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Degree Programme in Design

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PRODUCT DEVELOPMENT CASE: FROM CONCEPT TO MANUFACTURE OF THREE COMPONENTS OF OILON'S BURNER.

Bachelor's Thesis 2014

ABSTRACT

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Product development case: From concept to manufacture of three components of Oilon's Burner.

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The position of the designer in a product development is often placed at the beginning of the process when the first ideas have to be created and then shaped to achieve a major concept. In fact the designer works closely to the development team, as this thesis shows, and must be able to follow the product design until the product is ready for the manufacture.

The company have commissioned this work while developing a new series of burners. In this project the design is an important element between the improvements of the products that Oilon has settled as objectives. The thesis is considering only a part of a major design project where the designer is involved. The designer in this work wanted to give the reader a picture of designing a product in a company environment, selecting three elements of the major project.

In the thesis, the process of developing three main concepts is described in detail; the use of external sources helped the designer to improve his methods to search ideas and elaborate them. The designer worked in a team during the entire product's development process where the team was the R&D group of the company.
This gave the possibility to analyse the results and improve them in a very short time.

The constant need to report about the developments achieved and the changes, while making the thesis, makes the designer constantly analyze the method used.
In the development phases, the timetable and different backgrounds of the R&D group make the design process difficult but in this thesis the process adopted gives satisfactory results.

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KEY CONCEPTS

W= Watt

Is the unit of electrical power, is the rate of the electricity used at any time when supply electrical energy to a device. Multiplying ampere, amount of electricity, to the amount of volts, the force of it, the result are the watts.

MW= Megawatt

The megawatt is equal to one million (10^6) watts. They are used to measure the output of a power plant.

CAD, computer aided design

CAD indicates the sector of the software technologies and in particular of computer graphics to support design activities (design) of both virtual and real objects. Computer Aided Design systems have as their objective the creation of models, especially 3D of an artefact.

Rapid prototyping

Rapid prototyping is a set of techniques aimed at achieving the so-called industrial prototype. These can be conceptual, functional, technical or pre-series, and in any case can perform different functions in company: can serve to evaluate costs, cycle times, response of the market and so on. Rapid prototyping is usually done by 3D printing by additive layer technique to create three dimensional objects. (Roebuck, 2011)

Concepting

It is the approximation of the picture of a new product, the shape, the technical aspects and the benefits for the final users. (Kettunen 2000, 56).

Concept defining

Concept definition is the design phase where different options are taken in consideration to define product's solutions. This is basically to create a mission statement to keep as objective during the development stage. (Kokkonen 2005,19)

Concept solving

In concept solving the product to design is already known. It is usually used in a product development project during the research of solutions or specifically technical or design details are sought.(Kokkonen 2005,19)

Product development

It is the process that takes a company to create new products or improve product's characteristics that offer new or additional benefits to the customer. Product development is divided into different stages that are start-up, sketching, developing and finishing (Jokinen, 2010)

Productization

In a conceptual stage is the process of refining sales, marketing and operation issue for a product or a service internal to an organization, to make it suitable as a commercial product (Parantainen 2007,11).

Sheet metal bending

Bending is a metal forming process in which a force is applied to a sheet of steel, bending it at the desire angle and shape. Bending is usually performed on a machine called press brake which can be operated manually or automatically. Standard or customize tooling are used to perform the production; the first one allows low initial costs and it is suitable for low volumes. The second can be used for specialized bending operations based on production quantity, metal material and degree of bending. (Kauppinen1991, 89)

Laser cutting

Laser cutting is used to cut materials based on computer-controlled parameters using a high-powered beam. When the laser beam is driven along the material, it vaporizes, burns or melts everything is in its paths creating a high quality surface that doesn't need to be finished which is the benefit of using laser cut. (Kauppinen 1991, 51)

RIM

Reaction injection moulding is a forming technology that provides a solid part made in polyurethane resin. It is economic and suitable for both small and high volume productions. Two liquids are injected into a steel framework where the mould is placed; the liquids react to form a lightweight and flexible form. After that the part can be removed and eventually machined. (Thompson 2010, 64)

CFD

Computational fluid dynamics is a technique where the numerical methods are used to solve and analyse fluids behaviour, i.e. liquid and gas behaviour. Computers are used to perform the necessary calculations used to simulate the interaction of liquids and

gases with defined boundaries surfaces. The accuracy and speed of simulation software is used in complex scenarios, which may include for example burner, boilers and its components.(Davidson, 2002)

Frequency converter

A frequency charger converter or drive control unit is used for controlling the motor speed by changing the supply frequency.It adapts the operation of the motor to demand, minimizing energy consumption and wear. (Tammotor Oy, 2009)

Boiler

Boilers systems as the most basic definition says are closed vessels in which water is heated for the production of steam and hot water. Boilers are usually warmed by the burning process of oil or gas. The fuel burns in the fire tube. After the fire tube, the exhausted gases continue towards the reversing chamber and run through another fire pipe placed on a higher level than the first one. In some boilers, the passage through the reversing chamber happens again before being exhausted through the chimney. The fire pipe outside surface is covered by water. Through the pipe's thickness the heat warms the water to vapor condition.

There are different types of boilers utilized for different purposes like running a production unit, sanitizing some area, sterilizing equipment, to warm up the surroundings. (Huhtinen 2004, 112)

IP

The IP or ingress protection rating is a system for classifying the degrees of protection provided by the enclosures of electrical equipment. It is regulated by a standard which is the IEC60529. The Standard has defined the IP as a two digit code.

The first digit describes the degrees of protection of a certain container against the ingress of solid object. The second digit designates toward the ingress of liquids. (SFS-EN 60529 + A1:2000)

1 INTRODUCTION

The need of comfort and increase demand of energy has been a driving force for the creation of several devices that made a significant difference in human's life so that people manage to live their life better and enjoy their daily activities properly. It is difficult to imagine everyday life with unsteady possibility use of electricity, industries and cities providing goods and services without having an efficient use of the energy available. With burners, the production of energy is possible by an increasing number of fuels. However, the desire of the company to supply to the customers very efficient burners with always better solutions, takes the challenge to another level where Oilon has driven lots of its resources. The product development department of the company has given the possibility to combine design methodology and the internal competence. The designer through this thesis shows what are the tools and results of this collaboration.

1.1 Oilon Oy

Oilon is a Finnish family-owned company that has operated in energy and environmental technology for more than fifty years. The company nowadays sells its products in over 35 countries all over the world; production plants are in Finland and China. The products are used in power plants, waste incineration, marine boilers, district heating plants, for heating or cooling large buildings and facilities, and for heating private houses (Oilon, 2014).

1.2 Burner

A gas burner or oil burner is a mechanical device that burns a gas or liquid fuel into a flame in a controlled manner. Depending on the process in which the device is in use, the source of the heat for the production of energy is different. Over the standard gases and oils, the company has developed burners which can use a wide variety of process gases, bio fuels and gases with low heating values. Oilon burners are sold and used over the world in different purposes, from the production of the electricity by natural gas to the waste incineration, from the production of heat in marine boiler to the most common use of heating private houses.

Oilon's produces burners for a quite vast variety of applications and the range of power which the burner can produce; it goes from 20 kW up to 80MW.

A Monoblock industrial burner, depending on the type of fuel fired is composed by the main body of the burner, the fan wheel with the electric motor, the air intake, the burner head, oil pump or gas valves and electric module. The body contains all this components and it is screwed on the boiler facade by a flange.

To sustain combustion process 3 elements are needed fuel, oxidizer and ignition source (Baukal, Jr. Charles E. 2003, 4). From the nozzle, in the burner head, the fuel is released and ignited in different methods. The flame and its combustion take place inside of the boiler. The energy produced is used differently, based on the type of process. The head of the burner, where the flame is ignited and fed by the fuel, is situated at the rear end of the burner which is inside the boiler when installed. The flame ignited, to maintain the process, has to be fed by air and the fan wheel spin by the electric motor gives the right amount of it to generate the necessary flame and burning conditions. The fan wheel is located in the centre of the burner together with the electric motor. The electric module controls the burner's working sequences; it is usually placed on the top of the burner so that for maintenance and installation the access is favoured. The journey of the air from the air intake, through the fan wheel and the burner head is very important to succeed in optional burning conditions. The design of the body of the burner follows the instructions given by the results of mathematical elaborations studied by CFD engineers of Oilon.

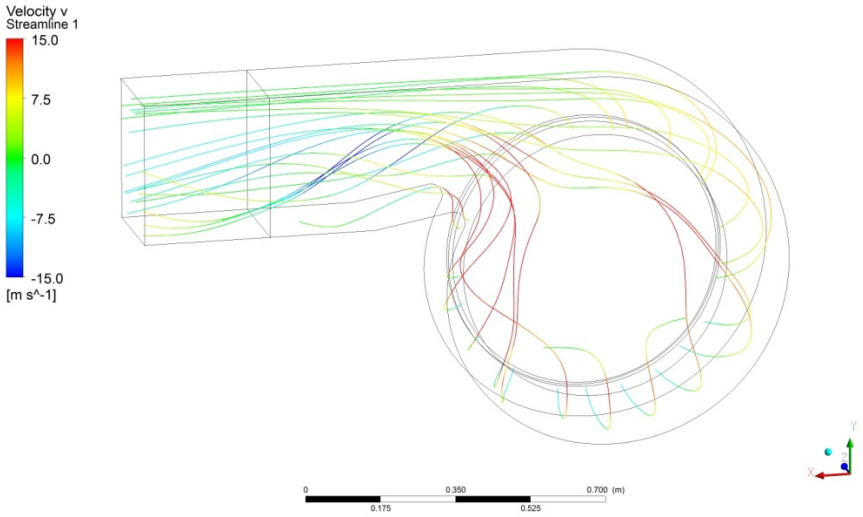

Figure 1. Example of CFD calculation. Oilon’s Archive. 2013

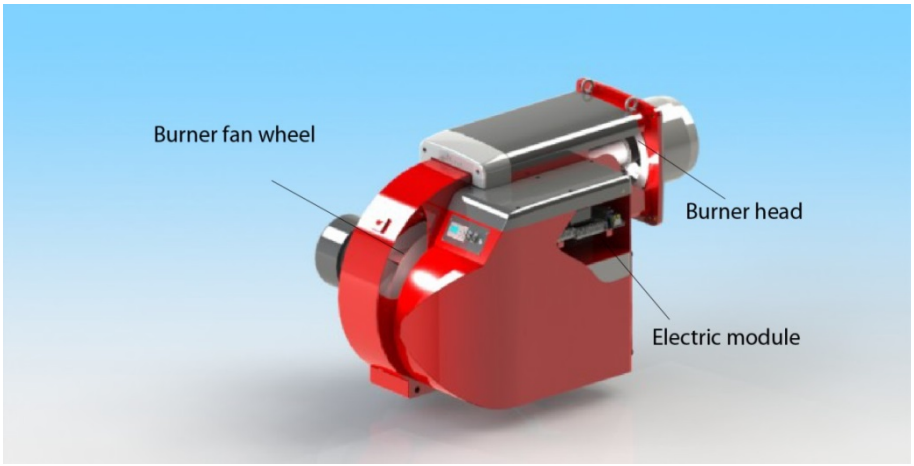

Figure 2. GKP350 Burner rendering. 6.9.2014

In the picture below, a cross section of a boiler to clearify the brief introduction given before. In the image a burner of 75MW is connected to a boiler where the flame burns and warms up the fluid contained in the piping system which is the grey skirt contained in the blu box and yellow insulation (figure 3). The fluid then will be used subsequently to produce energy, wheather is electricity or heating.

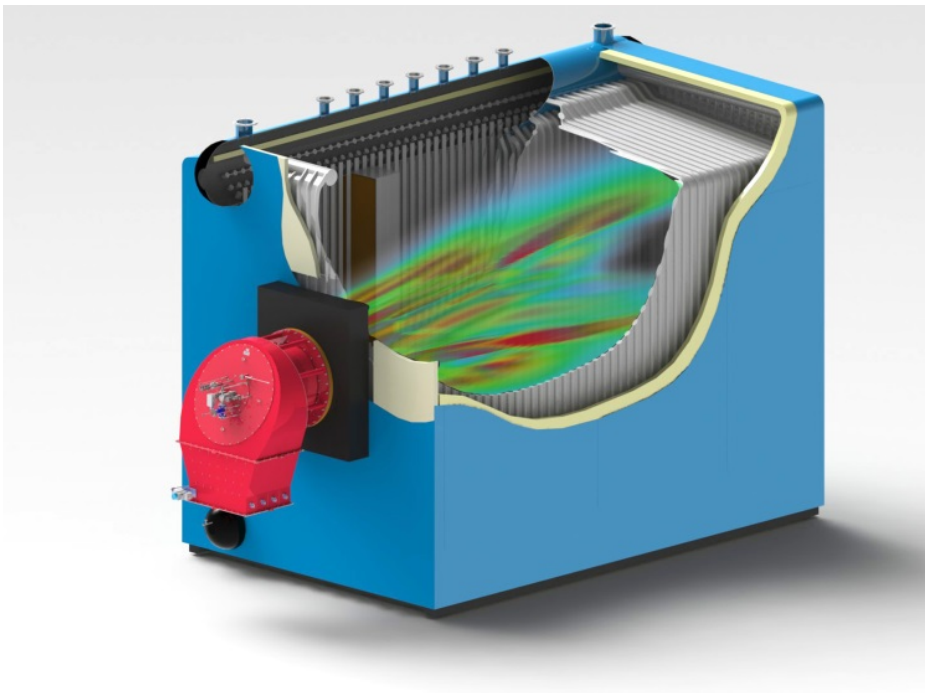

Figure 3. Burner installed in a boiler. 16.7.2014

The lifespan of a burner is more than twenty years, once installed on the boiler, burner doesn't not have to be removed anymore until it will be replaced. Anyhow a frequent maintenance that has to be done at least once a year helps to maintain emissions and consumes on desired level. The maintenance is performed mostly on the burner head and its components likewise fuel filters, pumps, screws and joints. Only professional personnel can work on industrial burners, a normative explains how general maintenance has to be done, giving rules to perform safely and avoid any damage on the equipment. The most demanding tasks for the product development team are improving energy efficiency, decreasing emission, and developing new solutions using renewable energy sources.

1.3 Design objectives of the project

The main project has the objective to implement burner models design and technology. The R&D team as a development process target had been imposed the following objectives. First of the six is the recognisability of the products and of the brand. Products that are destined to a worldwide market have to provide a value through their aspect and design. Characteristic like the look, feel, touch, sound and material used produce some core values that have to be respected when products are developed. Attributes of the product as reliability and durability or elements like colour, material and finishing create a signature that produce consistency in the brand. This increases the loyalty from the customer (Mumgaard, 2012).
Following, the company is seeking to improve the manufacturability of the burner. The burners have to be developed maintaining the modularity principle working in all the parts of the burner, from the fan wheel to the electric panel, from the burner head to the oil pump. This characteristic is maintained from the first stage of design, the burner and its components are developed in single parts which are consequently assembled together to form modules. The necessity to eliminate costs is the other factor to improve manufacturability.

Considering the dimensions of a burner, it is a necessity and requirement to provide a simple installation avoiding wiring and piping connection located in difficult places maintaining accessibility to the burner's internal parts for easy maintenance. This characteristics are obviously an enormous plus when offering to a customer a burner which is already well known for its quality and performances.

Oilon burners as explained at the beginning of the thesis are suitable for a large number of processes and power plants, in which are involved different types of fuel and different boiler or processes. This good adaptation to different body systems and processes has to be maintained in this new series of burners. The last requirements and appreciate property is the low level of noise produced by the burner. Oilon has set that the limit has to be maintained below the 80 dBA without a separate silencer.

The new range has to provide consistency within these objectives with modern design. The models have to represent the quality of the materials avoiding any compromise with economical solutions and improved combustion technology.

2 BOUNDERIES OF THE PROJECT

The project consisted of a design, from concept development to manufacture of the chosen concept. The work is approached particularly from the point of view of the productization where various elements of the company not directly linked to the R&D team have also participated. In the process the first step is conceptualization which will be presented shortly, after that, I concentrate on the realization of the concept. This thesis focuses on the design of 3 particular components of burner GKP 350 MODEL, the design and manufacture. The thesis describes how the concept level plan develops to the production of the products. The designed parts are the frequency converter cover design, lifting lug design and location and burner's head spyhole design and location. The project started in April 2014 and finished in September 2014.

2.1 Research question and the context

The main project started before the design project. It focused on 3 industrial burners of 3 MW, 4 MW and 5 MW with variations of combustible used as gas, oil and gas and oil together.

Facing new markets and with it new needs, Oilon aims to develop a burner range which would be technically ahead compared to the competitors' products. The products have to represent a company that is in full expansion and needs to present its burners with clear visibility. A major research has been made to achieve an upgrade for what is the manufacturability of the burners, the installation, accessibility for maintenance and the adaptation to different production facilities. Considering the expansion that the company had during the past 20 years, production dislocated in 2 different countries and products sales all around the world, Oilon wants to make sure that its staff and its customers can get a new burner range that is a clear improvement from an already successful range of products. These objectives were shared with me at the beginning of the design process, in the spring 2014, together with the fact that the burner had to be easily manageable for installers and maintainers. It has to be considered that the burner weight over a three hundred kilograms so it is movable only with the support of a machinery.

The research question forms as how a concept develops in a design development to a product ready for the production? During the different project phases, the exchange of

ideas and suggestions between the members of the team emphasized the most fruitful concepts for design and again for the product. The framework shows the main factors related to the project. These are special treaties with large areas, which are closely linked to each other during the productization. The framework (figure 4) is carried out by a virtuous circle, where the centre is to examine the issue, and around the factors that influence it.

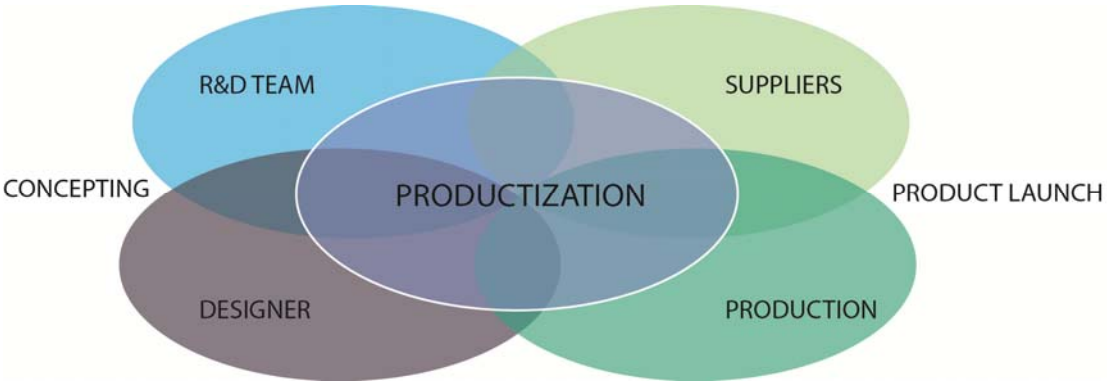

Figure 4. Frame of reference (Anttila 1996, 97) (The picture has been made by Michele Danelon to translate the text from Finnish to English)

The framework focuses on creating products and around it there are the parties involved. Product development is done in close collaboration with the designers, team development, production, as well as subcontractors. In the initial phase of the project the designer or team of designers and R&D team evaluate the first results. For the transition from design to production, product development teams, production and subcontractors must work together to solve the problems that might risk to be faced in the future. Thanks to close cooperation, rationalization has been maintained rapid and effective. As the project progressed closer to the launch, the responsibility was transferred to the product development team and product design to subcontractors as well as production.

Product development is industrial design, manufacturing, marketing and technical development that co-operate in an industrial environment, and its aim is a financially successful product (Kettunen 2000, 46).

Through the help of product development, an old product can make a new sales success. In product development, the biggest challenge is that the used investment can pay for itself after a few years. (Sounio 2010, 137).

2.2 Research methodology

The connection between me and the company has been facilitated from the fact that I am employed by the company and I have been a part of R&D team for several months. I was in close contact with all the partners, including the assembling line personnel which are important from the manufacturing point of view. This project was very productive in the sense of the research methodology that, while developing, has taken shape has active analysis. From the design point of view, active analysis offers possibilities to keep continuous control in all the phases from the design and manufacturing point of view (Anttila 1998,320). The data acquisition activity has been done through the observation and interview, the designer actively interacted with the different parts (Tuomi & Sarajärvi 2002,84).

2.3 Project schedule

The main project started in the late summer 2012 when the needs of the Oilon's customers and production have been analysed and the targets of the new burner generation were spotted. My participation in the project started only a year later and continued until late summer 2014 when the first prototype of a smaller version of the GKP450, the GKP350 has been sent to the production.

The first project, related with the burner, came onto my desk only at the beginning of April 2014 when the first burner's prototype had to be assembled for a fair in China. A version of the first GKP450 was ready to be delivered to Oilon's production facilities in China and get ready for the exhibition but the frequency converter cover was completely missing. The first request in this project was the frequency converter cover design. After the intense week of work to find the right solution for the requested cover, I started to work on the development of a more extensive work. The GKP450 of 5.5MW needed to be scaled into a smaller version of 4.4MW, the GKP350, that the components described in this thesis are part of.

The design process can be divided into two main parts. The first one gives the tools to develop product's properties, first ideas and schedule of the project. Working on the timetable (Appendice 1) has given an overview of the work to be done. The time spent trying to draft a day-by-day plan has not just given a suitable timetable to the project manager, but it has given the tool to improve the method used to reach the final concept. (Goodwin 2009, 386).

After this, the designer makes several suggestions for the design of the product and the characteristics of the design and visualization, either by computer or by hand. When all the components have reached the desired entity the designer can move to the implementation phase. In the implementation phase, the designer works in collaboration with the production, and provides the necessary and technical drawings, which are connected, for example, to the appearance of the product and the instructions for use.

2.4 Main project design achievements

The R&D team together with an outsider designer office designed the burner series, that the study was aiming at, and achieved the objectives of the company. Basically, comparing with the previous model, the maintenance access point is totally different. Before all the body of the burner was rotating on hinge which is positioned on the right or left depending on the needs (figure 5). Now only a metal cover on top of the machine is needed to be removed. This improvement allows easier accessibility to the burner head and major visibility of the internal components of the burner. Because the burner doesn’t need to be rotated to the side (figure 6), less handling room is needed that improves suitability to more boilers. The burner, opening on the side and because of the electrical motor can have difficulties in some cases where the boiler construction doesn’t allow the whole aperture of the burner on the hinge. With the new burner’s design the same body can be used for all the variants of fuel used.

Figure 5. Aperture of the hinge. 3-5mw/2. Oilon’s Archive. 2013

Figure 6. Analysis of the various installation sites and assembly of elements. Oilon’s archive. 2014

The new series (figure 7) presented a quite vast areas protected by plastic covers which made the design very unique and clean but some difficulties were spotted during further developments. Some decision, based on material costs, quality and acoustic performances were made to avoid the use of plastic covers.

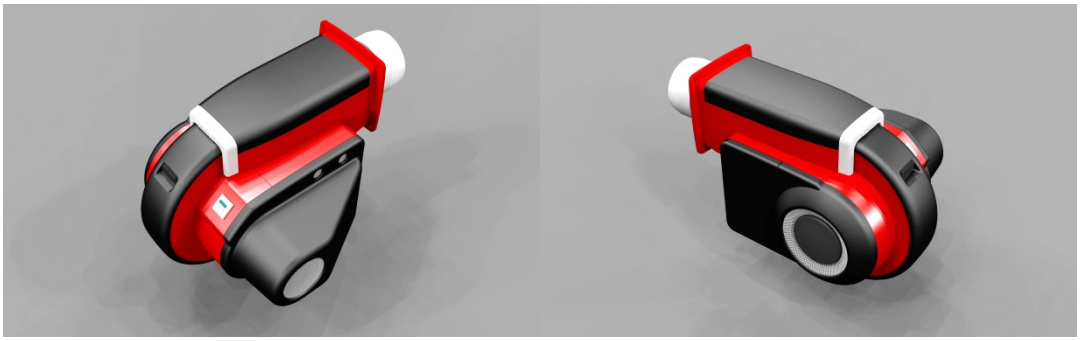

Figure 7. First prototype of 3-5Mw new serie. Oilon’s archive. 2013

This allowed me joining the project. Removing the cover needed a major structural modification which included the three parts that the thesis is explaining about.

3 CONCEPTING

3.1 The starting point of conceptualization

The initial point of the developing stage is the question, how to develop a conceptual design going through a product development to have at the end a product ready for a serial production? During the study, ideas born from concepts concretize into plans and finally into products. During the project we go through the development process in different phases.

The designer itself can design simple technical products from the beginning to the end but a new product design is a group work (figure 8) where the designer can co-operate with the R&D team in different areas. In this group, the designer concentrates on the product's shape and usability.

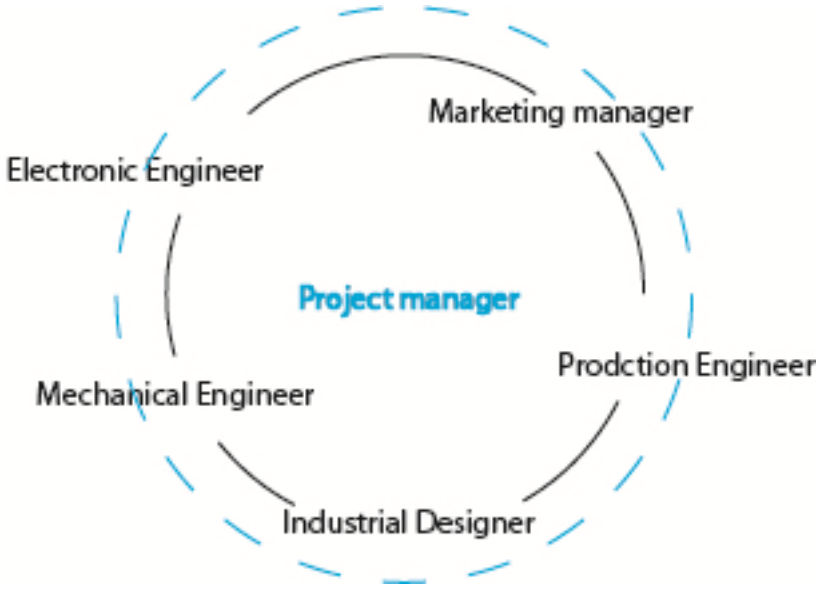

Figure 8. Framework (Kettunen, 2000, 12) (The picture has been made by Michele Danelon to translate the text from Finnish to English.)

The meaning of conceptualization is to create new and innovative products for the market. Conceptualization can be done without the direct objective of the production or the pressure of production requirements. Conceptualism is not intended to directly solve the design problem but helps the design to go to the right direction. (Keinonen 2003,28-30).

The development process in use in the specific case is the one that has been quite successfully used by me in a previous project in the same company (figure 9). I, quite new in the field, had to have engineer supervision in the development stage, because of the specifics of the project and non-familiar technical issues. This avoids loss of time in the development sessions with the R&D team.

In the specific case, considering that one of the three objectives discussed in this thesis, is to have a positive impact in a fair where the newly designed product is presented, not only the engineer acted a supervisor but, sales personnel and management team members participated in supervision too.

The supervision happened by simply personal visits or more effectively with email exchange.

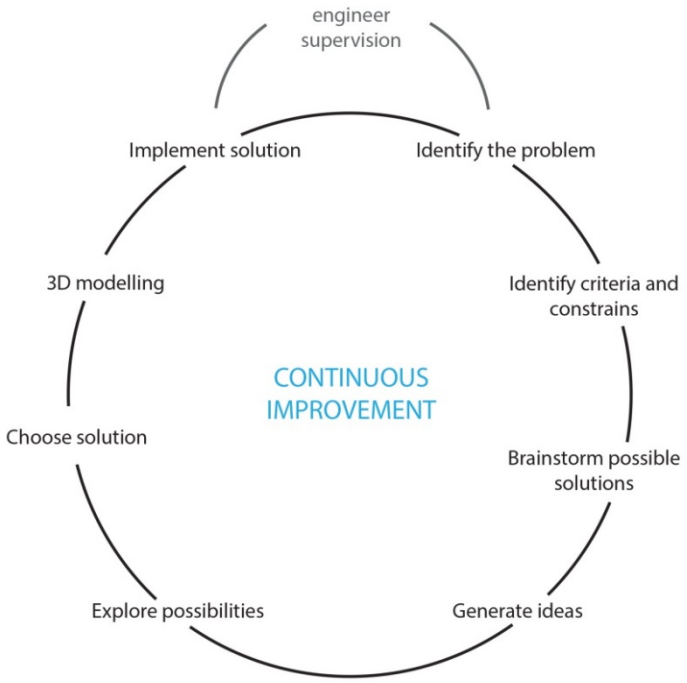

Figure 9. Development process (Michele Danelon 2013,14).

3.2 Concept maps

The maps are tools to define and make visible the knowledge in a certain domain, project or product. These tools are useful to represent it and organize it, giving an issue more importance or make it visible. Concepts, thoughts or facts are “labelled” with words that are linked together creating a relationship between them. In concept maps it is important to have a question and reference to it during the development of the map. An area, like in our case the burner, has to be selected and after those key concepts have to be identified. Once listed these key concepts in an appropriate rank order it is possible to start mapping (Novak, 2008). The use of the concept maps in this project helped me to visualise and keep organised what were the major features of the products. Practically, maintaining the name of the product in the middle, I wrote all around key words that I have collected during briefing, team meetings and feedback. (Appendices 2,3,4). In this way the panorama of the needs and target is always visible.

3.3 Concept definition

During the process, in a team, all the concepts have been analysed in detail to achieve another level through comments and suggestions. The concept selected between the amounts of ideas proposed by the designer can be considered defining concept. The object of this is to create the picture in detail of the becoming product (Keinonen 2003,41).

3.4 Frequency converter cover.

The device is placed on the top of the electrical motor and is in dimension as big as the motor. The converter supplied was presented on a light grey plastic cover (figure 10) that wouldn’t fit the design achieved of the burner. The request was clear, propose a new cover for the device that would have meet the objectives proposed in the main project.

Figure 10. Frequency converter cover. Emotron brochure. 2009

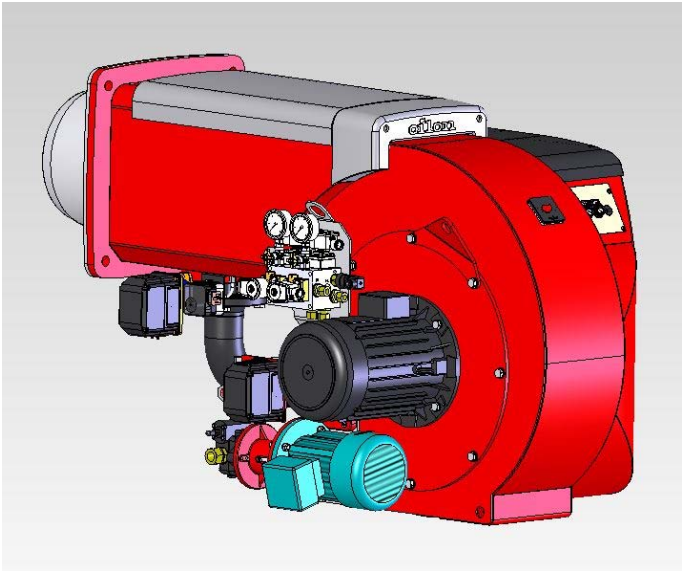

Figure 11. Electric motor position, rendering. 10.9.2014

The dimension some details of the cover were imposed by the frequency converter container, the location of the electrical supply and place for screws. The base of the box (figure 12) is aluminium casted in which six fastening threads were made. Inside of the box all the electronic components are placed. It is connected with the motor by an aperture in the bottom.

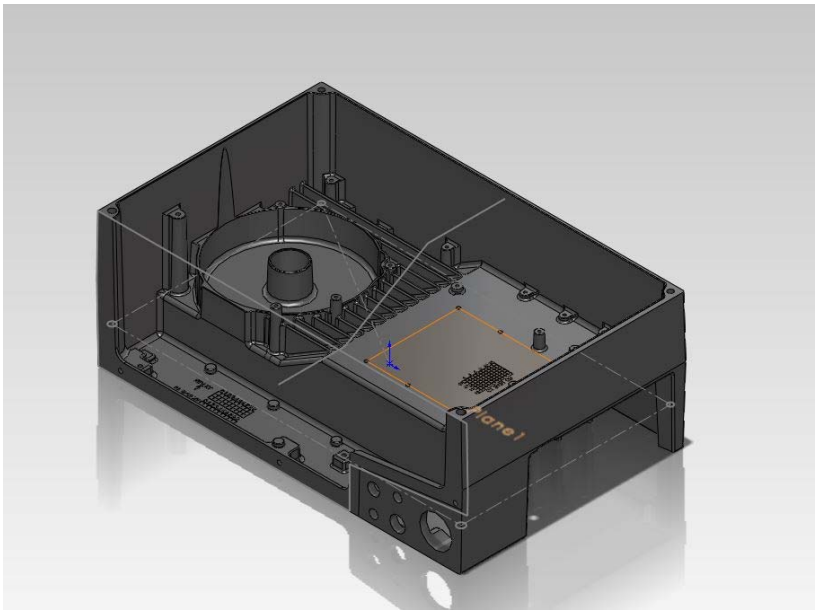

Figure 12. Frequency converter container rendering. 5.5.2014

The cover of the frequency converter is provided by a control panel to adjust the values and regulate the required values to adjust motor pauses and relative programmed starts. Furthermore, the front part of the cover is designed with an aperture to allow wiring connection. Five cable glandes are screwed on the base of the frequency converter through which the cable supplies energy. Considering the very limited time and the fact that the burner was still in the prototype phase, the only realization method possible for the cover at that time was 3D printing. Anyway the solutions considered were all thought to be produced by RIM method, which is the most convenient production method for plastic parts used in Oilon's burner. The company's logo needed to be quite in evidence since the prototype would have been exposed in a sector fair in China but anyway it wouldn't have been removed for the series production. A modern and clean line was desired and the shiny black was chosen as colour.

3.5 Lifting lug

A lifting lug is a device which is welded, screwed or can be part of the main component body where to connect and tight the lifting device connector for handling purposes. The other purpose of lifting lugs is, most probably not only for burners, the possibility to tie the machine on the transport case to avoid falling during the freight. Burners of this capacity have to be placed on the front of the boiler by the use of cranes or

suitable lifting systems. Once lifted and placed in front of the boiler, the installer screws the machine on the intended place which is provided with threaded holes.

Lifting lugs can be placed on the top of the product as well as in the bottom but what has to be taken into consideration is that the burner, in our case, has to maintain the balance or vertical position. At least three lifting points have to be placed considering to create a triangle where the vertex is in the middle. In the main design two of the lifting lugs were already placed just before the flange and two underneath the top cover (figure 13) but they become available only when the protection was removed.

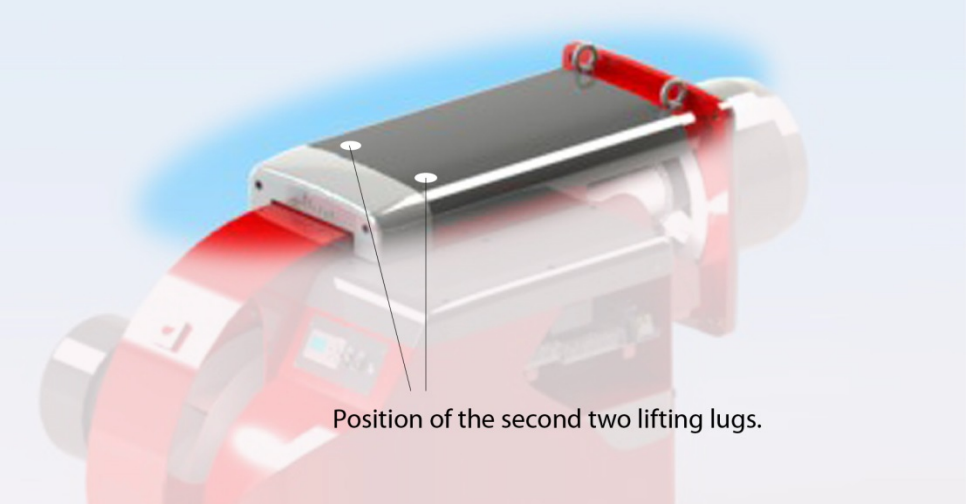

Figure 13. Lifting lugs on the burner rendering. 10.9.2014

The burner is thought to be delivered with all the modules assembled and only the external piping and electrical wiring has to be done by the customer. Because of this the cover doesn't have to be removed at all and so the second lifting lugs become usable only in production phase for welding, painting, moving for stoking but not for delivery issues and installation.
Usually in the premises where burners are moved, cranes or forklifts are provided by hooks with a safety lock. Hooks present standard measures which in our case made me consider one or more holes of about fifty millimetres of diameter.

Incorporating the elements in the body of the burner or giving a hidden presence so that it will not be noticeable simply as a lifting lug is the target of the customer. The importance of maintaining the clean line achieved in the burner design is essential.

3.6 Burner's head spyhole design and positioning.

The spyhole is an aperture that allows controlling the burning conditions. For maintainers and installer it is fundamental to have it during commissioning and maintenance phases. The location is important to grant a complete visualization of the flame and burner head, view doesn't have to be obstructed by other burner's components.

In the prototype designed in the main project, the spyhole was contemplated to be part of the plastic cover of the fan wheel enclosure. In that situation, it would have been part of the outline, not being seen from the prospective side. The location of the spyhole was optimal considering that was behind the components that usually have to be monitored. Anyway, plastic covers suggested with the first prototype by the design office had been avoid since were components that compromise the effective cost of the burner (figure 14).

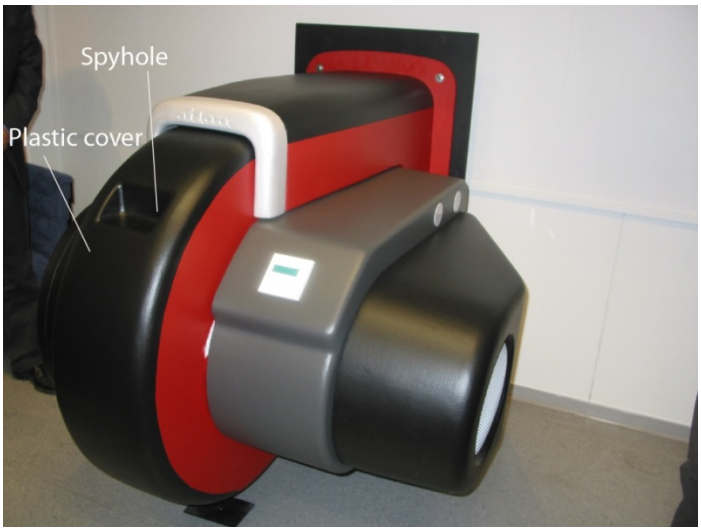

Figure 14. First GKP450 prototype. Oilon Archive. 2013

Because the burner's clean line was to be kept as untouched as possible, possible solutions of moving the spyhole position to the side were considered.

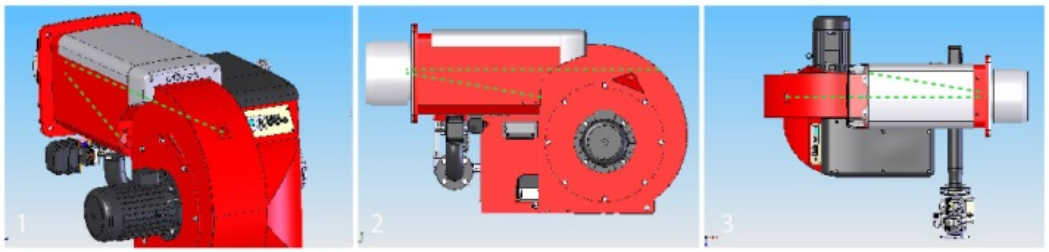

Figure 15. Spyhole position and sight direction rendering. 20.9.2014

The spyhole is usually covered by a glass or plastic because a certain pressure is present inside the burner.

The protection especially if is made of plastic alters the image. Shadows and reflections are usually to happen not giving a real response to the needs of the maintainer, this happens when the inclination of this protection is more than twenty degrees in relation to the vertical plane.

3.7 Result of concepts

The conceptualization phase during the frequency converter cover design felt like a small detail because working with a very tight schedule, it was concentrated in a smaller lap of time but it has given the results needed. Understanding the needs and brainstorming with the engineer team allowed me to define concepts. Answering the customer's needs requires that the needs of the customers and wishes are known (Vuokko 1997,81). The use of concept maps allowed me to achieve a clearer idea of the object to design and at the same time it speeds up the process. Working with an unusually short schedule imposed by the company with no chances to postpone it, imposes to find tools suitable for the situation. The explanation of the concept developing stage it is found in the following subchapters. After brainstorming phase and concept maps that become sufficiently wide to give enough material to move to the conception stage, the designer starts developing the most promising ideas, from where most probably will arise new ideas (Kettunen 2000,75).

4 DESIGN PROCESS

4.1 Frequency converter cover concepts

This first project demanded to re-schedule the projects where I was involved in and concentrate all the resources to conceptualize, design, request feedbacks, make the prototype and install the product, in about a week. Once I received from the supplier the file of the 3D container I started to work on the creation of the first ideas.

The concept map dedicated to the converter's cover has demonstrated that in the analysis to identify the criteria and constrains to create the first concepts, was important to take into consideration the position of the device. There were two main aspects. The first was that the burner would be exposed on a fair, so the people would look at it mainly from the top. This made me discover what burner's outlines were surrounding the cover. The second aspect from the maintainer's point of view was that a device like a frequency converter doesn't need maintenance often and that is why I prioritize the visual appearance instead. The first aspect, most probably considering the pressure of the situation, has driven me towards the realization of the first sketches. From the side view, the burner presents only rounded lines**;** the electric motor and the air fan wheel's enclosure are both rounded and converging towards the burner head. This round and soft shapes are visible as well from a prospective point of view. From the front, back and top view, the lines are straight or just softened with big radius.

4.1.1 Square shape

This version has taken shape maintaining most of the characteristics similar to the original cover proposed by the supplier. One singular cover to close the upper side and front aperture was fastened on the same point used by the original cover with six screws. Consideration for the type of gasket has been done but because the container is provided by a channel for the gasket, I considered the use of it to maintain the protection level IP55. The gasket would have been placed on the channel and secured the sealing by adhering to the cover. Somehow this doesn't affect the design neither the typology of production.

The top of the cover would have given space for the digital controller and the logo of the company. The side of the frequency converter is kept quite short to allow the air

flow going through the aluminium container and cool down the components of the converter.

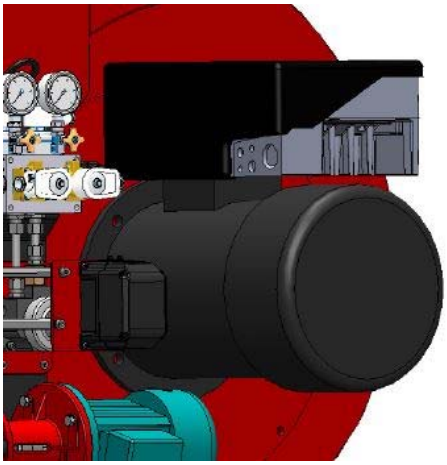

Figure 16. Frequency converter container rendering – Square option. 25.9.2014

4.1.2 Rounded Shape

In this case, the cover's development started following the suggestions of the concept map that focuses on the recognisability, shape and position. This emerged from the feedback that I perceived during the session with the other members of the R&D involved.

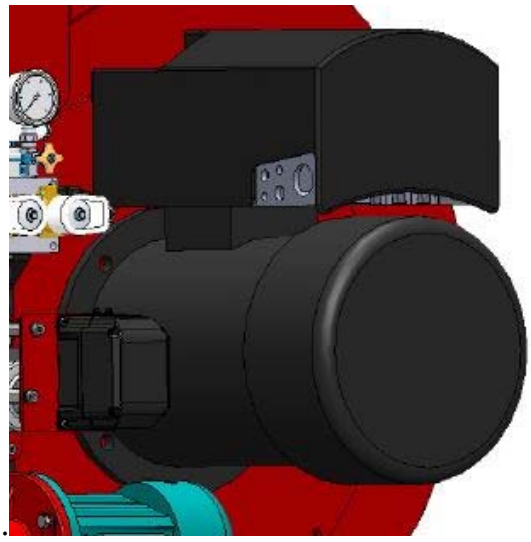

Figure 17. Frequency converter container rendering – Round option. 25.9.2014

The cover presented has been ideated following the round curves that are composing the side of the burner. Being installed on top of the motor and having on the background the container of the air fan wheel, I opted for a concentric side cut. The shape selected allows the position of the frequency converter from zero degree to ninety with rotation of thirty degrees. This is possible because electric motor bolting system has bolts welded on the side of the air fan wheel in this way. This option has covered completely the box of the frequency converter encouraging the customer in the fair to believe that the company has developed own converter. The top curvature grants enough space for the company's logo and the controller but I preferred to dedicate to it its own area. This is also not to create visual obstacles when reading the Oilon's brand name and not to leave the top too simple and plane. A flattened corner is designed and in the opposite side can be placed the company name. Like in the previous concept, the front panel is provided with an aperture for the connection panel. Six screws for each side maintain the cover in place and sealed.

4.1.3 Wave shape

In consequence of the previous covers suggested, the third concept chosen provides quite a lot from the round shaped cover but improving the top part with a wavy shape. This would have given a more modern look to the whole component allowing anyway to find a place for the logo and control panel. In this case, the positioning possibilities of the frequency converter on top of the motor would have been as many as in the curve model. The fastening points in this case are four screws and they are located on the top of the cover.

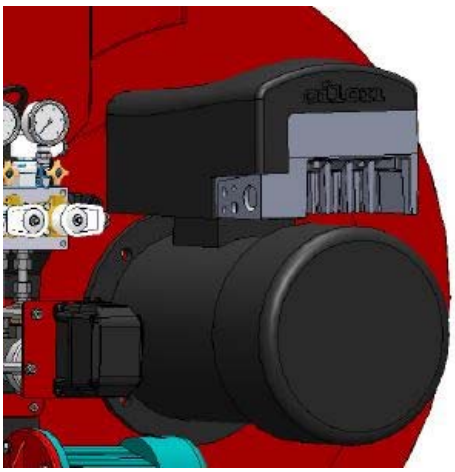

Figure 18. Frequency converter container rendering – Wavy option. 25.9.2014

The more complicated shape doesn’t give any space to the logo to be adapted on the top of the cover but is considered on the side, which is the front when installed on the motor. The cover like the first accepted concept presents a generous aperture below the logo not to interrupt the air cooling flow. Command panel is thought to be placed on the inside part where the electrical wiring is.

4.1.4 Chosen concept - Cover

A further analysis with the team members has removed the most improbable solution and left with the accepted ones. Between the three solutions that have reached the final stage the Rounded shape concept has been selected as favourite from the technical and esthetical point of view. The cover mostly, compared with the others, is designed so that it covers the most of the aluminium box of the electronic devices. Even so, it allows the air flow to cool down the components. Anyway in a second time, blowers where installed on the side of the aluminium container. The considerations made for the sealing protection have not been anymore contemplated because in this situation the cover would have been displayed in the fair where the IP standard is not required. For the production, it will be reconsidered. The cover grants generous space for the wiring and for the command digital panel. Certainly, considering that the prototype would have been exposed in a sector fair in China where Oilon’s brand is very strong, the company’s name appears visually significant and distinguishing as the brand has to be.

The perspective issue thought at the beginning of the conception phase is resolved. Weather the burner side with electric motor and frequency converter would have been watched from the side or from the top is resolved. The concentric side cut together with the colour that is the same of the motor, has camouflaged the big container. The company logo has done the rest diverting the meaning from the real purpose.

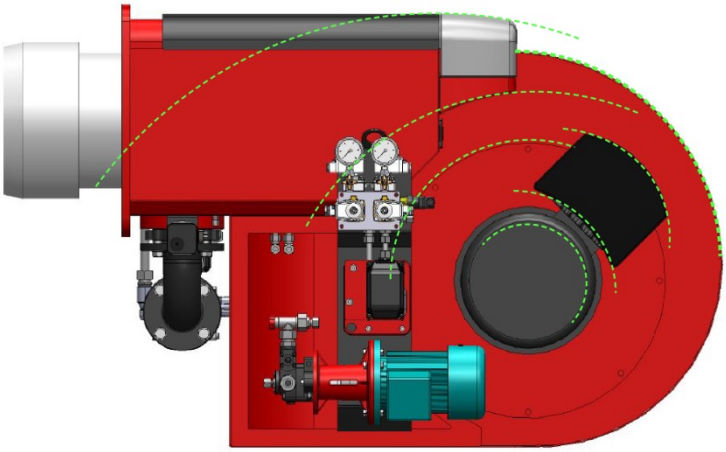

Figure 19. Round option rendering – Side view. 25.9.2014

4.2 Lifting lug concepts

In the concepting stage of the development of the lifting lug, I had a very prolific production of ideas between shape and location. What are presented in the following chapters are the versions that have already been evaluated by the R&D team members after a first ideating and sketching stage. For convenience, I sub-divided the concepts in centrally positioned, sided and low positioned.

.

4.2.1 The centrally positioned lug

The series of lugs are all positioned in the central part of the burner closed to the command panel. This lifting lug have been developed having a basic thought that three would be the connection point, two close to the flange and one on the side of the motor. The burner has a considerable weight due to its components and the fact that the body is completely made of steel sheets of thickness between three to eight millimetres. Depends on shape and bending, the lugs designed have thickness of five or eight millimetres and all of them welded on the top sleeve of the air bumper or on the frame of the command panel.

The major issue with a solution of this type was to place in the most visible place a simple bracket that was usable only during a few moments of the burner's lifespan, the production time, delivery, installation and maintenance.

These reasons encouraged me to ideate something rather minimal but with the risk not to consider the resistance to the lifting strength in an adequate way. All this considerations were born analysing the concept map made.

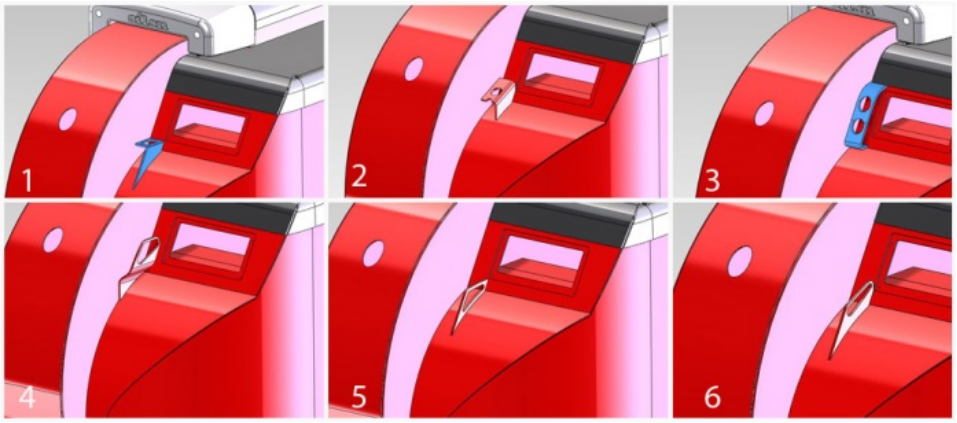

Figure 20. Lifting lug renderings – The centrally positioned. 1.10.2014

Some of the solutions were appreciated from the esthetical point of view but for cost rationalization were not the most suitable ones. An integrated version where there is no need to cut with laser a separate element and weld was preferred.

4.2.2 Sided positioned

Brainstorming all the first possibilities and collecting the feedback of the engineers I concentrated on moving the lug's position towards the external edge of the burner. Most of the solutions were providing an extension of different shape and dimension to the curve mantle on the air bumper. This solution, whatever would have been the shape of the bracket, is integrated on the structure of the burner directly from the sheet manufacture, cut and mangled at the same time and welded with a long seam all along the edge.

Furthermore taking in consideration that the electric motor is the heaviest component of the burner, I have provided the burner with a lifting lug on the left hand side or motor side.

Based on the experience of the centrally positioned lugs, I figured out quite soon that not many places were suitable for installing a lug. Bottom edges were somehow hampered by the motor and oil pump and top or external edges would have cut and collapsed the clean smooth edge of the burner.

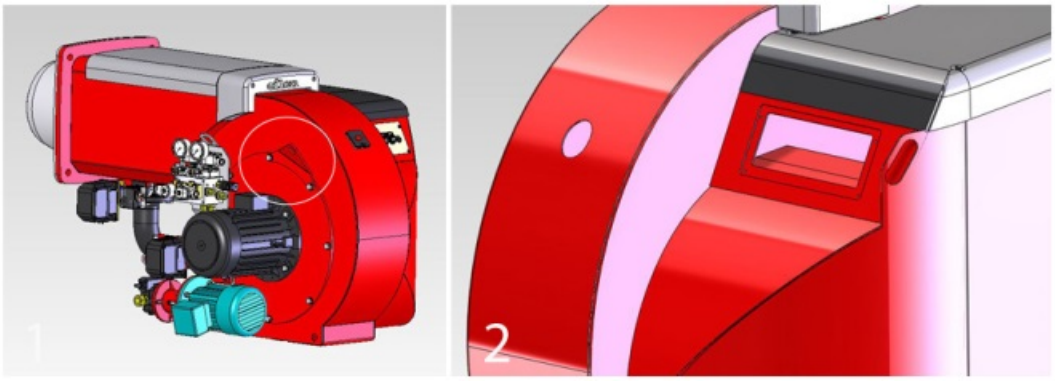

Figure 21. Lifting lug renderings – The side positioned. 1.10.2014

The solution presented in the Figure 21 window 1 has the advantage to be installed on the motor flange and secured in place by screws M12 which strength is much higher that the weight of the burner. The advantage of this solution is that no welding is needed but even more that the element can be removed and installed in another position in case that the stability is not satisfactory.

4.2.3 Low positioned

All the three solutions have been developed together, in the conception phase. I analysed position, shape, function, stability, manufacturability as the concept map suggested for the three positions. In this chapter, some of the lug's options in Figure 22, are designed to be welded and some are part of the structure to avoid cost and problems explained previously. Having the lifting tightening point on the lower part of the device, in my considerations, would assure major stability considering that lugs are placed on the edges of the major length of the burner.

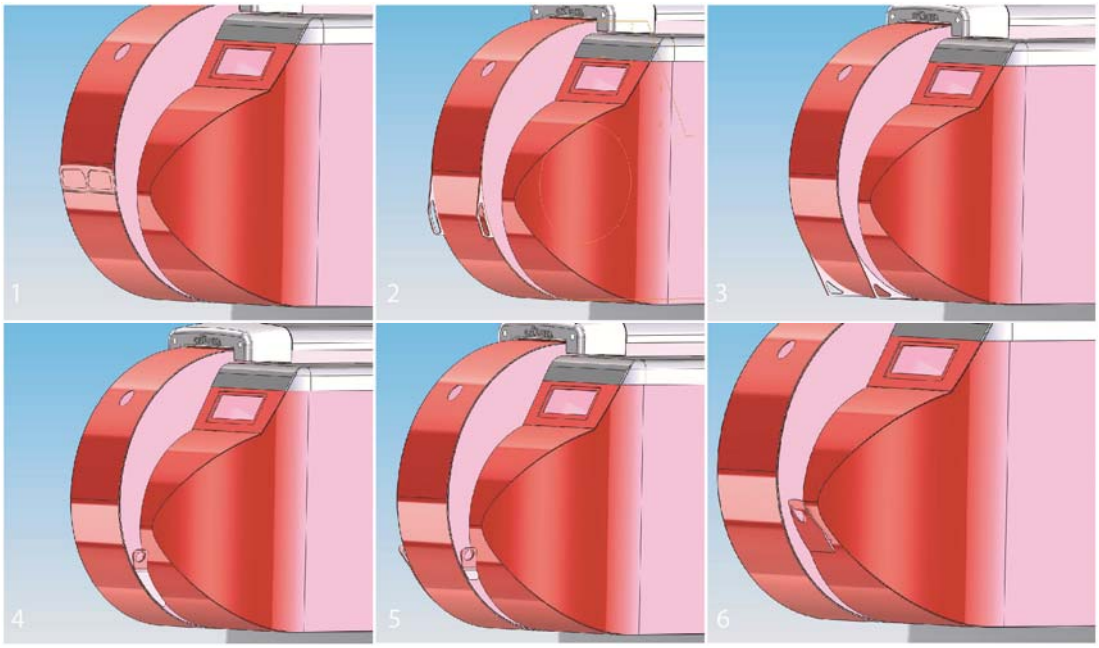

Figure 22. Lifting lug renderings – The low positioned. 1.10.2014

4.2.4 Chosen concept – Lifting lug

The final analysis brought the company and myself to understand that the burner needs more stability during transport and previous design didn't provide enough flat surface where the burner would sit. The image 1 of Figure 23 shows how the lifting lug B is made by including two corners with a hole of fifty millimetres to the side of the burner's body when cut with the laser. Welding subsequently an "L" shape plate provides flat surface and consistency to the body.

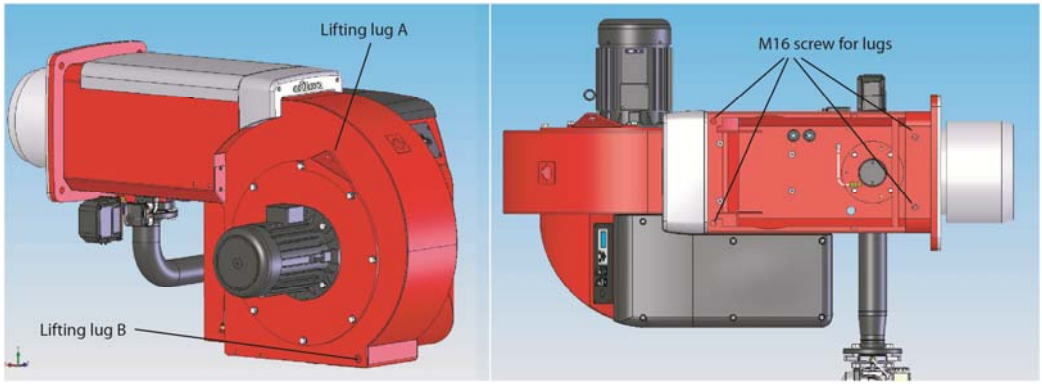

Figure 23. Lifting lug renderings – Chosen design. 5.10.2014

The second lug A in the image 1 of Figure 23 has been kept in consideration due to its low manufacturability cost and a successfully passed test. The bracket screwed to the flange is a very useful result maintaining the burner when lifted for prototype testing absolutely in balance.

4.3 Burner's head spyhole concepts

4.3.1 Plastic cover

For most of the small component's design of the burner there has been a discussion whether it was convenient produce them in plastic or metal. The first options accepted for the spyhole after the concept stage were including a plastic cover.

Some of the burners of Oilon's production present a pipe that exits from the body of the burner, straight from the burner head. The function of this pipe is to give place to the spyhole, helping to targeting the flame and visible in the head of the burner. The first solution in Figure 24 presented a cover clipped on the pipe that sits on the edge of the burner. The outline follows the top cover and the Oilon plate's curvature. The design considers the protection glass installed on plastic cover but hasn't been developed in this stage of the project. The second solution sees the pipe coming out from the body of the burner and a cover that is clipped on the side of a half dome that is welded on the edge of the burner. With this solution, the cover is lifted up rotating it ninety degrees upwards if the need is to watch inside or can be removed if the burner needs to be lifted. The dome has two holes of fifty millimeters where a steel pole can be inserted and then the lifting device will be fastened.

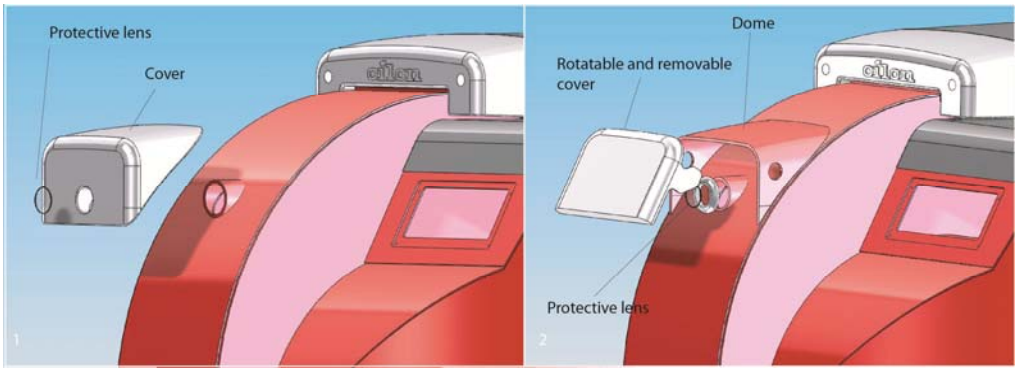

Figure 24. Spyhole renderings – Plastic covers. 5.10.2014

4.3.2 Spyhole over on lifting lug

The continuous analysis in the process, the ideas developed and concepts proposed allows me to understand which of the solutions are the most accepted or disparaged. Often happens so, that what I believe is the most interesting concept it is not and what is made with a doubt is accepted. There is always a lot to learn from brainstorming with the colleagues of R&D or production department.

In this case, for example, the element suggested previously had as a main idea the unification of the spyhole and lifting lug, as well as the plastic as covering elements. Some of the elements were much appreciated but clearly the plastic needed to be removed. In this way the suggested concept in Figure 25 was born proposing the lifting lug and Oilon's standard cover.

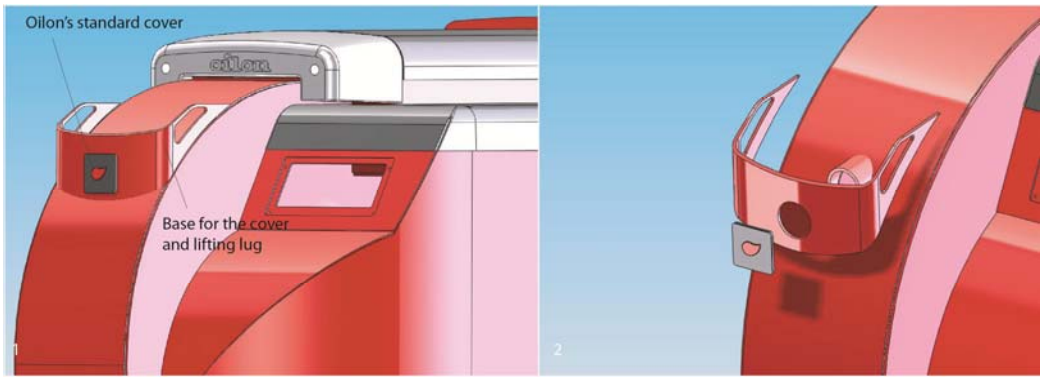

Figure 25. Spyhole renderings – Spyhole over on lifting lug. 05.10.2014

This is the first time that the Oilon's cover comes to visibility, accidentally before none has mentioned it and I didn't realise myself that I could use it. Allowing the use would have accelerated the process much. The system is pretty simple**:** there is a square base where an enlarger glass is mounted and the top cover with Oilon's logo rotates on hinge (Figure 26).

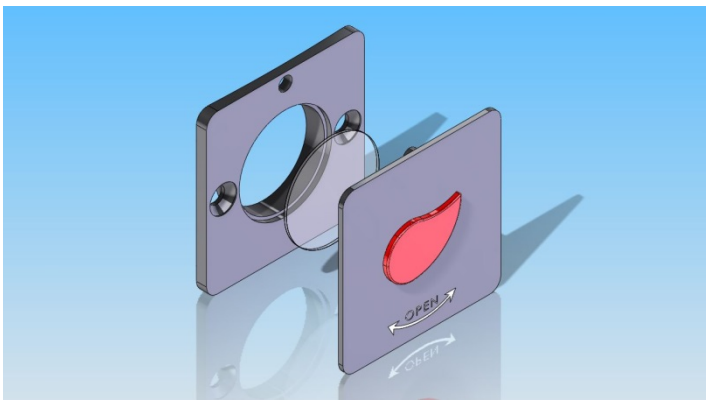

Figure 26. Oilon's standard spyhole cover's rendering. 05.10.2014

4.3.3 Oilon standard spyhole cover on flat surface

The standard cover is used in most of the products assembled by Oilon. This made the situation quite obvious to use it in the most simple and efficient way. Removing the dome or plastic covers suggested that compromise the external outline of the burner resulted very easy. The research team decided to place a ten millimetre thick base on the perimeter to fill up the tangency tolerance where to screw the cover (Appendice 9.7). The only unsure issue is whether the inclination would compromise the view but test results have assured enough good visibility.

Figure 27. Spyhole rendering – Chosen solution. 05.10.2014

5 SELECTED CONCEPTS DESING AND PRODUCTION METHODOLOGY

5.1 Frequency converter finishing and prototyping.

The cover as previously decided is printed with a 3D printer. As the part is that big, considering the capacity of the printer's tray, it needs to be printed in two different parts and then glued together. The suggestion of the supplier was that it would be printed with ABS-material and using layer thickness 0,254 mm. Printing would be faster and more inexpensive if 0,33 mm layer thickness is used but it makes surface finishing more slower and difficult. Also for the Oilon-logo will be better using 0,254 mm layer thickness.

To gain the best surface quality, parts would be printed as shown in Figure 26.
In the window 1 of Figure 28 a detail of the logo is printed. The green colour represents the model's material and light blue is support material which is used in 3D printing to support the real material that forms the item. At the end of the process is washed away and the plastic material stays.

The corners of the logo in the image 2 of the figure 28, rounded in dark blue colour, will be a bit rounded because the part is built using a thin plastic thread.

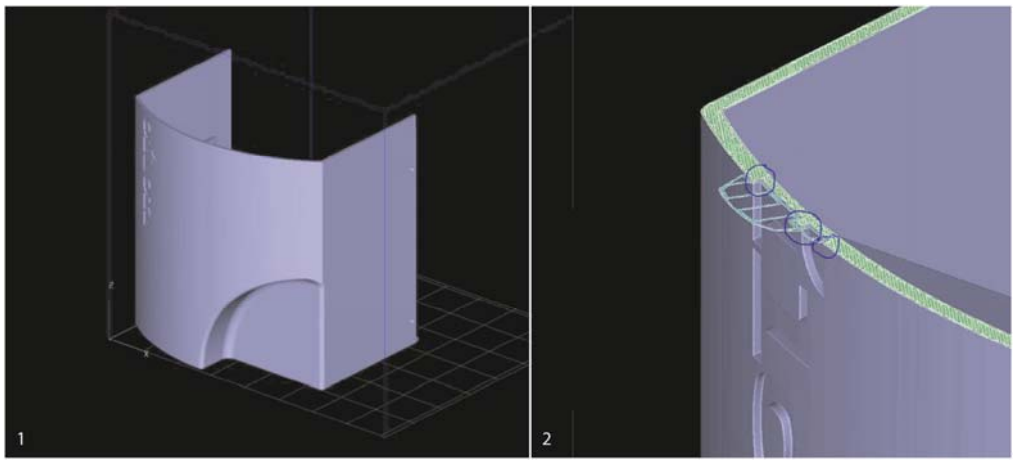

Figure 28. 3D printing. RP case. 2014

The quality of the surface suggested from the supplier was enough for the purpose considering that the cover is grinded and subsequently painted to achieve a smooth layer of black paint.

Because of the quite big dimension of surface on the top, the cover present internally a cross spine to improve the resistance of it. Considering that the burner would have been exposed in a fair neither channels nor marks for seal has been included in this model.

Sealing solution was anyway discussed and left to a further development when the burner would have been ready for tests.

5.2 Lifting lug and spyhole production's specifics.

The lifting lugs and spyhole production will take place together with the production of the whole body of the burner. In the company, the designer has the duty to produce the technical drawings to allow the process of laser cut and sheet metal bending needed to achieve the designed shape. The elements will be manufactured and assembled to the burner's body, following the technical drawings and 3D file that I have produced.

6 OUTCOMES

The subject of the thesis has been discussed with Oilon's department director which has participated actively to the selection of it. Being employed in the company gave me the possibility to choose the right subject between different projects that I am involved in. The decision to discuss the development of the three components came after evaluating project's developing processes, stage of the development and technical information involved. In the thesis I described the design process applied to achieve the product's final design which is the same process that I use for all the other products design. The thesis subject was selected also because when I started to write it, design and prototype were already modelled and steps of the process recorded.

The project gave me the chance to take advantage of what my skills are considering the degree that I am achieving and my previous studies. In the materials used, processes and production assumed I needed knowledge and training which I got during my course of study. An overall knowledge learned in previous academic experiences helped me to finalize technical issues usually related to the engineers.

The team work has been vital for the success of a project, the communication between me and the other members of the product development centre involved in the project has always worked prolifically to achieve a final common goal.

The positive experience strengthens the feeling to work for a company where personnel involved and their knowledge creates an ideal atmosphere to face new challenging projects.

I am personally very satisfied with the results**.** I believe that I achieved the objective of the company discussed at the beginning of the thesis maintaining the high standard of the quality obtained during the whole burner's design process. Material, outlook, technical details have been elaborated and perfected following Oilon's objectives and its brand demand.

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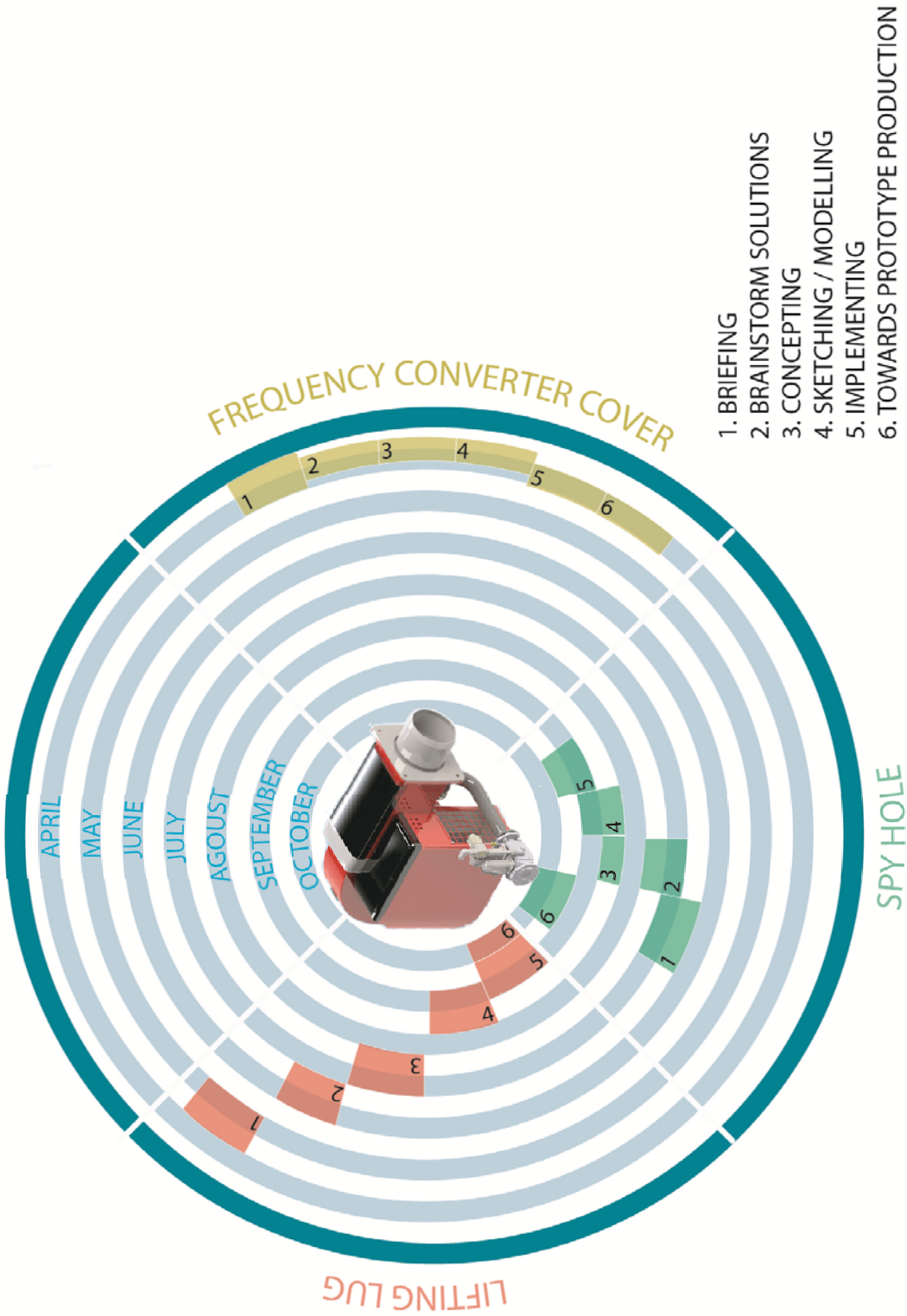
8 LIST OF FIGURES

9 APPENDICES

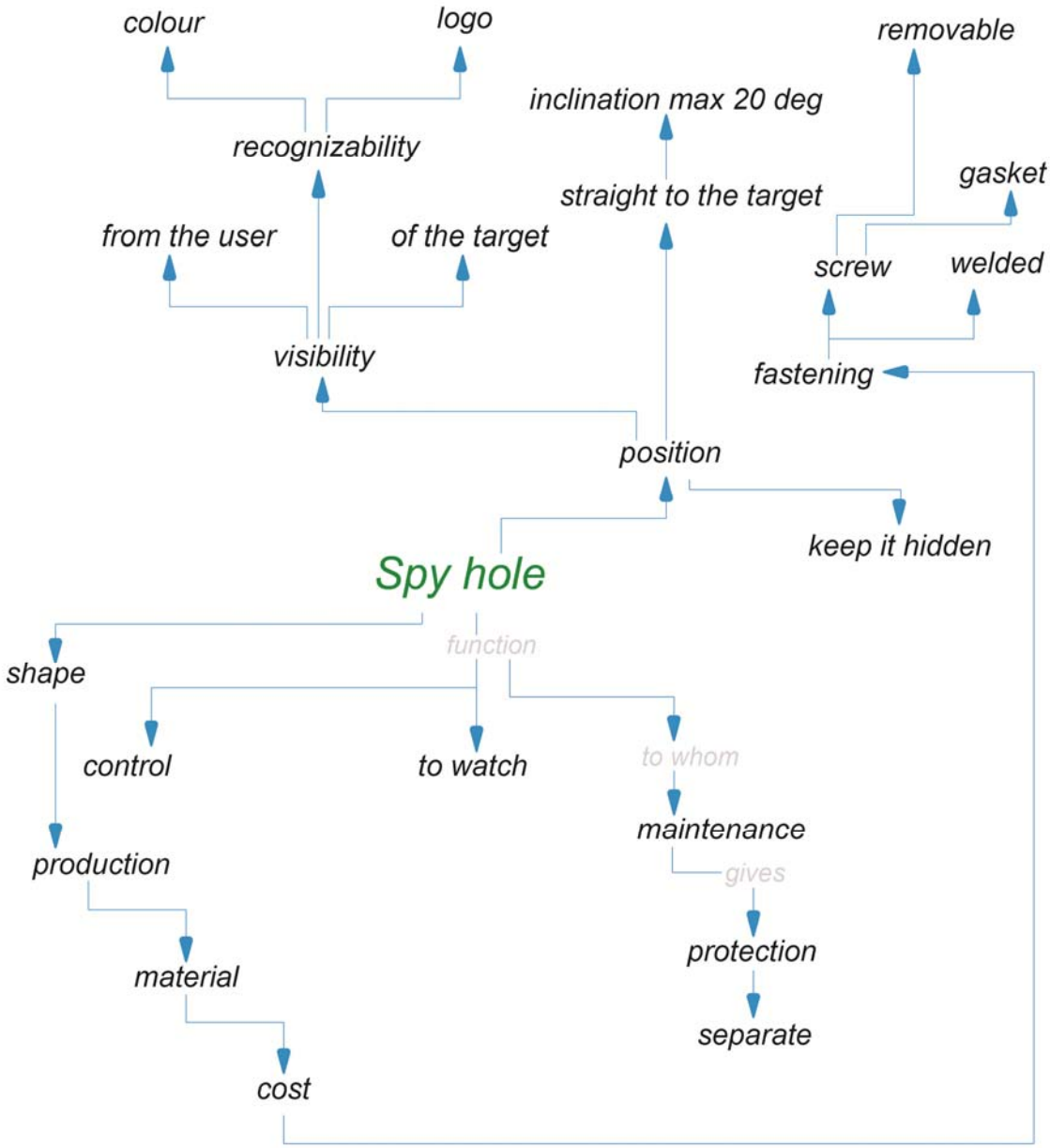
9.1 Timetable



9.2 Concept map 1

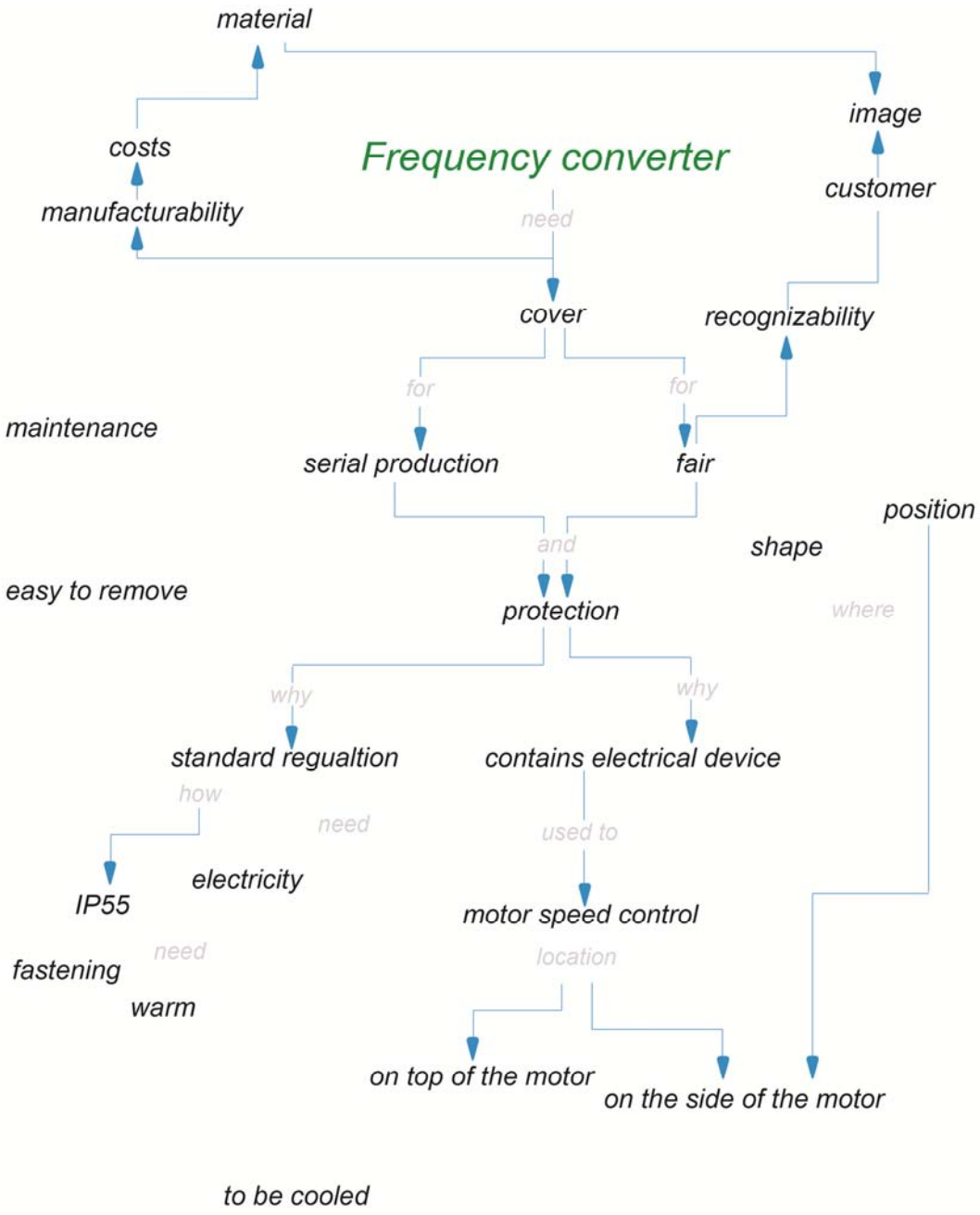
Concept map 1

9.3 Concept map 2



Concept map 2

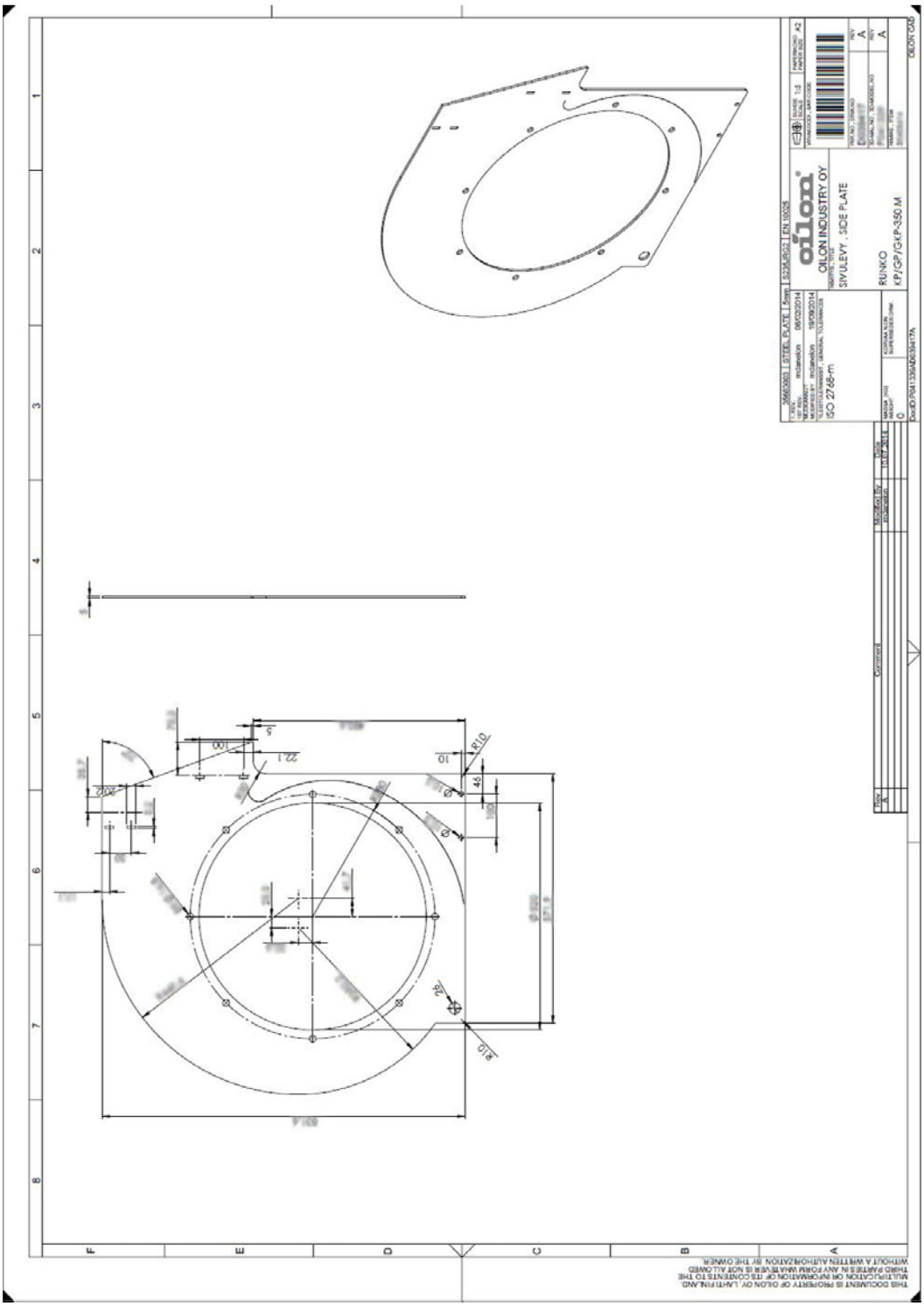
9.4 Concept map 3

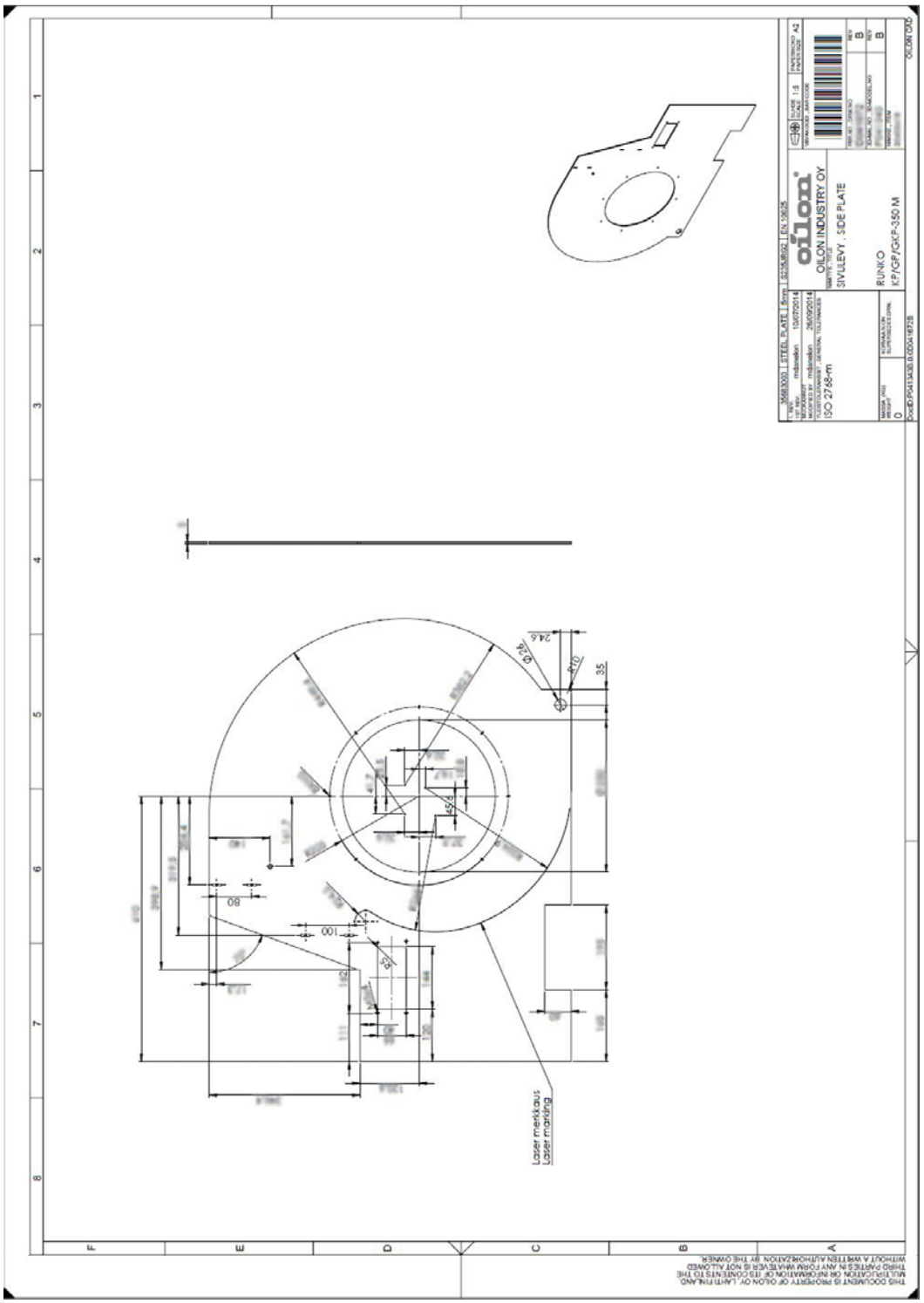


Concept map 3

9.5 Frequency converter cover

9.6 Technical drawing Lifting lug

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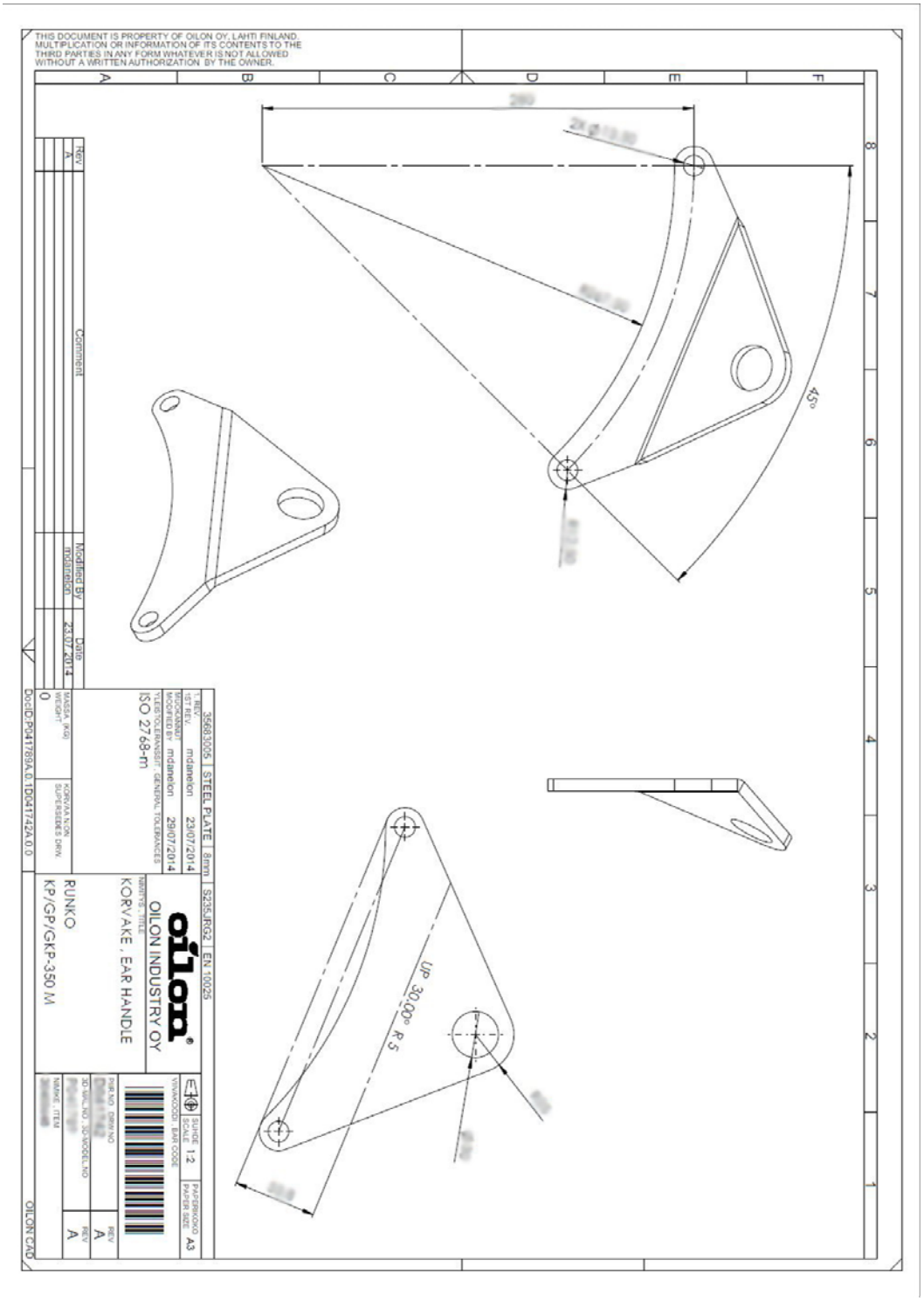
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9.7 Technical drawing spyhole