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Paper

CUT AND ETCH OF STAINLESS STEEL TROPHY BY AWJ

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ABSTRACT

The work for the confection of trophy in stainless steel is described using advanced technology of abrasive waterjet. The etch and cut of parts from plates were carried through in the module of abrasive waterjet at the Laboratory of Rock Mechanics in the Mining and Petroleum Engineering Department Polytechnic School of at University of São Paulo. The initial conception made by architect and its further modifications are described step by step in this article; the final work was crowned of success.

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1. INTRODUCTION

Figure 1 shows a conception of a trophy drawn for the organizer of Brazilian event, 4th EBRACE, to be distributed during its accomplishment in March of 2006.

As it can be observed in the initial project, the trophy is constituted by three stainless steel parts in-cased. The circular base of the trophy would have two grooves for rabbet of the vertical parts, with a diameter of 18 cm and a thickness of 5 mm. The ver-tical parts in turn would have a rabbet that will form the assembly presented in the inferior part of Figure 1. These last two parts would be cut of stainless steel plates with 3 mm of thickness.

2. GENERALITIES

Advanced techniques of cutting, milling and clean-ing of engineering materials as glasses, rocks, metals and polymers among others, use high speed and pressure waterjet. In reality there are two systems (Momber & Kovacevic, 1998): the suspension wa-terjet that has two-phase (abrasive and water) and the injection waterjet that are three-phase (solid abrasive, water and air).

The cut of fuel ducts, as gas or oil, requires the use of the called suspension waterjet that has acro-nym ASJ (abbreviation for the name in English of Abrasive Suspension Jet). This system is prevented from the presence of the air oxygen, therefore, any spark decurrently of the impact of the garnet in the steel could provoke an explosion for the remaining vapor presence of the fuel (Mendes et al. 2000).

The second system, that works with pressures of the order of 290 MPa or superior, is understood as ultra-high pressure waterjet, called injection waterjet or known as acronym AWJ (Abrasive Water Jet). This system is available in the University of São Paulo and has been used for researching cut of rocks (Cortés & Hennies, 2003; Cortés et al., 2005; Lau-and & Hennies, 2005).

The powder abrasive more commonly used is a mineral known by the name of garnet, a silicate rock (Hennies et al., 2003).

When required to perform the task of cutting the Trophy, since the module of abrasive waterjet at the University of São Paulo, makes use of a modern imported system of U.S.A., financed by FAPESP, was tried as first stage to confection the requested project. Recording the contour of the figures by milling, and to follow cutting its perimeter in stainless steel plates of the three parts.

For this purpose, it was necessary to create drawings in CAD in the computer system with three parts, for there etch and cut.

The automated system of etch and cut of parts of company OMAX, uses computer programs and is composed of two software programs known by the names: Drawing (Layout) and Confection (Make).

The main objective of the Layout software is to create a plotline that begins at a known origin and then goes through all the lines of the desired drawing (arcs or straight lines) ending in a final point.

Therefore, the drawing of the desired forms must be designed, auxiliary lines to connect all drawing are added, and finally a path is determined for the route that must be traversed by the systems nozzle.

The Make software uses the ordered archive generated for the Confection of the part, and is the CAM (Computer Aided Manufacture) of the system.

In the next items the stages are described in more detail for the needed drawing to confection the trophy.

3. THE 3 DRAWINGS IN CAD OF THE PARTS

One verifies in the conception of the project of Fig-ure 1, that the Trophy FEBRACE 4th is composed by three parts, two vertical parts you incased between itself (parts of number 1 and 2) and a circular base (part 3) with groove for the rabbet of the two vertical lines.

For the accomplishment of the project was nec-essary to create five drawings, being two of only etch and three of etch and cut.

As in the etch of the waterjet it creates a kerf of the order of 1 mm of width, some details as very small letters of the base had been eliminated.

Figures 2 until 6 show the archives of these draw-ings that have the terminations dxf, of the programs in CAD.

For the confection of the first model we use available stainless steel plates, that had been used as electrodes in previous projects being available as remnants in the Department, and gently yielded by the of Ore Treatment Laboratory.

The Figure 7 identical to previous Figure 6 shows in green lines the contour of the remnant of the stainless steel electrode.

The sequence of operations for the confection of the three constituent parts from its drawings above illustrated in archives with termination dxf is the use of these archives to create others with termination ord.

The order is made to indicate to the system what route or way the nozzle of the machine must follow to confection the part. The color of the line indicates what must be made. Thus, when the line is green there will be a simple displacement of the nozzle. There are five colors of cut quality, that go from red to blue. The gray color clearly indicates that etch will be made using abrasive.

In the ground of the Figures 2 up to 7 a squarelined net can be seen, it serves as a scale. This squared net has a side of an inch.

All the drawings presented above had been made in the software program called layout, that follows the systems of abrasive waterjet of company OMAX. The order is exactly made in this layout software program with a command called path.

4. ETCH AND CUT OF THE PARTS

Once drawings of the archives with terminations in dxf are made, and commanded generating archives of same name but with termination ord, the work can move on to the stage of etch and cut of the parts.

As parts 1 and 2 possess etch in both sides, it was necessary to first etch the front, and then invert the plate, to record the verse and also cut its contour.

In the Figure 8 it is shown front of part 2 in which a simpler rectangle (see drawing of Figure 4), which was initially etched, followed by capsized for then the etch of the verse and to be also cut. In Figure 9 (drawing of Figure 5) it is shown the second stage in the confection of part 2.

The job of abrasive waterjet in metal cut normally creates kerfs or grooves that have peculiar geometry, as it is shown in figure 10.

In this kerf a superior area can be noticed where the cut is smooth, followed by a rough area. The slower the speed of nozzle translation, the higher the quality and the smaller the zone of the roughness cut area. Besides, the impact of the abrasive creates a rounding in the superior part of entrance of the abra-sive waterjet that is the called the initial zone of damages and in metals it forms small burr in the in-ferior part seen the material to be malleable.

An additional aspect is: the width of the top in general is little bigger than the width of the base of the kerf and its relation is the known as tape. In Figure 10, the nomenclature normally used to assign to each one of these geometric elements is indicated. In Figure 11 it is shown a photography of the etch and cut Trophy in the system of the module of abrasive waterjet.

The cost for simple cut, or etch and cut can be evaluated, depending on the desired quality. For evaluation of the costs 3 alternatives had been stud-ied, that they are excellent finishing (quality 5), good finishing (quality 4), and reasonable finishing (quality 3), calculated for each part the time of confection and the associated cost. The result of these data is presented in Table 1.

In total 120 programmed cuts, the conclusion is that the cost of the work can oscillate between 1488.96 and 881.88 Reals. In this table the times of cut without the evaluation of the etch time had been only evaluated. As in the etch it uses bigger speeds of the nozzle, the additional cost for unit is little significant.

5. PROJECT OTIMIZATION

Deeply analysing the initial project of the Trophy FEBRACE 4th, it has been verified that an optimiza-tion was necessary. The etch of the metal made by the abrasive waterjet, always introduced in the initial point a deeper point, which was impossible to pre-vent. Thus, with the done etch not by waterjet but by the laser technology presents a better finishing.

Another aspect to modify was the thickness of stainless steel plates to be used for the confection of the two vertical parts and of the horizontal base, ini-tially foreseen to be of 3 and 5 mm respectively, they could be changed to give minor weight to the trophy, if the used plates can be reduced for 2 and 3 mm.

Finally, the third and last aspect for economy of cut, a modification is done in the base of the profiles of the vertical parts, which have now rabbet rectan-gles in the base.

This way, new drawings were used for cutting the parts, plates of 2 mm for the vertical parts and of 3 mm for the base of the trophy were used.

In Figure 12 this new optimized project with the drawing of the three parts is presented. Figure 13 shows part number 1 in which a weather vane is drawn over a rectangle. Figure 14 shows part number 2 a vertical rectangle. Finally, Figure 15 shows the base of the FEBRACE trophy.

6. CONCLUSION

The Figure 16 shows a photography with the FE-BRACE 4th Trophies that were cut by the advanced abrasive waterjet technology and etched by laser technology, and, distributed to participants of the event as honor for performance in the areas of sci-ence or engineering in March 2006.

7. ACKOWLEDGMENT

The Authors wish to register here his acknowledgment to FAPESP and CNPq for the financial support of the waterjet project researches.

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11. TABLES

Table 1. Make evaluation cost of cut.

Name	Quality	Nº	Time	Unity	Total
tro01	Quality 5	40	4,51	13,54	541,68
tro02	Quality 5	40	1,95	5,85	234,12
tro03	Quality 5	40	5,94	17,83	713,16
	Total	120		R$ 37,22	R$ 1.488,96
tro01	Quality 4	40	3,59	10,76	430,44
tro02	Quality 4	40	1,56	4,69	187,68
tro03	Quality 4	40	4,57	13,72	548,88
	Total	120		R$ 29,18	R$ 1.167,00
tro01	Quality 3	40	2,71	8,14	325,68
tro02	Quality 3	40	1,20	3,59	143,76
tro03	Quality 3	40	3,44	10,31	412,44
	Total	120		R$ 22,05	R$ 881,88

12. GRAPHICS

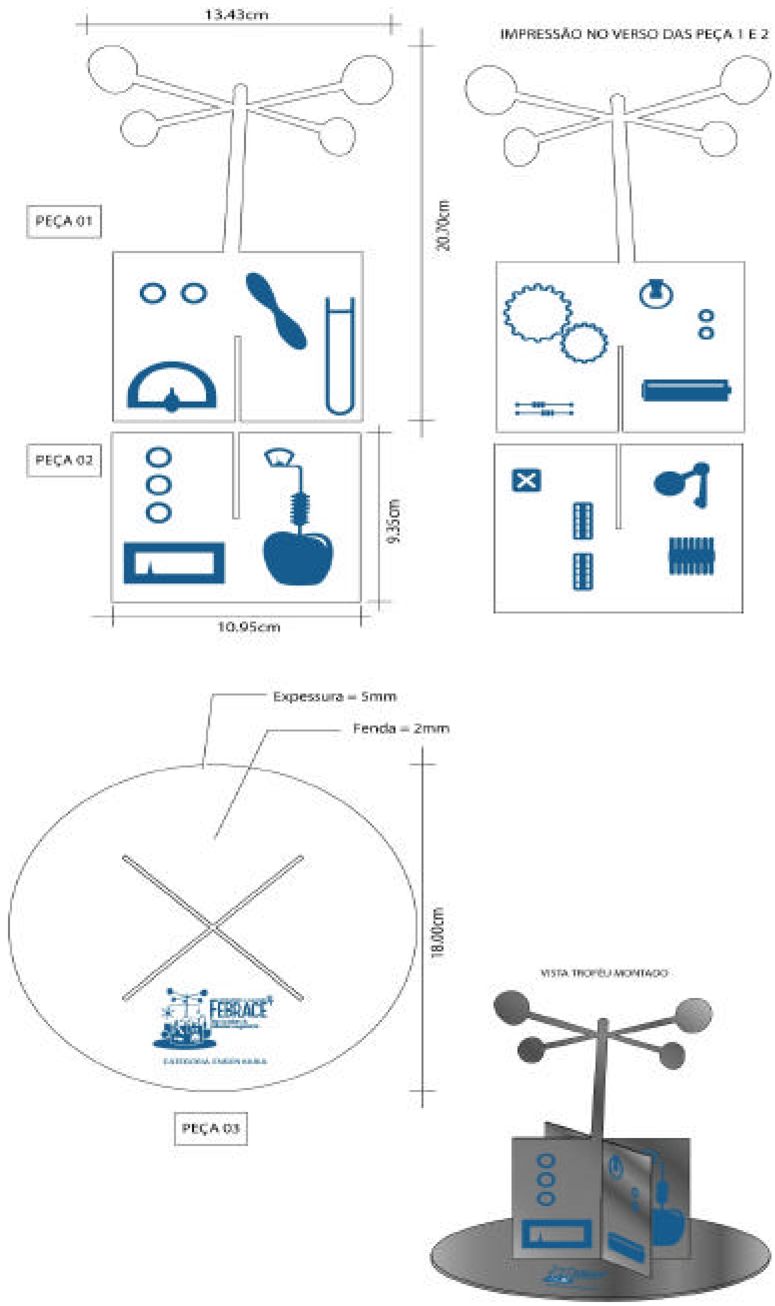

Figure 1. Initial Design Concept

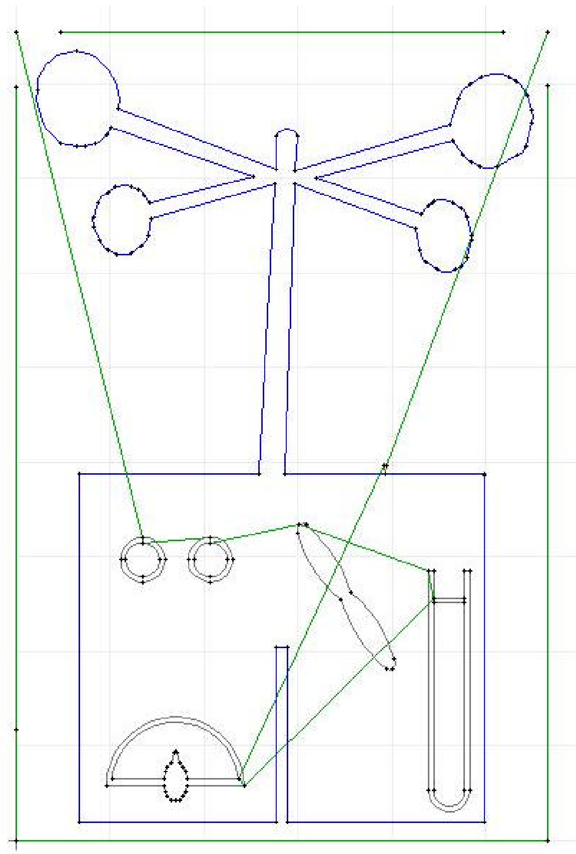

Figure 2. Drawing of part 1 front

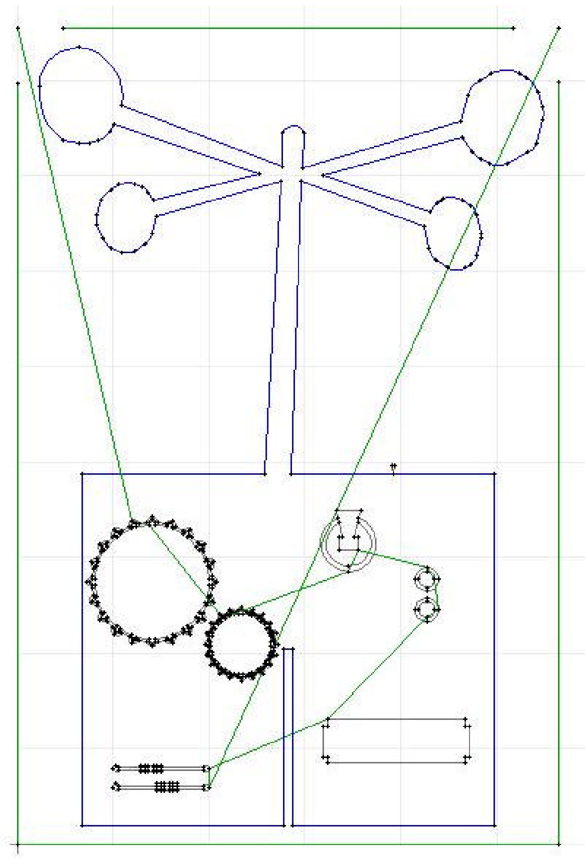

Figure 3. Drawing of part 1 back

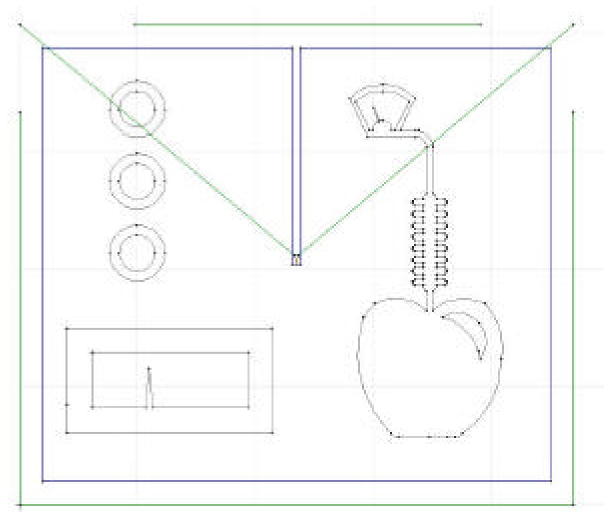

Figure 4. Drawing of part 2 front.

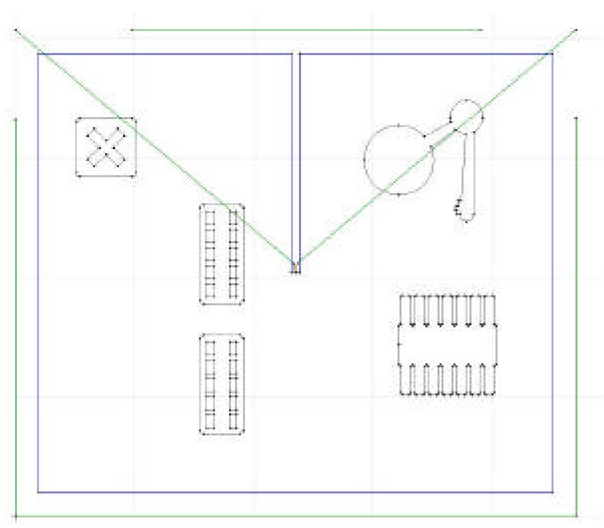

Figure 5. Drawing of part 2 back.

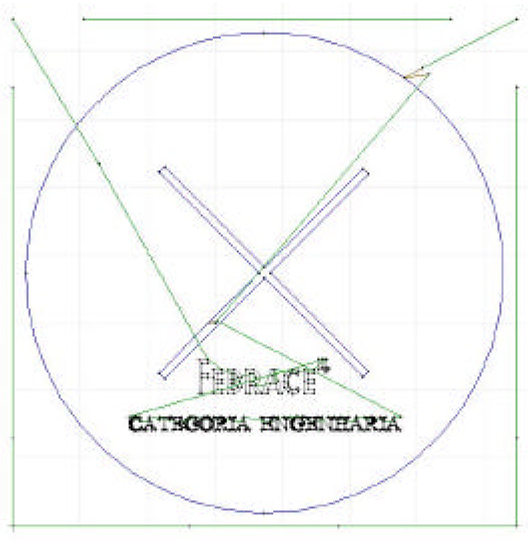

Figure 6. Drawing of part 3 – Base.

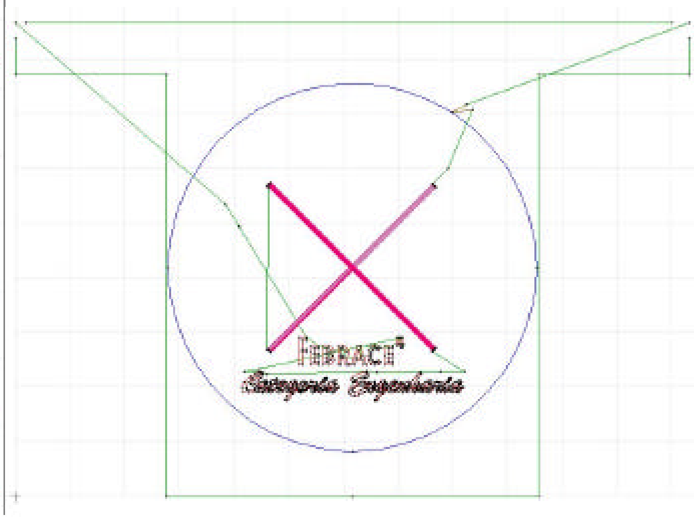

Figure 7. Drawing of part 3 –
Base in the electrode plate.

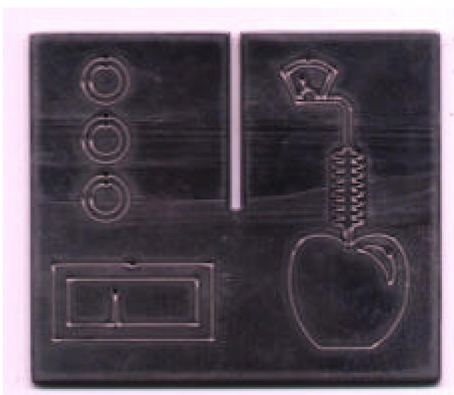

Figure 8. Front of part 2.

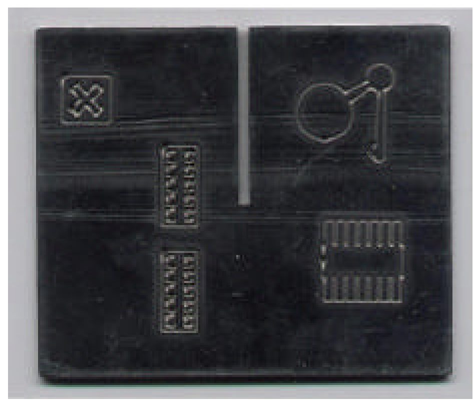

Figure 9. Verse of part 2.

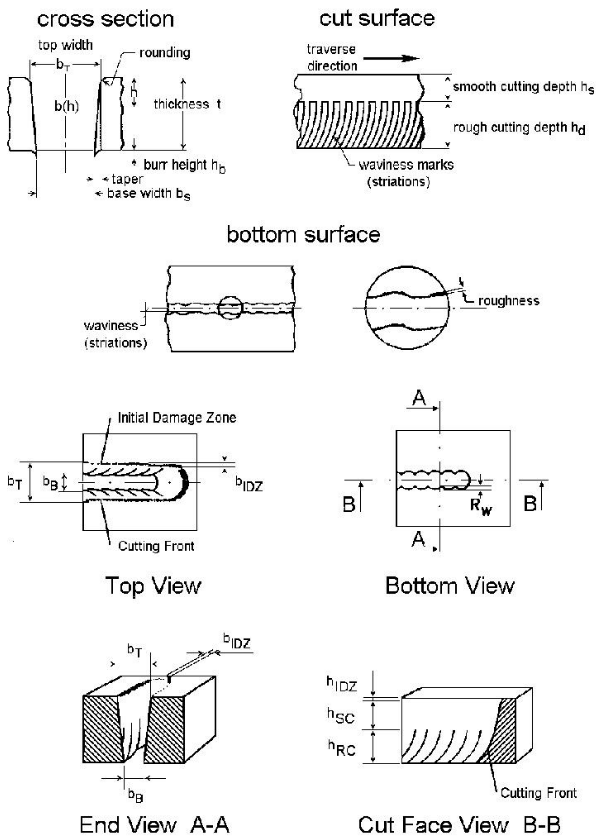

Figure 10. Waterjet kerf geometry.

Figure 11. FEBRACE 4th photography etch and cut by sbrasive waterjet.

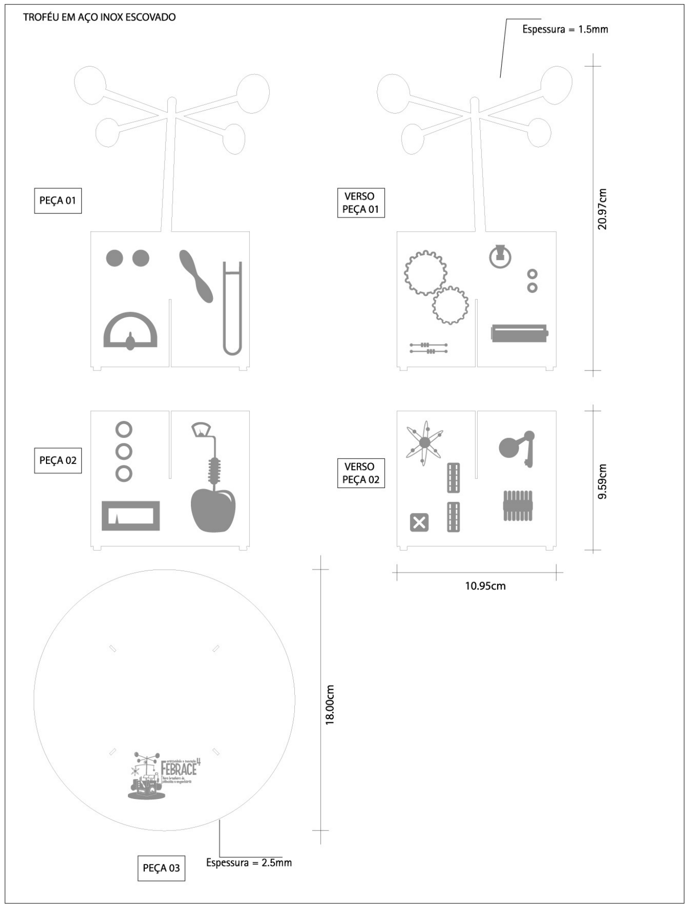

Figure 12. Optimised Trophy final project in stainless steel.

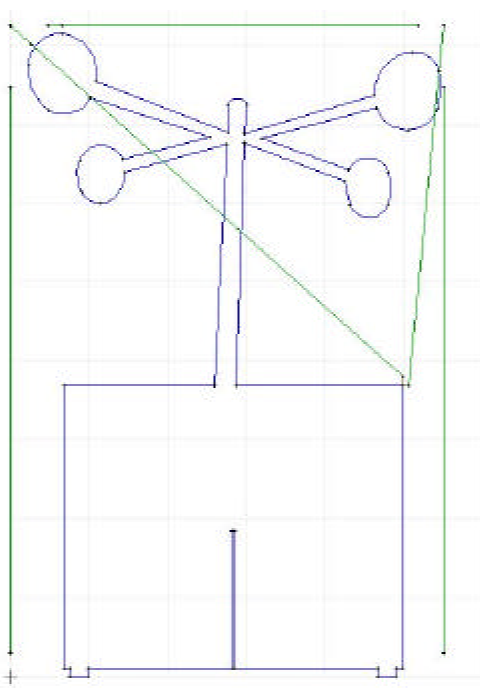

Figure 13. Final cut drawing of part 1.

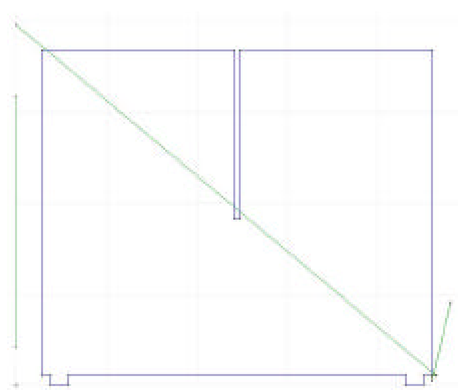

Figure 14. Final cut drawing of part 2.

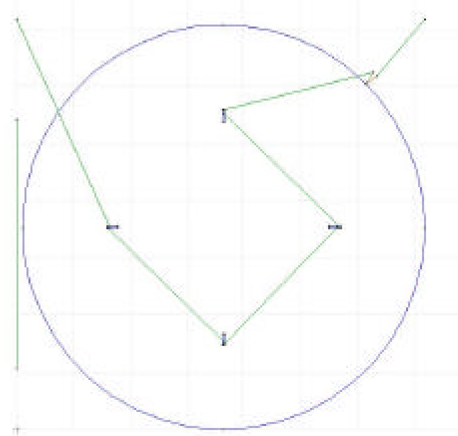

Figure 15. Final cut drawing of part 3.

Figure 16. Stainless steel trophy after laser milling.