



Expertise  
and insight  
for the future

Zaida Brito Triana

# Improvement of the Particle Size Analyzer PSI® 300I

Metropolia University of Applied Sciences

Mechanical Engineering

Thesis

28/05/2019

Author(s) Title	Zaida Brito Triana Improvement of the Particle Size Analyzer PSI® 300I
Number of Pages Date	33 pages + 0 appendices 28 May 2019
Degree	Mechanical Engineering
Degree Programme	Mechanical Engineering
Specialisation option	Mechanical Engineering
Instructor(s)	Pekka Salonen, University tutor Mika Salonen, Kari Immonen, Valtteri Torppala, Company tutor
<p>This project record contains the steps that were made in the design process of the improvement of the Particle Size Analyzer PSI® 300I. There was a first brainstorm and sketch design step in which it was decided what were the main dictations that were going to be taken into account. After this part there were CAD designs modelled and discussed and then, there were some selected ideas for being developed following the conditions.</p>	
Keywords	Particle Size Analyzer, PSI, redesign.

## Contents

Abbreviations	4
1 Introduction	1
1.1 The Company, Outotec Oy	1
1.2 The product- PSI Particle Size Analyzer	1
2 Starting point	2
2.1 Aspects to solve	2
2.1.1 Prevention of blockages in nozzle screen	2
2.1.2 Drain valve design	3
2.1.3 Level switch position	3
2.1.4 Improvement of the maintenance	4
3 Design concepts	5
3.1 First sketches	5
3.1.1 Prevention of blockages in nozzle screen and improvement of the maintenance	5
3.1.2 Drain valve design	10
3.1.3 Level switch position	14
4 CAD Designs	19
4.1.1 Prevention of blockages in nozzle screen and improvement of the maintenance	19
4.1.2 Drain valve design	22
4.1.3 Level switch position	25
5 Additional requirements	27
6 Selected designs	31
6.1 Nozzle concept	31
6.2 Tank access concept	32
6.3 Express drain valve concept	32
7 Conclusions	33
8 References	33

## Abbreviations

PSI	Particle Size Analyzer, the product that is going to be redesigned.
SW	SolidWorks, The program that was used for creating the CAD designs and editing the original ones.

## 1 Introduction

### 1.1 The Company, Outotec Oy

Outotec Oy is a process technology company focused in leading technologies and services for the sustainable use of Earth's natural resources and listed on NASDAQ Helsinki. Their 4,000 top experts are driven by each customer's unique challenges across the world. Outotec's comprehensive offering creates the best value for our customers in the mining, metal, energy, and chemical industries.

Their compromise is with Sustainable use of Earth's natural resources, always with the aim to continuously improve our performance in economic, environmental and social responsibility.

Their website is [www.outotec.com](http://www.outotec.com).

### 1.2 The product- PSI Particle Size Analyzer



*Figure 1. Real model of PSI 300I*

PSI 300 Particle Size Analyzer is an on-line sizing system for mineral slurries. It is used to monitor and control grinding, classification and thickening in mineral processing plants.

The analyzer system reports the analysis results to the plant automation system for real-time process monitoring and control. A variety of particle size distribution characteristics can be selected as outputs.

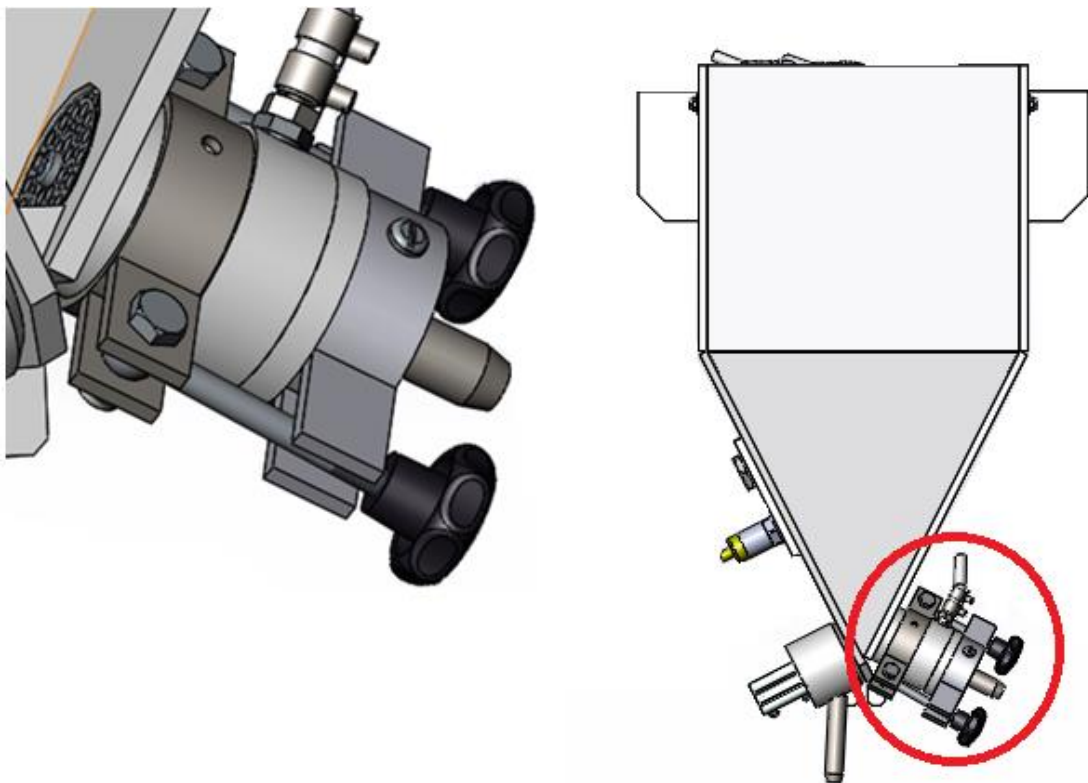
The analyzer is a compact stand-alone device with options according to specific requirements of each application. The system operates on a continuous basis 24 hours a day with minimal maintenance. The weekly maintenance routines include checking the sampling system and cleaning possible trash buildup in the secondary sampler.

## 2 Starting point

### 2.1 Aspects to solve

#### 2.1.1 Prevention of blockages in nozzle screen

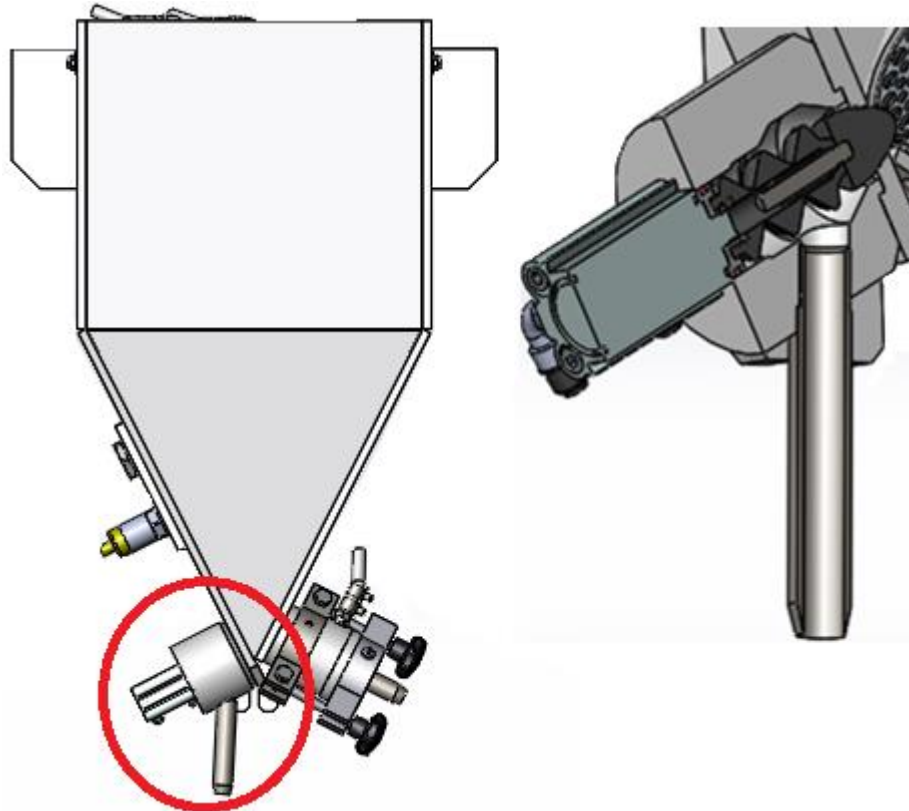
The original design had some drawbacks that cause blockages and maintenance problems. The ores usually get stuck at the bottom parts and the design of the nozzle screen didn't facilitate removing the central part from the cover. Here, Figure 2, it has been summed up the starting situation points and the requirements related to them:



*Figure 2. Detail of the nozzle screen.*

### 2.1.2 Drain valve design

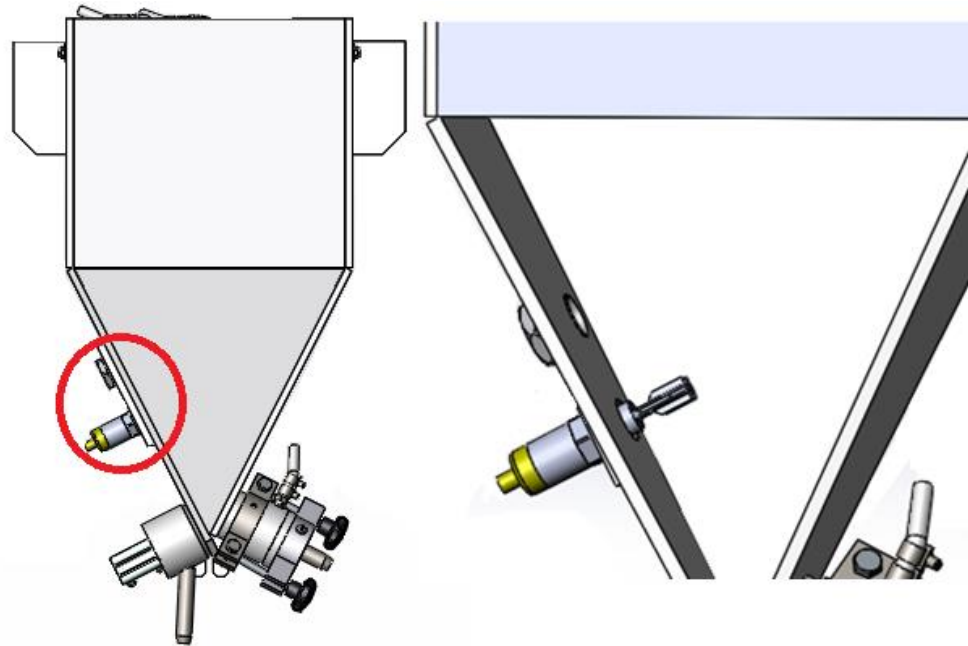
In the Figure 3 can be appreciated that the express valve had a complex design with a rubber spring that was automatically activated with a hydraulic system when it was necessary



*Figure 2. Half section on the express drain valve.*

### 2.1.3 Level switch position

The slurry used to get stuck due to the inclination, Figure 4, so there were false level detections that affected the normal functions of the particle analyzer.



*Figure 3. Level switch position.*

#### 2.1.4 Improvement of the maintenance

The original design had some difficulties for accessing to the tank bottom for maintenance and cleaning and for removing screen nozzle.

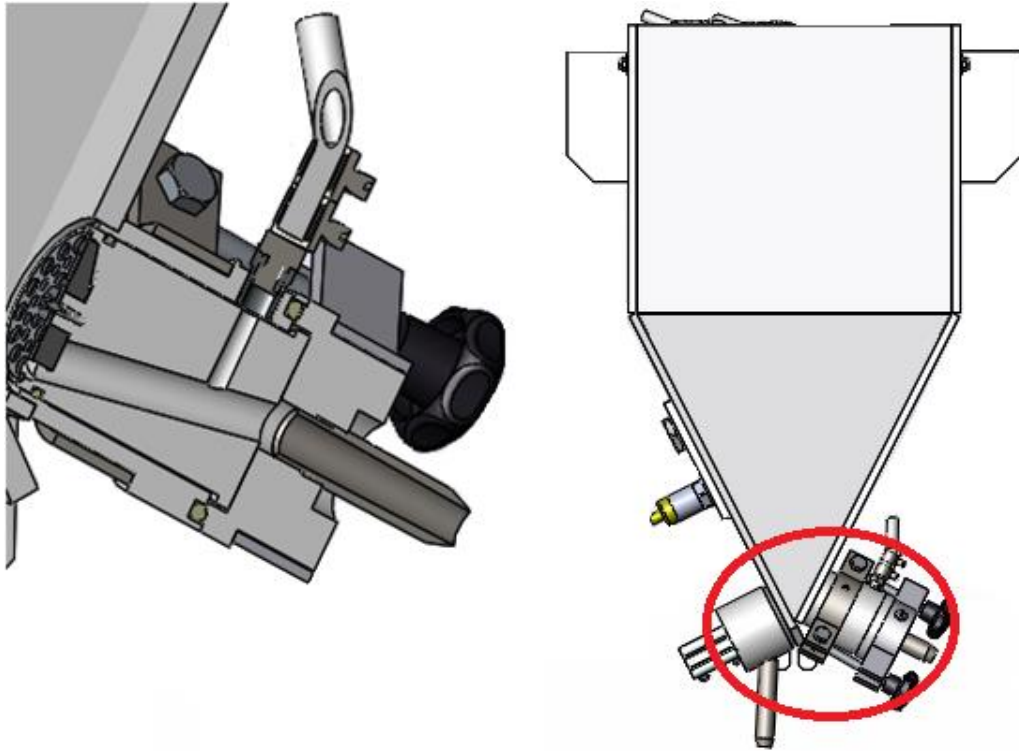


Figure 4. Half section of the screen nozzle

### 3 Design concepts

#### 3.1 First sketches

##### 3.1.1 Prevention of blockages in nozzle screen and improvement of the maintenance

It was decided to develop to versions of the idea 1, Figure 6,7 and 8, both share the adjustable cover. Starting from the original idea it was created a new design with a bigger inclined nozzle screen for making it easier to unlock.

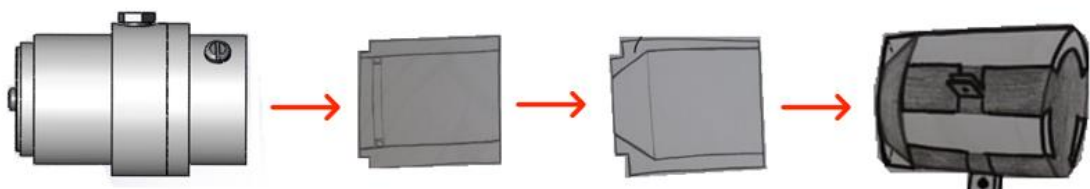


Figure 5. First sketch of the IDEA 1.



Figure 6. Sketch of the IDEA 1.1.1

Table 1. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Easier way to remove screen nozzle.</p> <p>Maintains the position.</p> <p>The screws will help keep the cover tight even after many uses.</p>	<p>The cover is complex to weld.</p> <p>Maybe access for the maintenance is not solved.</p>

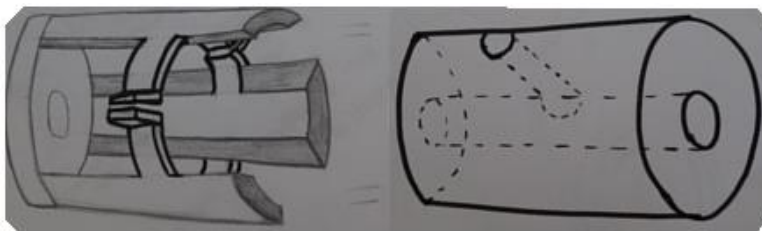


Figure 7. Sketch of the IDEA 1.1.2

Table 2. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Easier way to remove screen nozzle.</p>	<p>Complex to manufacture.</p>

No tools needed to remove screen nozzle.	Complex to maintain in the correct position.  It could be that the cover is not enough to prevent the central part from falling.
--	--

Keeping the original design in the connection part with the main structure in order to avoid creating a bigger hole. The inclined part in all the surface of the central part might be the solution for removing the nozzle screen easier, Figures 9, 10 and 11.

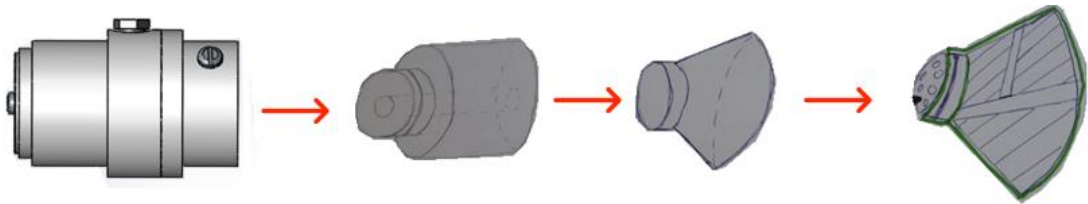


Figure 8. First steps on the IDEA 1.2

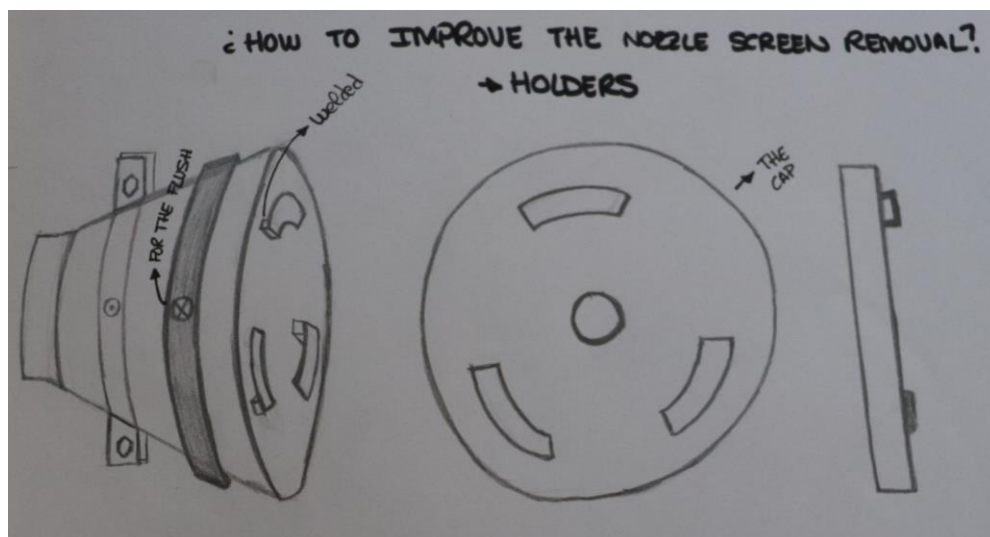


Figure 9. Sketch of the IDEA 1.2.1 with the holders and the covers.

Table 3. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>No big changes on the original design are needed.</p> <p>No tools needed to remove screen nozzle.</p> <p>Helps to maintain the position.</p>	<p>Complex to manufacture.</p> <p>Maybe access for the maintenance not solved.</p> <p>Maybe if a hammer or something similar is used the holders can get damaged.</p>

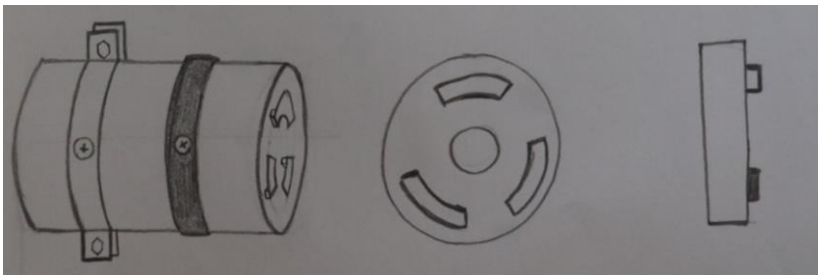


Figure 10. Sketch of the IDEA 1.2.1 with the holders and the covers

Table 4. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>No big changes on the design are needed.</p> <p>No tools needed to remove screen nozzle.</p> <p>Help to maintain the position.</p>	<p>Complex to manufacture.</p> <p>Maybe access for the maintenance not solved.</p> <p>Maybe it would be still difficult to remove the screen nozzle.</p>

This idea, Figure 12, was trying to create a new design concept for the PSI with and square structure changing the position of the express drain valve and the screen nozzle.

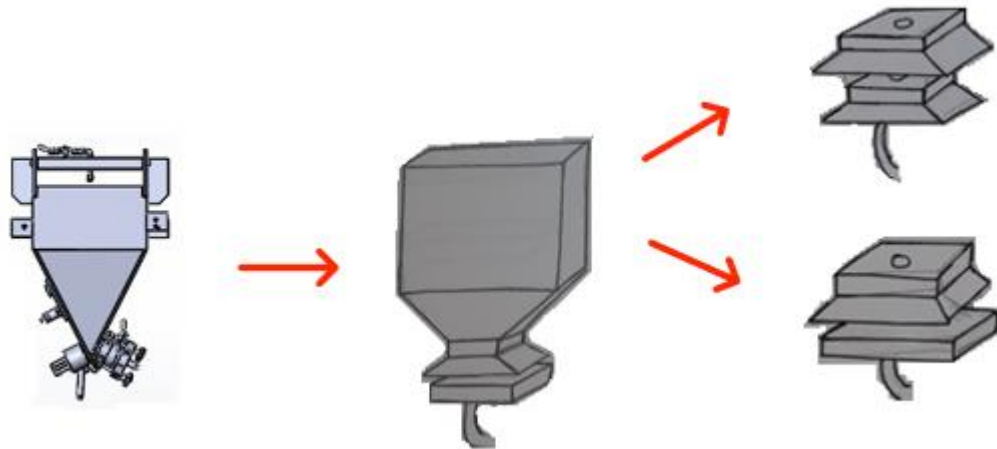


Figure 11. Sketch of the first steps in the IDEA 1.3.1 and IDEA 1.3.2.

Table 5. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
Easier to manufacture.	Big changes on the design are needed.
Better access for maintenance.	The slurry may get stuck in the edges.

### 3.1.2 Drain valve design

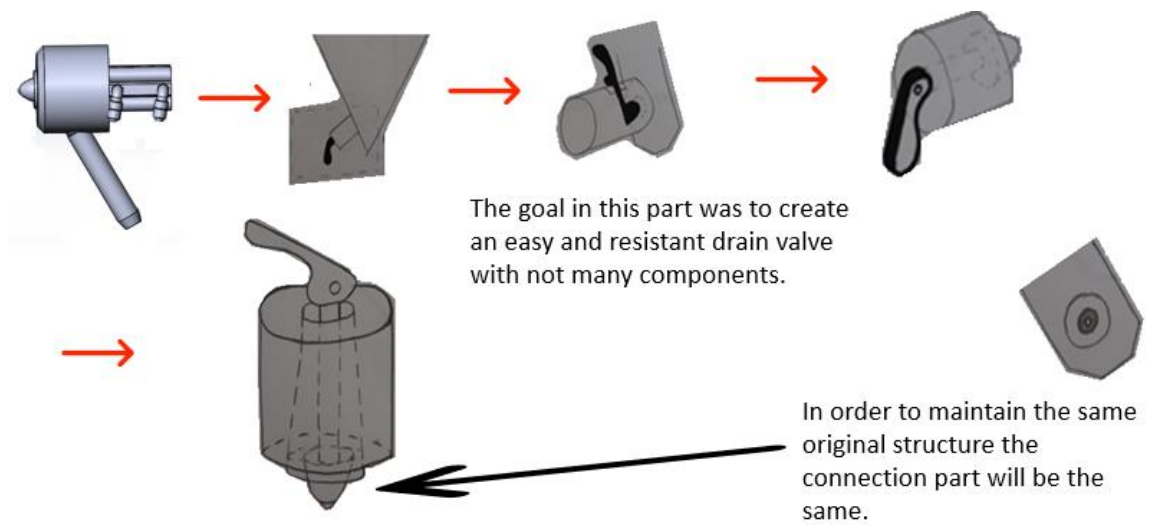


Figure 12. Sketch of the first steps in the IDEA 1.

This idea, Figures 14,15 and 16, was created with the intention of developing a simple design that will resist. First, with a design with spring holding the position, then with bars and finally with an elastic material.

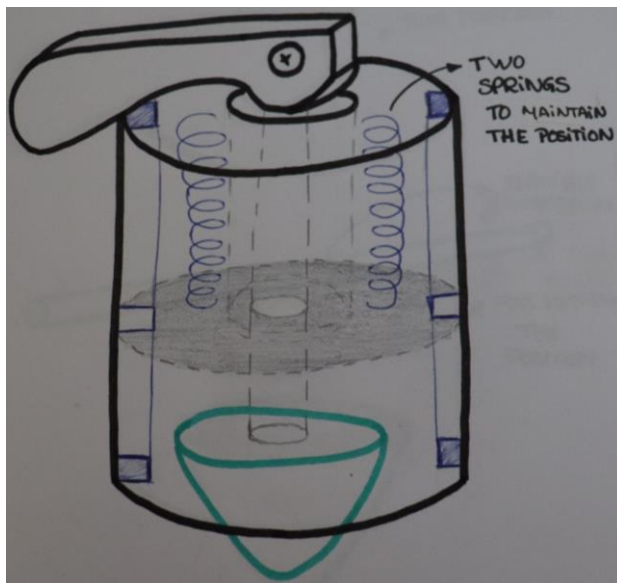


Figure 13. Sketch of the IDEA 2.1.1.

Table 6. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Simple parts.</p> <p>Makes the maintenance easier.</p> <p>Keeps the position.</p>	<p>Complex to keep the springs in the selected position.</p> <p>Maybe there would be leaks inside the springs camera.</p> <p>Not automatic.</p>

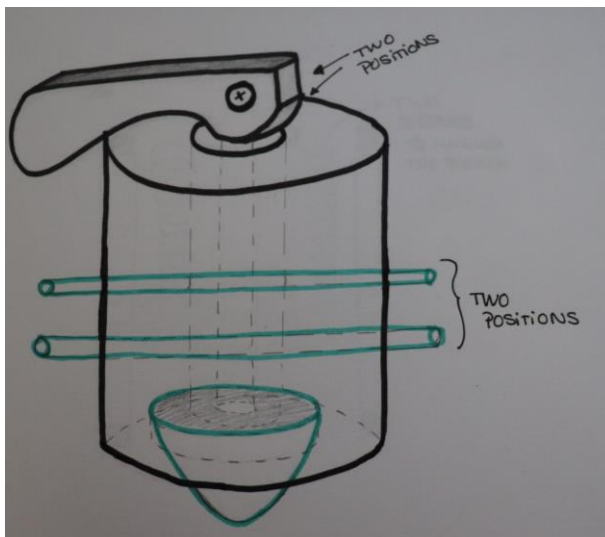


Figure 14. Sketch of the IDEA 2.1.2.

Table 7. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Cheap to produce.</p> <p>Easy to replace.</p>	<p>Complex to use.</p> <p>The tubes can break easily.</p>

	Not automatic.
--	----------------

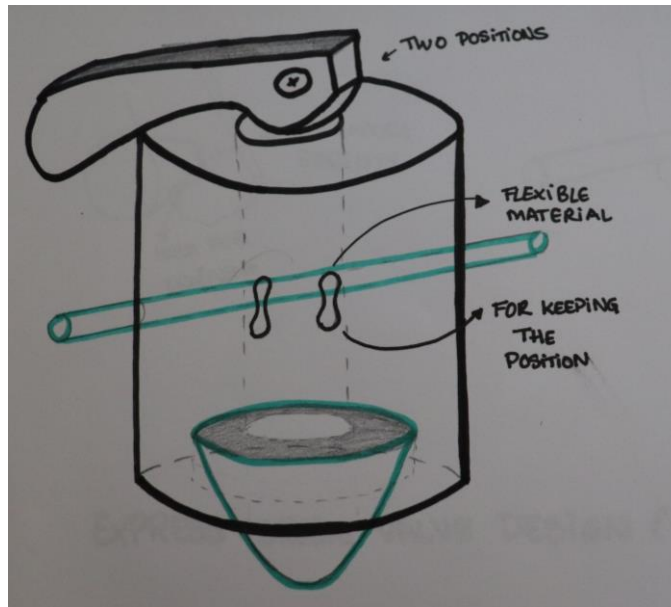


Figure 15. Sketch of the IDEA 2.1.3.

Table 8. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>No specific tools required.</p> <p>Keeps the position.</p>	<p>Complex to manufacture.</p> <p>Complex to find the correct material to use.</p> <p>It can break easily.</p> <p>Not automatic.</p>

This idea, Figure 17, came from the original express drain valve and tried to combine simple parts with a bigger camera for preventing blockages.

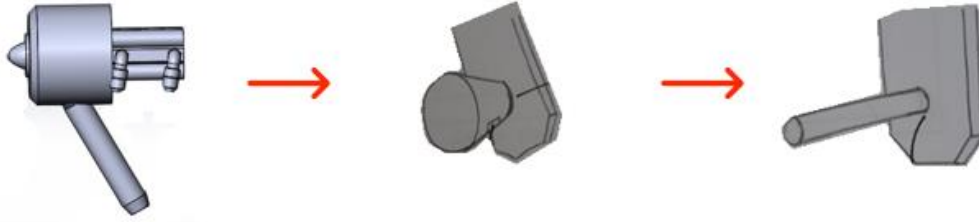


Figure 16. Sketch of the first steps in the IDEA 2.2.

Table 9. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>No specific tools required to open it.</p> <p>Cheap to produce.</p>	<p>Complex to keep in the correct position</p> <p>It can break easily.</p> <p>Not automatic.</p>

Taking in account that the original design was automatic this idea, Figure 18, was thought to be automatic. The spring was thought to keep the position.



Figure 18. Sketch of the IDEA 2.3.

Table 10. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
Cheap to produce.	It may get jammed.
Automatic.	A sealing would be needed.

### 3.1.3 Level switch position

The main challenge in this part was to create an idea that didn't change much the original design, specially in the top part.

This last part was something to have in mind on the designs in the Figures 19 and 20, also the materials that would be used.

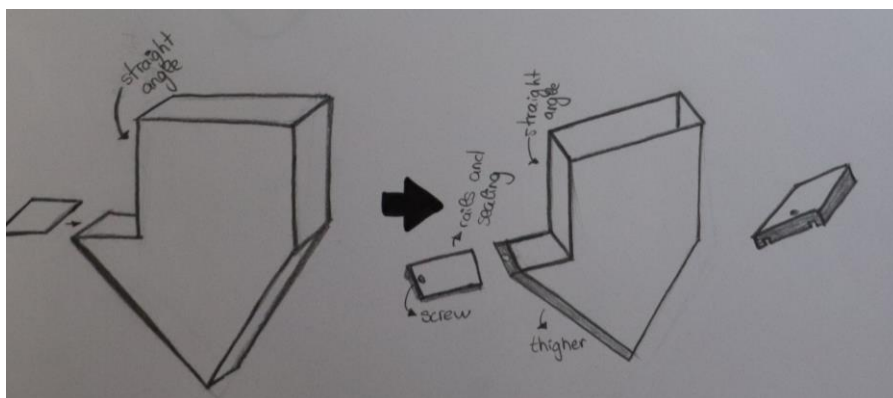


Figure 19. Sketch of the IDEA 3.1.1

Table 11. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
Not big changes from the original design.	Complex to avoid leaks.
Allows to have better access for maintenance.	Complex to weld the thick part.

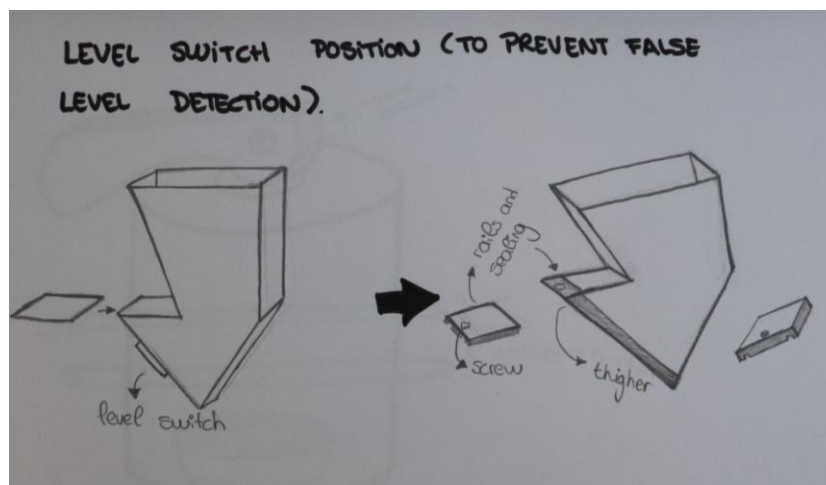


Figure 20. Sketch of the IDEA 3.1.2.

Table 12. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
Not big changes from the original design.	Complex to avoid leaks.
Allows to have better access for maintenance.	Complex to weld the thick part.
Maintains the same space on the top part so it's not necessary.	

With this idea, Figure 21, the original top part keeps the same, but the bottom part creates a vertical line that would prevent false detections.

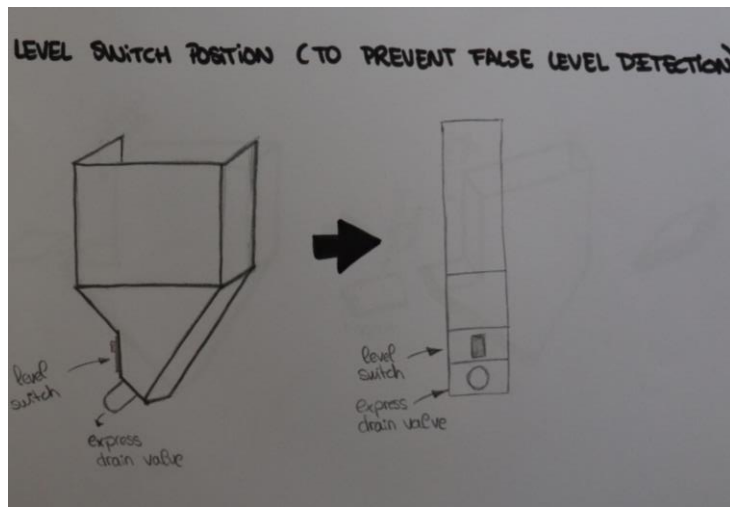


Figure 21. Sketch of the IDEA 3.2.

Table 13. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
Cheap to produce.	Changes the original design.
Easy solution.	Could cause obstructions due to the lack of space in the inferior part.

This idea, Figure 22, changes almost nothing from the original design and it was thought to be cheap and easy to produce and maintain.

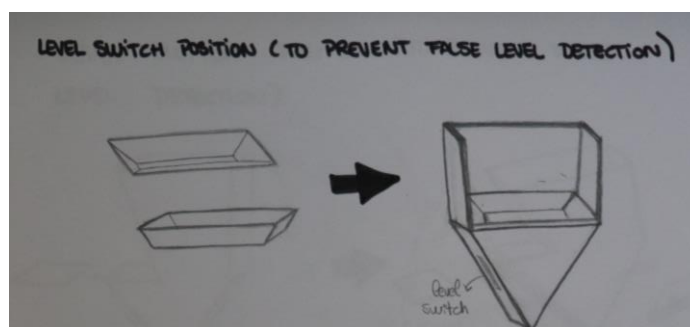


Figure 22. Sketch of the IDEA 3.3.

Table 14. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Easy to replace.</p> <p>Cheap.</p> <p>Easy to maintain.</p>	<p>There can be leaks.</p> <p>Maybe it would not solve the problem completely.</p>

This idea, as the one in the Figure 12, changes the original design and solves the problems creating a square structure.

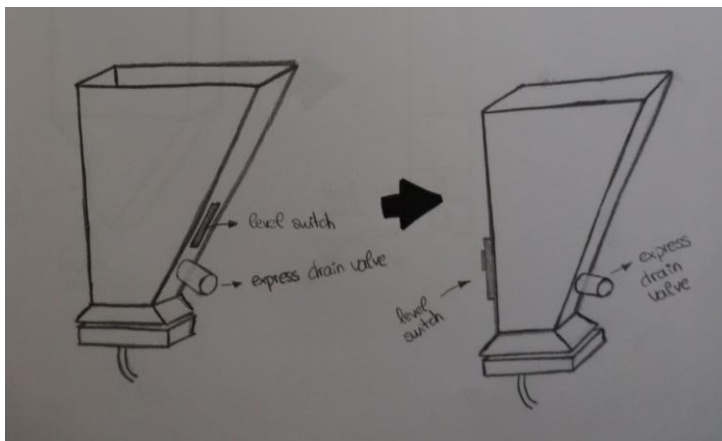


Figure 23. Sketch of the IDEA 3.4.

Table 15. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Easier to produce and to weld.</p> <p>Bigger space at the bottom for maintenance.</p>	<p>Changes the original design.</p> <p>Maybe the interior part would be too small.</p>

	Maybe there would be slurry jams in the screen nozzle due to the position.
--	--

This idea, Figure 24, as the one in the Figure 22, solves the problem with an easy and cheap solution.

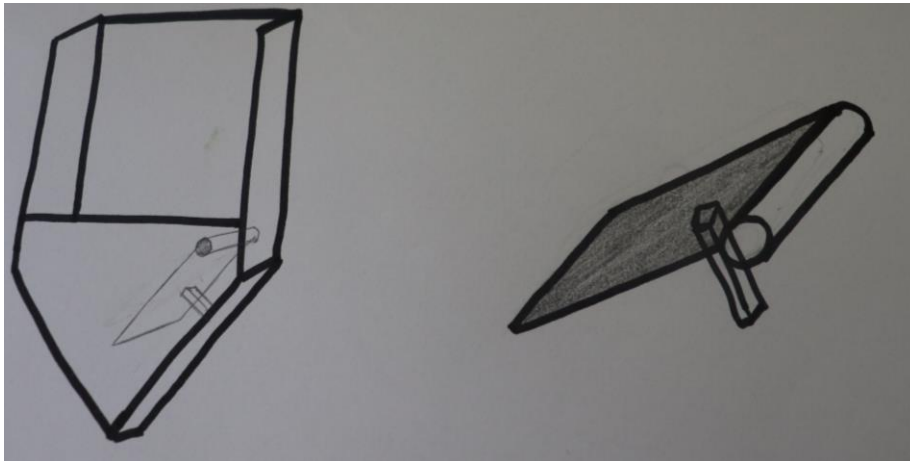


Figure 24. Sketch of the IDEA 3.5.

Table 16. Advantages and drawbacks related to the main characteristics of the idea.

PROS	CONS
<p>Easy to implement in already in the market products.</p> <p>Easy to replace.</p>	<p>Changes the original design.</p> <p>Could cause obstructions due to the lack of space in the inferior part.</p>

## 4 CAD Designs

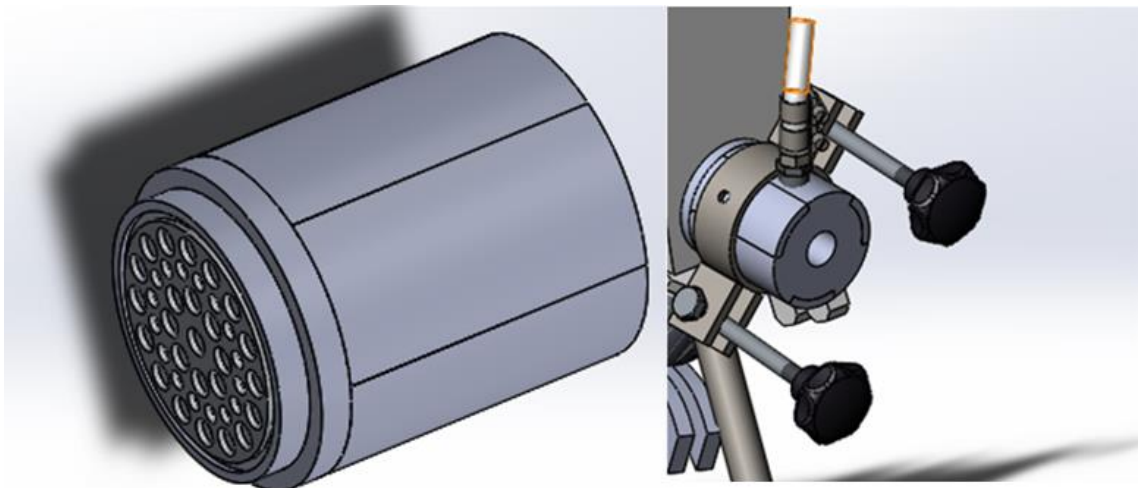
The program selected for the CAD design process was SolidWorks. The steps in the design process were taken through the files.

Using SolidWorks, there was created developed CAD designs from the original sketches. The CAD design process went deeper into the company requirements and the industrial possibilities.

A sum up of the principal guidelines there were considered in the selection process:

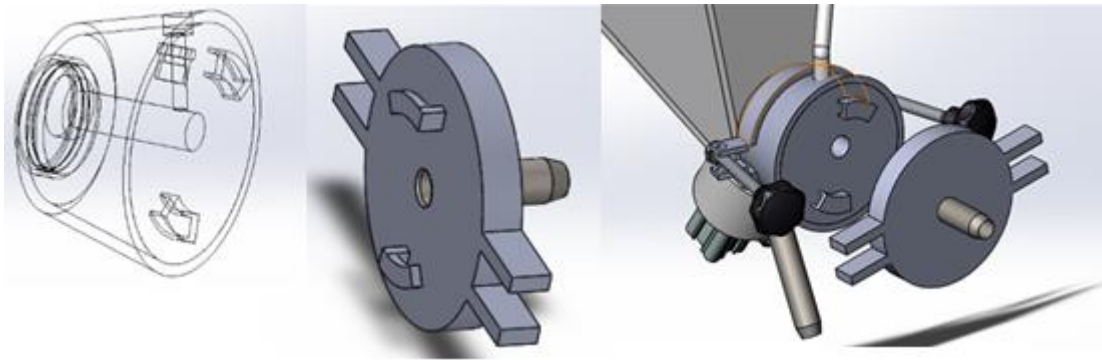
- Easy to manufacture.
- Resistant enough.
- Similar to the original designs.
- Easy to implement in the “already in the market” products.
- Automatic (for the express drain valve).

### 4.1.1 Prevention of blockages in nozzle screen and improvement of the maintenance



*Figure 25. CAD designs of the IDEA 1.1.1*

- Easy to manufacture. **APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**



*Figure 26. CAD design of the IDEA 1.2.1*

- Easy to manufacture. **APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**

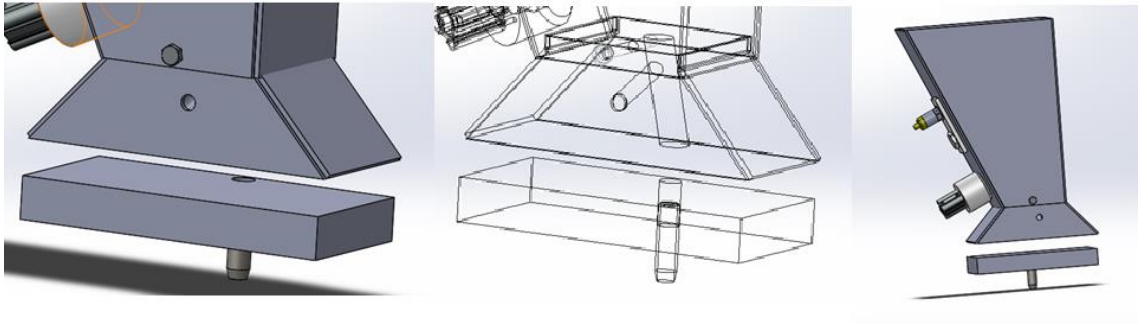


Figure 27. CAD design of the IDEA 1.3.1.

- Easy to manufacture. **APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **NOT APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**

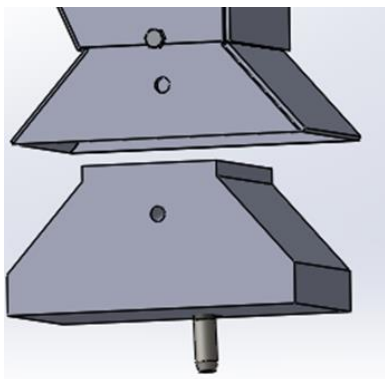


Figure 28. CAD design of the IDEA 1.3.2.

- Easy to manufacture. **APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **NOT APPROVED**

- Easy to implement in the “already in the market” products. **NOT APPROVED**

#### 4.1.2 Drain valve design

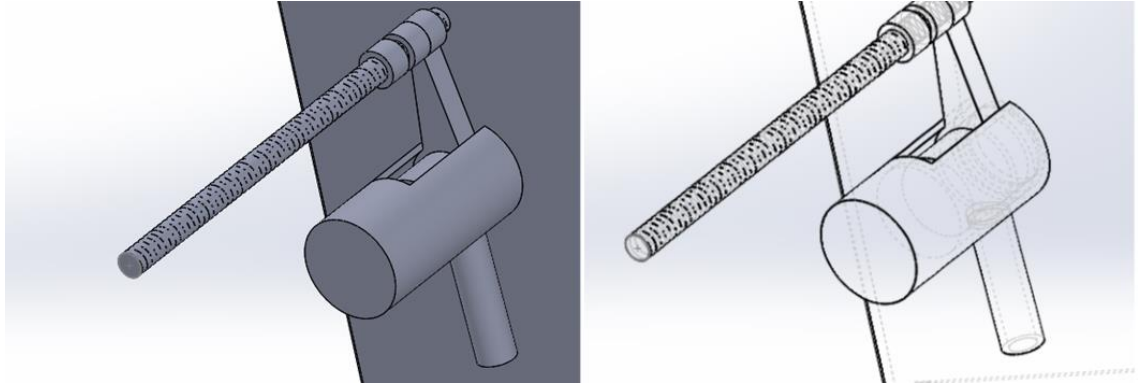


Figure 29. CAD design of the IDEA 2.1.

- Easy to manufacture. **APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**
- Automatic (for the express drain valve). **NOT APPROVED**

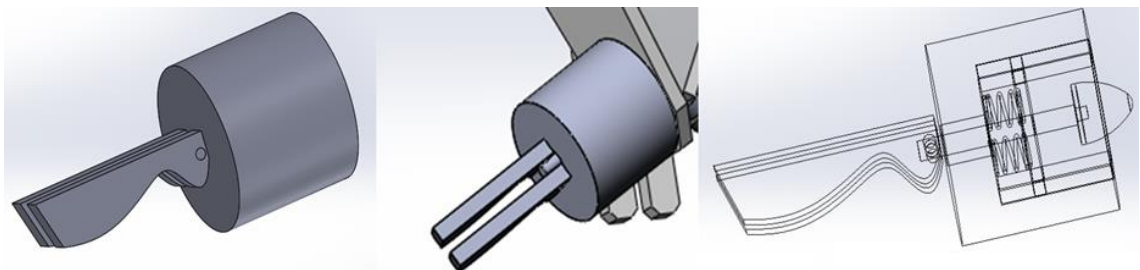


Figure 30. CAD design of the IDEA 2.2.1

- Easy to manufacture. **NOT APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**
- Automatic (for the express drain valve). **NOT APPROVED**

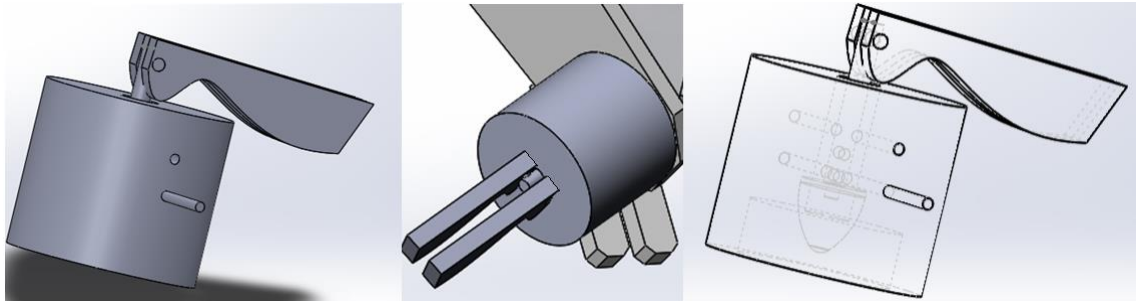


Figure 31. CAD design of the IDEA 2.2.2

- Easy to manufacture. **NOT APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**
- Automatic (for the express drain valve). **NOT APPROVED**

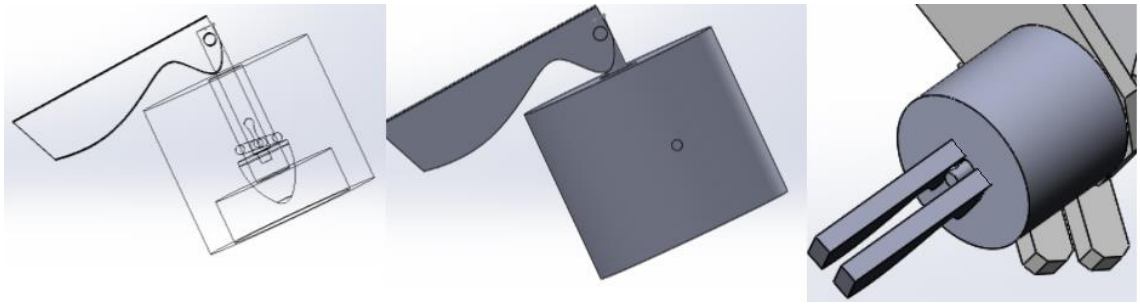


Figure 32. CAD design of the IDEA 2.2.3.

- Easy to manufacture. **NOT APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**
- Automatic (for the express drain valve). **APPROVED**

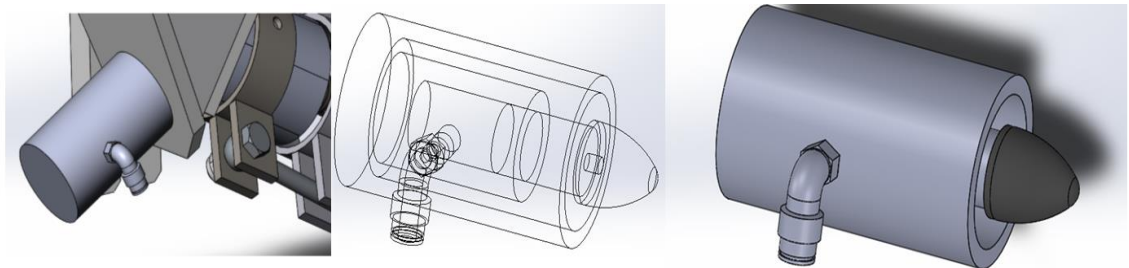


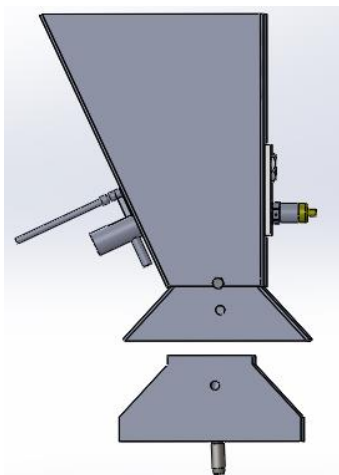
Figure 33. CAD design of the IDEA 2.3.

- Easy to manufacture. **APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **APPROVED**

- Easy to implement in the “already in the market” products. **APPROVED**
- Automatic (for the express drain valve). **APPROVED**

#### 4.1.3 Level switch position

For preventing false level detection. The slurry used to get stuck due to the inclination



*Figure 34. CAD design of the IDEA 3.1.*

- Easy to manufacture. **APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **NOT APPROVED**
- Easy to implement in the “already in the market” products. **NOT APPROVED**

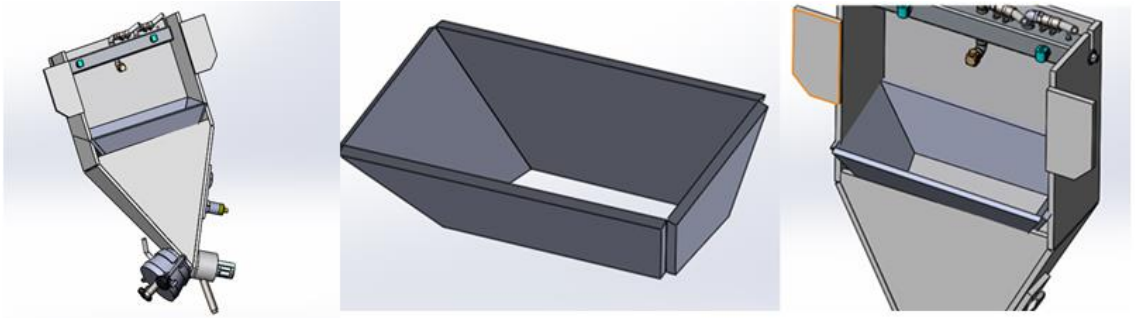


Figure 35. CAD design of the IDEA 3.2.

- Easy to manufacture. **APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**

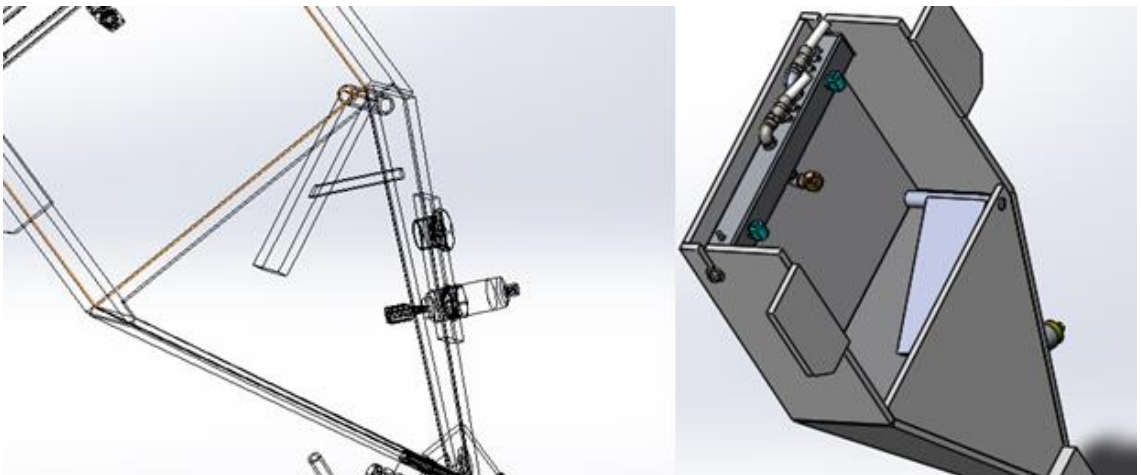


Figure 36. CAD design of the IDEA 3.3

- Easy to manufacture. **APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**

- Easy to implement in the “already in the market” products. **APPROVED**

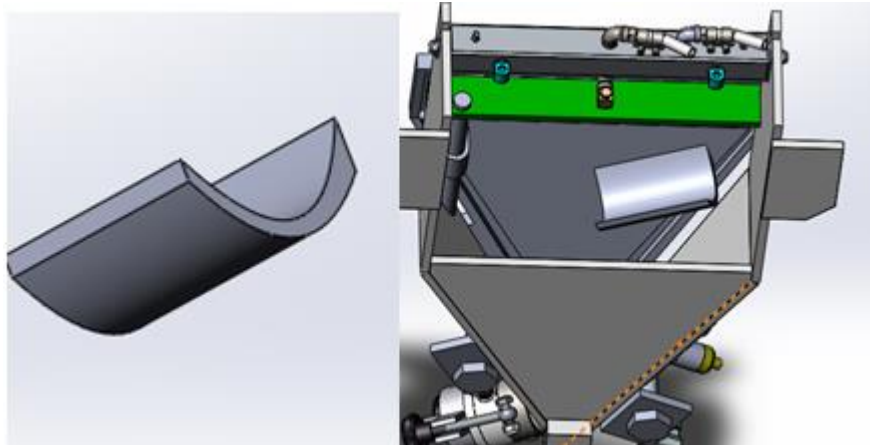


Figure 37. CAD design of the IDEA 3.4.

- Easy to manufacture. **APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**

## 5 Additional requirements

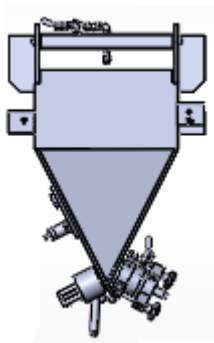


Figure 38. CAD part of the original design.

Creating a better access for maintenance through amplifying the screen nozzle hole was not enough. A floodgate that doesn't change the original structure would be the solution.

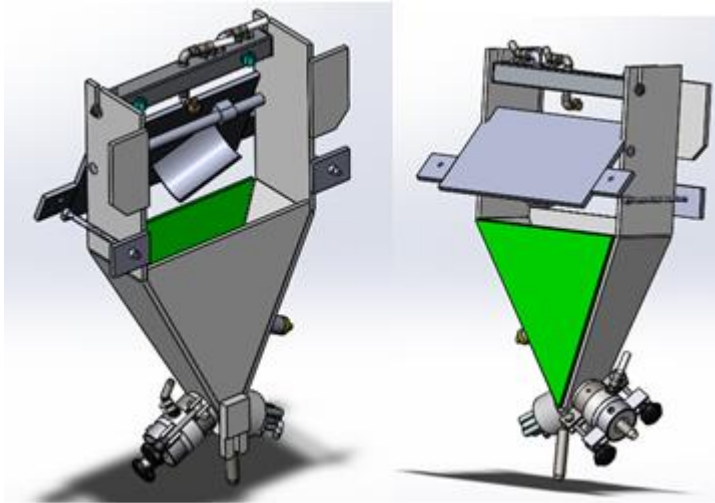


Figure 39. CAD design of the IDEA 4.1.

- Easy to manufacture. **APPROVED**
- Resistant enough. **APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **APPROVED**

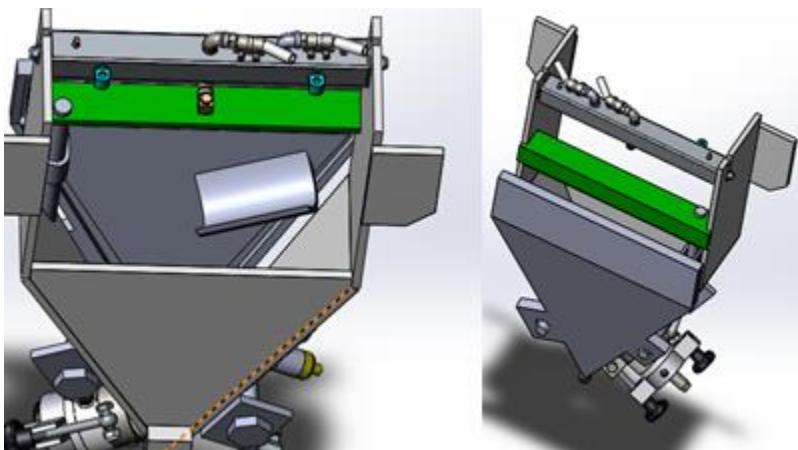
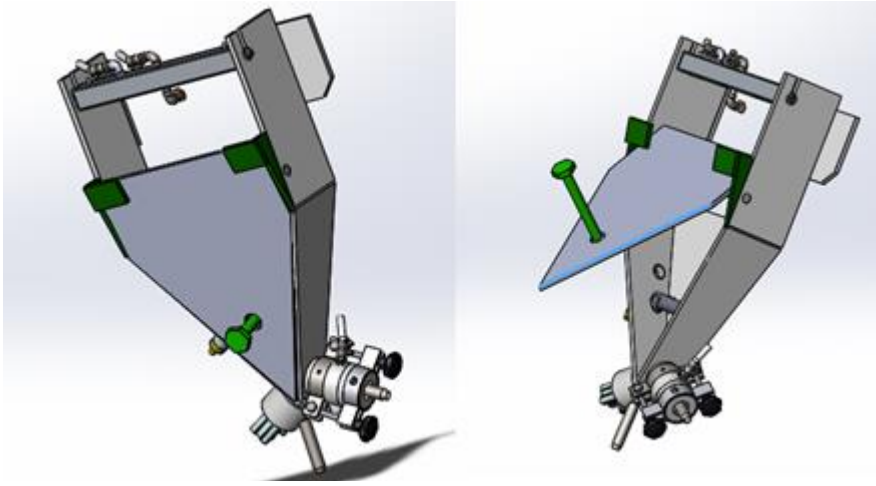


Figure 40. CAD design of the IDEA 4.2.

- Easy to manufacture. **NOT APPROVED**

- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **NOT APPROVED**



*Figure 41. CAD design of the IDEA 4.3.1*

- Easy to manufacture. **NOT APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **NOT APPROVED**

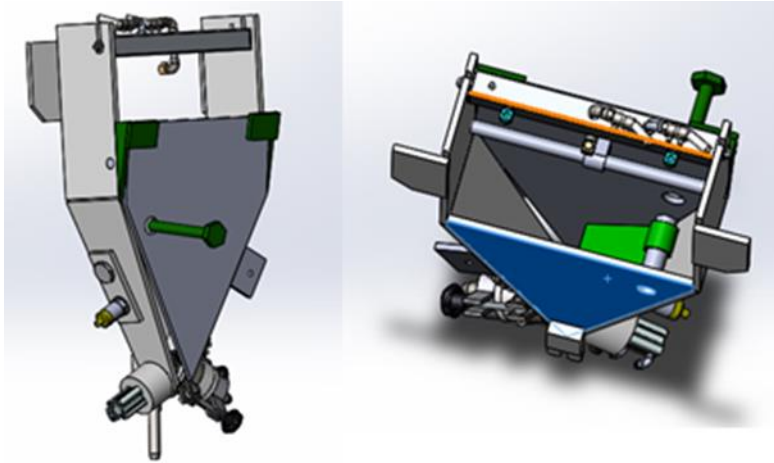


Figure 42. CAD design of the IDEA 4.3.2.

- Easy to manufacture. **APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **NOT APPROVED**

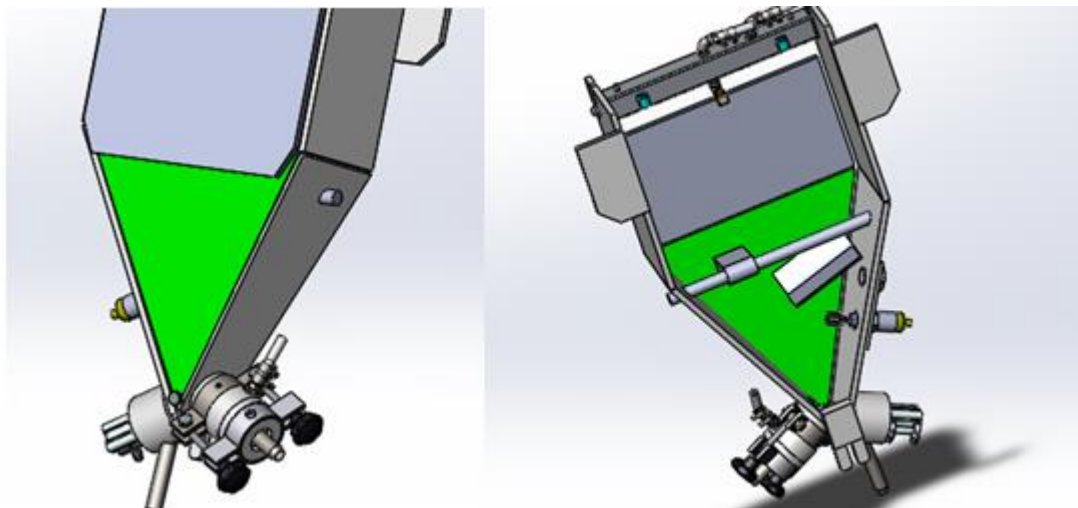
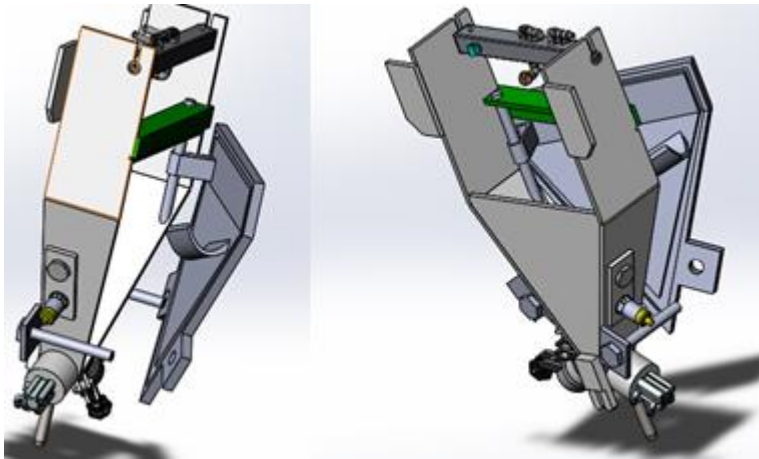


Figure 43. CAD design of the IDEA 4.4.

- Easy to manufacture. **NOT APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **NOT APPROVED**



*Figure 44. CAD design of the IDEA 4.5.*

- Easy to manufacture. **NOT APPROVED**
- Resistant enough. **NOT APPROVED**
- Similar to the original designs. **APPROVED**
- Easy to implement in the “already in the market” products. **NOT APPROVED**

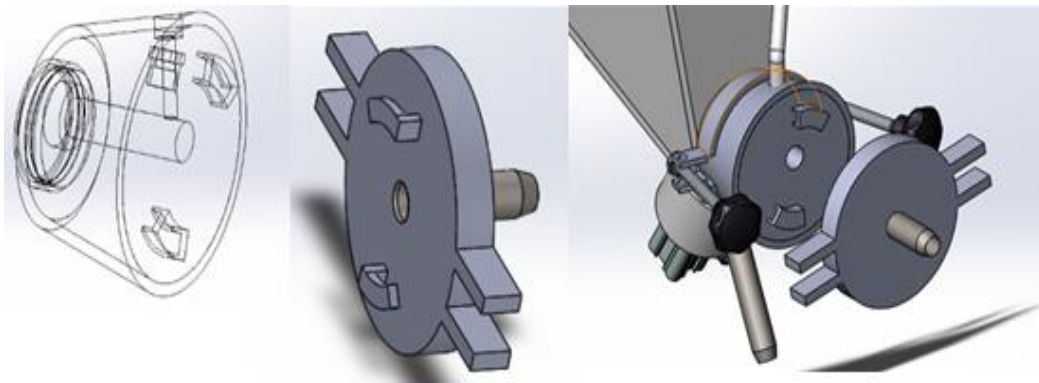
## 6 Selected designs

There were three designs that met the requirements better.

### 6.1 Nozzle concept

If we have a look at the IDEA 1.2.1, we can perceive that it can be manufactured with the same materials the original design has, a cover structure can be develop from this

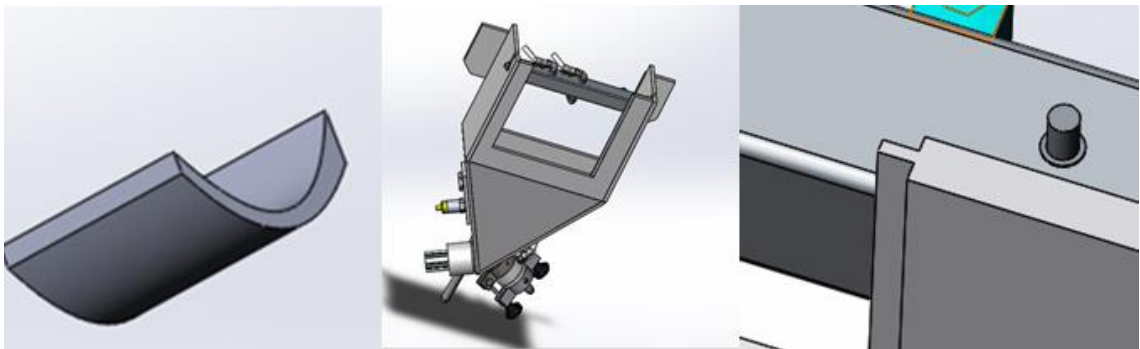
idea with the resistance required. The holders provide the solution for the maintenance problems in this zone, they help to maintain the position and to take the central part off.



*Figure 45. CAD design in details of the IDEA 1.2.1.*

## 6.2 Tank access concept

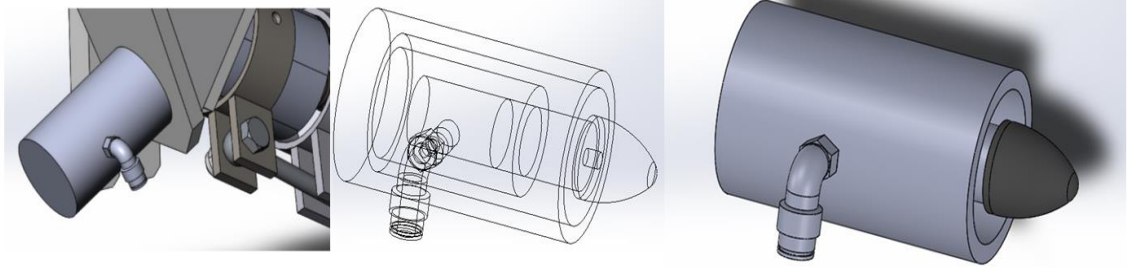
This idea has been taken from other Outotec's designs. It doesn't change the original design and it can be easily implemented to the already in the market products. There is also enough space for maintenance and the cover can be easily removed.



*Figure 46. CAD design in details of the IDEA 4.6.*

## 6.3 Express drain valve concept

The IDEA 2.3 combines simple design with an automatic system. The simple robust parts make the valve resistant enough and the connection part is the same as in the original design, so it can be easily implemented to the already in the market products.



*Figure 47. CAD design in details of the IDEA 2.3.*

## 7 Conclusions

The original design had some drawbacks that cause malfunctions as blockages, maintenance problems and false level detection. The ores usually got stuck at the bottom parts and the design of the nozzle screen didn't facilitate removing the central part from the cover. The express valve had a complex design with a rubber spring that was automatically activated with a hydraulic system when it was necessary and in the switch level position the slurry used to get stuck due to the inclination.

Brainstorming and sketch design were used as the first steps of the process, when it was necessary to create the route for the design process and the strategy that it was going to be followed. Then, there were CAD files created from those sketches in order to analyze in detail the characteristics of the possible designs in a more realistic condition.

After analyzing the CAD files there were some selected. Those concepts combined all the asked characteristics, improving the original design without changing it drastically and allowing to probably implement them in products that are already in the market.

Next step now should be creating models to test the concepts. They should be tested with the most feasible materials and maybe with the implementation in the already in the market product. As well, the standards should be checked, and the final CAD designs developed in detail.

## 8 References

1. [Www.outotec.com](http://www.outotec.com) and their original CAD files.