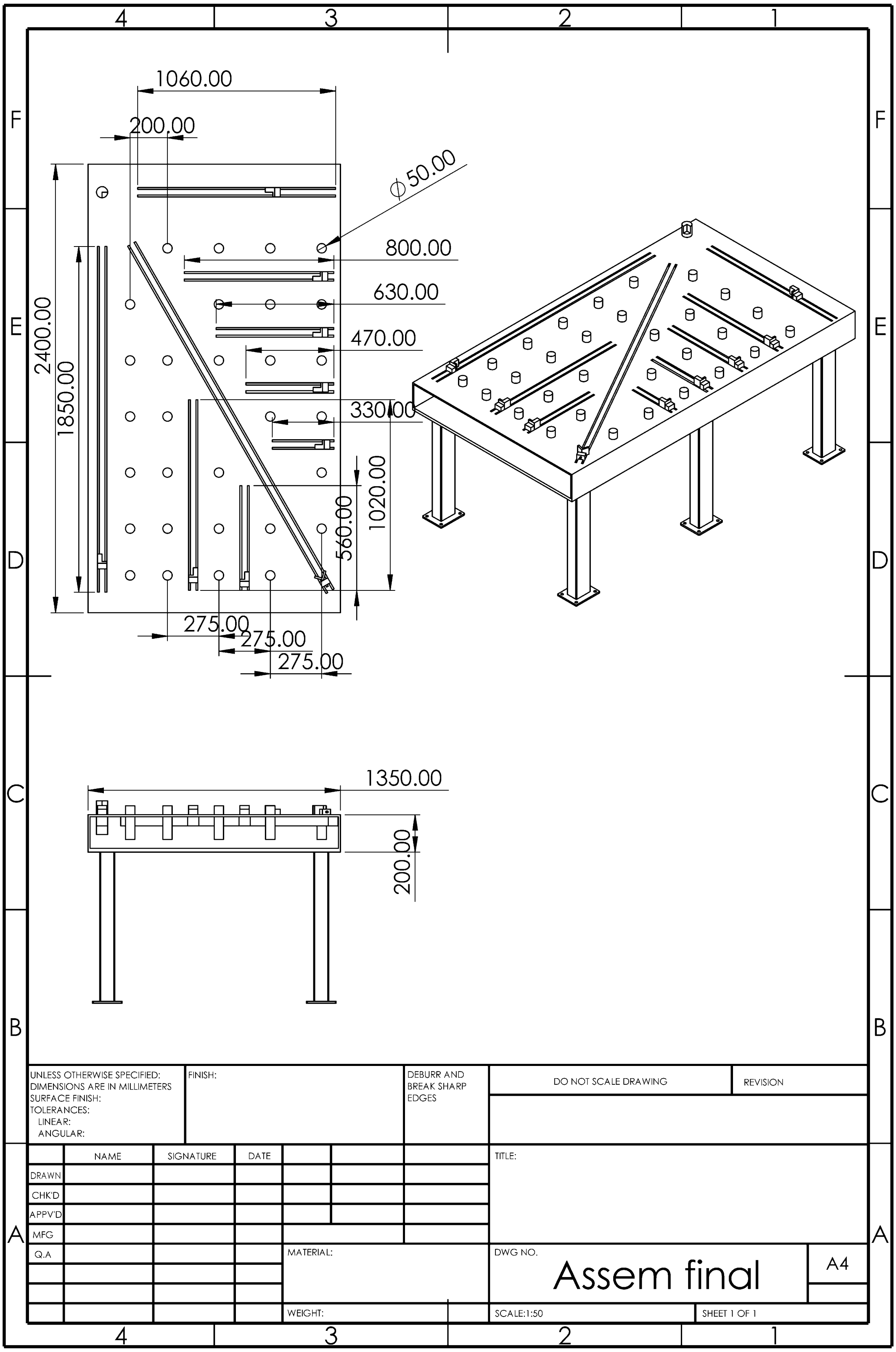
3x600 mm stroke: 4800 Euro

350 mm stroke: 1500 Euro

Profile cylinders: 30X 80 mm stroke: 3600 Euro

Therefore Total cost≈20500 Euro

4. Detailed design



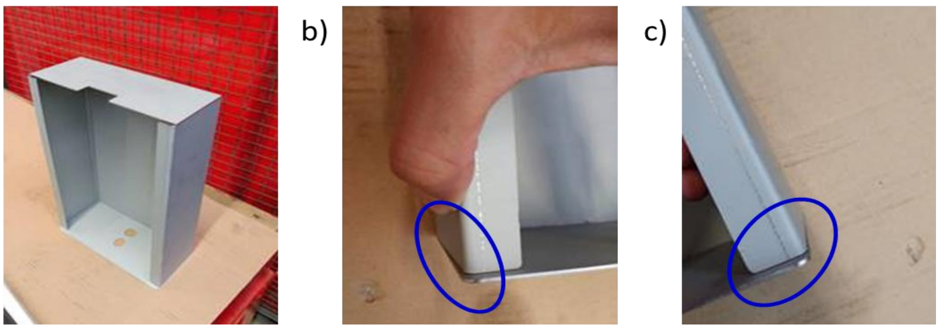
5. Conclusion and future work

This table has functionalities that are required to make this table flexible in terms of the dimensions and shapes of the product that can be held and welded on this. This is achieved by pre-programming every sequence and location of the part with respect to its movement by handling robot and welding robot. Whichever product comes the corresponding program needs to be selected and it will automatically move, place and weld the parts making it a time saving operation as compared to the current procedure.

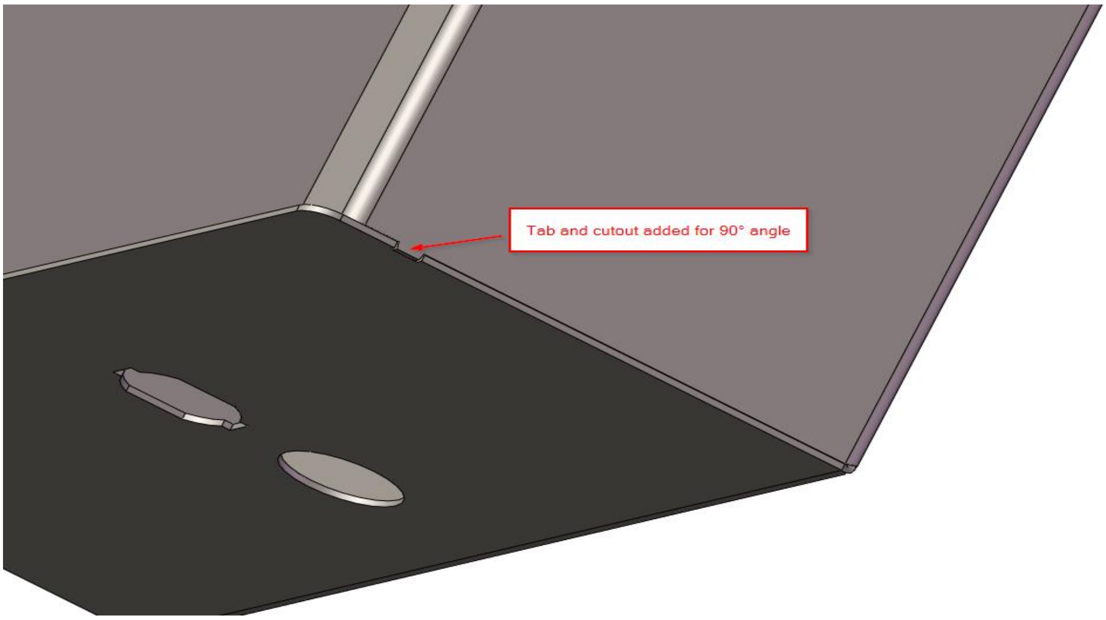
And also to test a product can be chosen and experimented to test the concept. An experiment can be done in a laboratory such with a handling robot to place the parts and the actuators from the company Festo should be used and programmed depending upon the dimensions for effective clamping. Then the handling, holding, welding and removal of the product can be tested to check for the feasibility of the concept and the accuracy of the welding.

And as for the future work is concerned the table concept with modules can be worked on in more detail when the technology needed to build that table becomes less expensive. And for the current chosen concept the major part of the work to be done is with respect to the re-engineering of the products to make it compatible with the new system. For example in one of the meetings with engineers of Pan oston some changes were discussed to make it easier for the parts to be handled by the handling robot and the following changes were made as shown below. Similarly the products need to be checked for their dimensioning freedom to make sure that they can be fitted exactly with the reference point and three rodless cylinders, if not the fourth corner shall be free and the handling robot itself shall hold the part while the welding robot does it work.

a)



Ensuring for 90 degree alignment



Changes made to ensure proper alignment

6. Reference

[1] ABB Robot studio

[2] Emerson – Aventics website

https://www.aventics.com/de/en/pneumatics-shop/rodless-cylinder-series-rtc-cg-pro.731933#avts-catalog-variant-overview

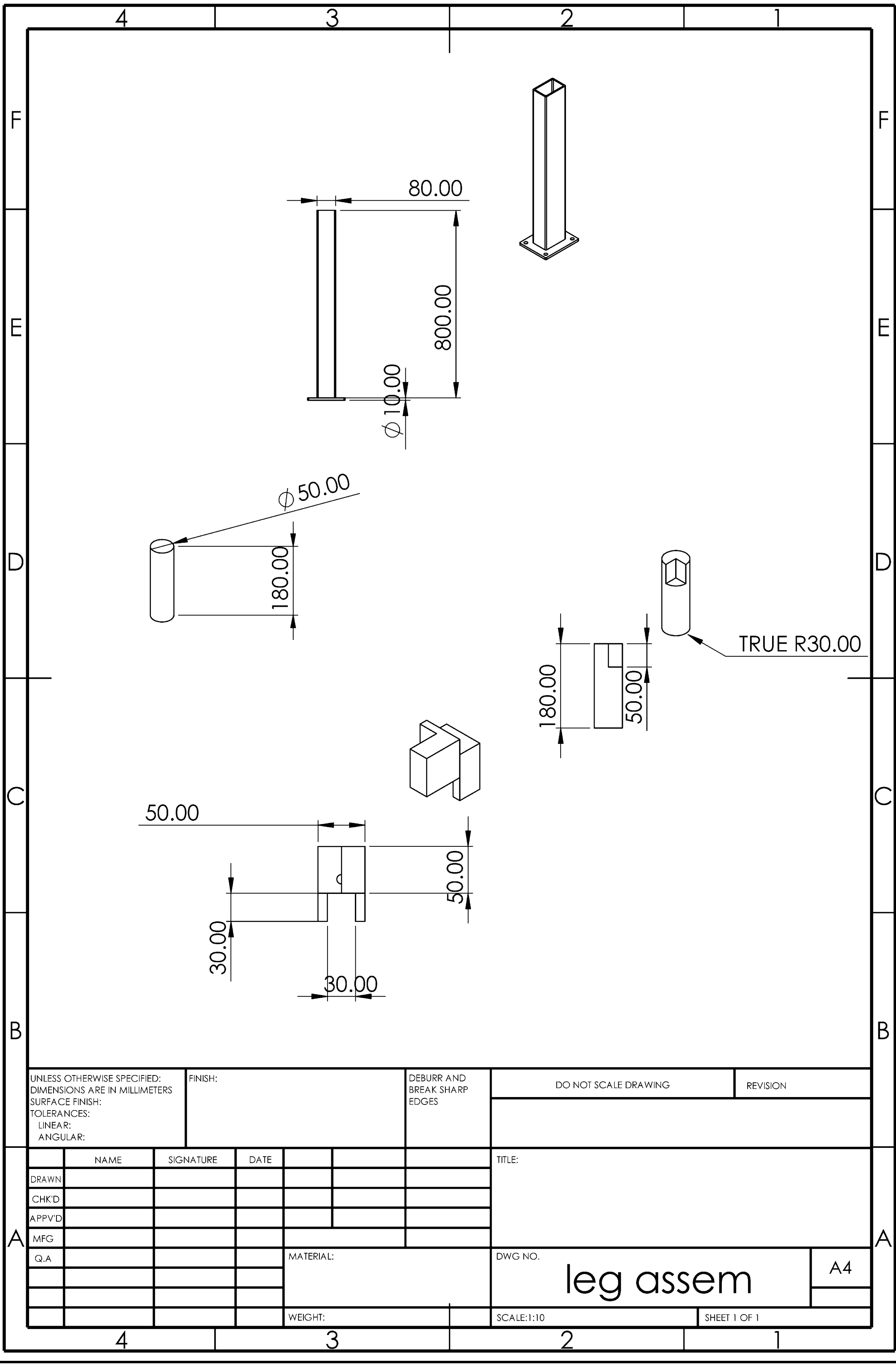
[3] Pan oston library

[4] Festo – Safety in Pneumatics website

https://www.festo.com/cat/nl_nl/products_011101

[5] Offline Programming of an ABB Robot Using Imported CAD Models in the RobotStudio Software Environment, December 2014.

7.Appendix



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