# GEOMETRIC 3D RECONSTRUCTION OF A MODEL FOR TURBINA RADIAL VIA SIMULATION CFD

**Cláudia Cristina Barbosa dos Santos, caucrisbs@gmail.com**
**Antonio C. Pinho Brasil Junior, brasiljr@unb.br**

Universidade de Brasília, Faculdade de Tecnologia, Departamento de Engenharia Mecânica, Laboratório de Energia e Ambiente, 70910-900 - Asa Norte - Brasilia - DF - Brasil.

**Augusto Brasil, ambrasil@ufpa.br**
Universidade Federal do Pará - Rua Augusto Corrêa, 01 - Guamá. CEP 66075-110. Caixa postal 479 - Belém - Pará - Brasil

**Antonio Piratelli Filho, pirateli@unb.br**
Universidade de Brasília, Faculdade de Tecnologia, Departamento de Engenharia Mecânica, Laboratório de Energia e Ambiente, 70910-900 - Asa Norte - Brasilia - DF - Brasil.

***Abstract.*** *The creation of a computational model, from a prototype of a piece, is necessary in order to modify, improving the quality of the areas and the efficiency of the model, creating replicas of a quick and analyzing the geometry. For this technique of reconstructing the model gives up the name of Reverse Engineering. The Engineering Reserve can be implemented through the following steps: measuring the physical model, the adjustment of curves and surfaces, and the making of the model. The data collection form of the prototype can be done by a Machine Measurements by Coordinates, or MMC. This has the next step to Reverse Engineering, modeling the surface, where the model is adjusted from the interpolation of the data captured. This work will be shown the virtual reconstruction of the hot-chamber of a turbo-compressor GARRETT, A/R.47 model. The methodology used for the reconstruction of geometric model generates complex 3D surfaces, with low geometric errors, both in the turbine wheel as in his box spiral. The model generated will be used to simulate the flow in both the domestic box spiral, as in rotation created in turbine. An algorithm to generate meshes tetraédricas is also used, allowing a convenient area discretization fluid and a refinement of mesh with the solid surfaces fixed and rotary.*

***Keywords***: Virtual Reconstruction, MMC, Numerical Simulation.

## 1. INTRODUCTION

In recent years the hydroelectric potential is going through a high saturation. This has led to studies for the implementation of alternative sources of energy.

In this paper studies of these sources, where the energy production occurs through the hot-chamber of a turbo-compressor and is optimized to operate as a steam turbine. For the study, it is the virtual reconstruction of the hot-chamber of a turbo-compressor GARRETT, A/R.47 model. This reconstruction enables future numerical simulation of the chamber, which allows its optimization.

The virtual reconstruction comes to creating a computer model. This is made from the prototype of the hot-chamber subtracted from the turbo-compressor. In general, this reconstruction is required in order to:

- change to improve the quality of the areas and the efficiency of the model;
- create replicas of a quick, and
- make an analysis of geometry.

This technique, where it aims to make the virtual reconstruction of the prototype, without any involvement of the mathematical methods to determine its shape (Bezier, 1990); receives the name of Reverse Engineering. This Reverse Engineering is to become the actual shares of the prototype models and concepts in engineering. This is as stages:

- measuring the physical model, or collecting data from the same;
- setting of curves and surfaces, the modeling data, and
- the making of the model.

The data collection of model can be done by a machine Measurements by coordinates. This is known as MMC and allows one to occur digitization of the model surfaces. Well, this creates clouds of curves and surfaces of these points, which allows its reconstruction.

The methodology used for the reconstruction of geometric model allow a definition of complex 3D surfaces, with low geometric errors, both in the turbine wheel as in his box spiral. This geometric 3D model built allows the construction of a solid model. And this model solid then, is the model used to build the field of simulation of internal disposal in this turbine, both for its housing spiral, and for its rotor, or rotating to their existing fields.

From this solid model created, which will be used for numerical simulations, there is its mesh using software, the CFX Mesh, which has this as function. And then, the model simulates up after the creation of its fabric, making the use of software CFX 11.0, both of ANSYS.

## 2. TURBINES THE STEAM

The Steam turbines are the machines that use thermal energy from the steam in the form of kinetic energy.

These are the function to transform the energy contained in the steam in the form of heat and pressure into mechanical energy.

They are turbine-type reaction, or steam under pressure from a boiler entering and leaving the turbine with the same flow, and in consequence, take up a huge force of reaction, with sufficient power to rotate one or more electric generators with a high power.

The basic elements of the turbine are:

• the box spiral, and

• the rotor, which has allocated blades around its circumference, so that the fluid in motion produces a force that drives tangential, making it spin.

This mechanical energy generated is then transferred through a shaft, moving machine, a compressor, an electric generator or a propeller.

## 3. CONSTRUCTIVE ASPECT OF MACHINERY OF MEDICINE FOR DIRECTIONS

The Machine Measurements by coordinates, or MMC, is an instrument that has the ability to determine the coordinates of points on the surface of the model being worked. From these coordinates, and using computer programs, one can calculate the geometric and dimensional characteristics of this model, and they could run their virtual reconstruction.

In the case specifically of the MMC constructive aspects of this work, you can cite its structure and its bearings, in addition to their displacement transducers, probes and their apalpador, its magnetic fasteners, its unity and control of its computational programs (GPAD).

The MMC, with its shares constructive, can be seen in Figure 1 below.

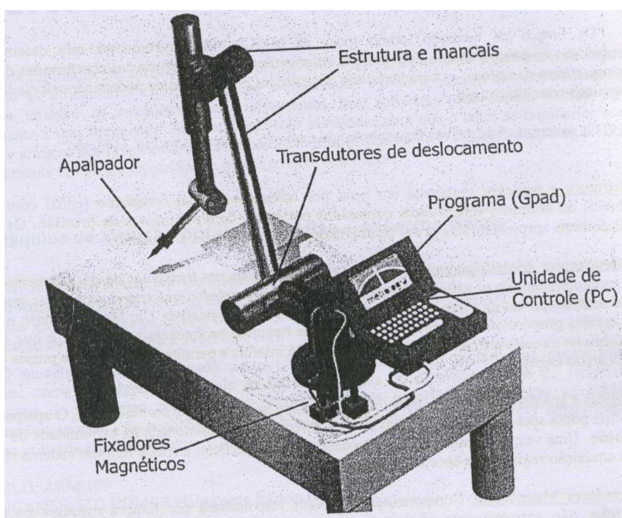


Figure 1. Machine Measurements by Coordinates

For the structure and its bearings, has been that this is made, usually by a set of aluminum tubes aeronautical or composite material. These tubes are connected through together with precision bearings. And in general, have six (6) articulated joints, which give them six (6) degrees of freedom, such as MMC used.

The displacement transducers are present in each articulation and the type angular and called encoder. This is a device opto-electronics, with 2 (two) graticulads scales that are printed in sheets of glass and have a displacement relative.

The probes and apalpador by function and find the points on the surface being checked. These apalpador can be of three (3) types, the peak drought, the sphere of steel, 15 mm radius and the sphere of ruby, with 6 mm radius. These are positioned at the end of the arm of measurement. Having determined the position of measurement on the play, the record of the coordinates of the point is run through a system of this trigger in the probe.

The magnetic fasteners are the components magnetized. They have the responsibility to fix the machine on the table of measurement. These, too, have a key that enables and disables the magnetic field. The control unit is a computer attached to the arm of measurement.

This unit performs control, processing the information obtained through computer programs. These programs are based on the method of least squares and convert the angles in certain Cartesian coordinates, making the calculations of geometry from the coordinates of certain points.

## 4. METHODS OF MEASURING

### 4.1. Machine Measurements by Coordinates

The method of measurement with an MMC, in its general form, presents the following steps.

1. Positioning itself to machinery and garment, finding the best position among both for the apalpador reaches virtually all points of the piece under study;
2. Start up the arms unit of measurement;
3. It opens up the software that captures data, converting them into IGES format, Excel and ASCI;
4. It opens up a file where data are stored;
5. Performs up the connection between the arm and controller unit. In this connection, tightened up the gray buttons in the arm and moves along its six (6) axes pleadings, until all their scales are met;
6. Choose is the type of apalpador to use in measuring, indicating that the computer program;
7. It presents itself in line piece, as a benchmark for measuring;
8. Setting up a strategy for measuring, setting up the sense of measurement, the number of points which will be measured, among other characteristics that are necessary for the geometry of the piece and detail desired;
9. Moves Up for measuring, moving up the origin of the system of coordinates of the reference of the machine to a reference in the piece, which facilitates the manipulation of data in CAD, and measuring the coordinates of points desired;
10. Save up data from the geometry in the file, and
11. Exports to them in the desired format for the virtual reconstruction of the piece in CAD.

### 4.2. The project

For the virtual reconstruction of this work, used as a model the box spiral, the hot-chamber, a turbo-compressor GARRETT, A/R.47 model. This can be seen in Figure 2 below.


Figure 2: Box of Spiral Turbo-Compressor used as a model for the measurement

Initially, it was made the measures the region's foreign box spiral. For such measures, it drew attention to the region so as to identify the points where they occur. These demarcations may be seen in Figure 3 and can be identified as the lines in the box spiral.


Figure 3: Box Spiral of Turbo - Compressor with the external boundaries for the measurement

Then, it moved the measurements of the region's domestic box spiral. For this purpose, it drew attention to the same internally, so as to follow the lines to implement the measures. The internal boundaries of the box spiral can be seen in figure 4 below.


Figure 4: Box Spiral of Turbo - Compressor with the internal boundaries for the measurement

Finally, measured to the turbine wheel, measuring only one of its blades. In Figure 5 below, you can see the rotor and the demarcations of measurement in this.

Figure 5: Rotor with the demarcations of measurement

To carry out the measurements, is used in the articulated arm and a unit of control, a computer, coupled with that arm. In this unit of control is a necessary computer program, which has as its core the conversion of the measured data. The computer program in this unit controller and was used is the G-Pad. In the case of sensors, used to the drought-edge sensors and sphere of steel, 15 mm in diameter. These sensors can be seen in Figure 6 below.

**(a)** **(b)**

Figure 6: Apalpador or sensors used to measure: a) Ponte Drought, b) Ball of Steel, with 15 mm

After the measures, made up the change of reference. This change was made passing reference to the machine to the point located in a piece under study. For a change, is used in a straight, one point and a plan, in the present model. They transfer well, the source for it, removing it from the articulated arm.

In the case of measuring the box of the spiral, following the demarcations as reference, and the case of measuring the diameter at the entrance and along the model, used to the sensor tip of drought. He was captured about 10 points to the box spiral, increasing the amount of points in the regions where the housing spiral curvature had been greater. And, in case of diameter, was captured around 5 points.

In the case of measuring the holes of the screws for fixing the box spiral and the connection between hot and cold chamber of the turbo - compressor was used for the sensor ball of steel with 15 mm in diameter.

## 5. RESULTS OF THE MEASUREMENTS

After the measurements, imported to a file format for the IGES measures. This file can be viewed through the image shown in Figure 7 below.

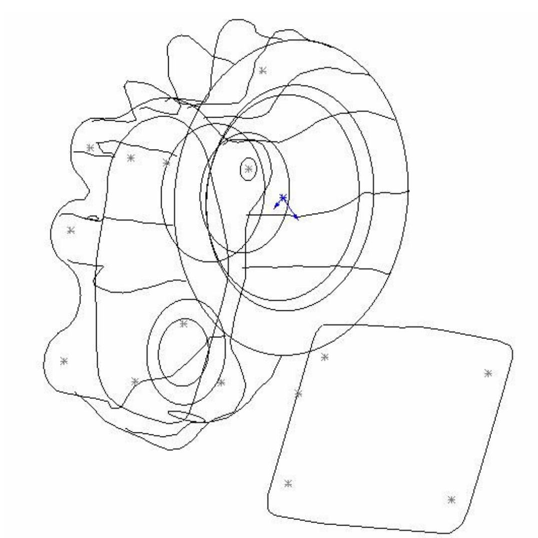

Figure 7: File IGES exported Program

From the file of the measures in IGES is possible to create technical drawings of the model in commercial CAD software. The commercial CAD software used in this study was the SolidWorks 2007. This commercial software allows the creation of a solid, which is the area required for the CFD simulation.

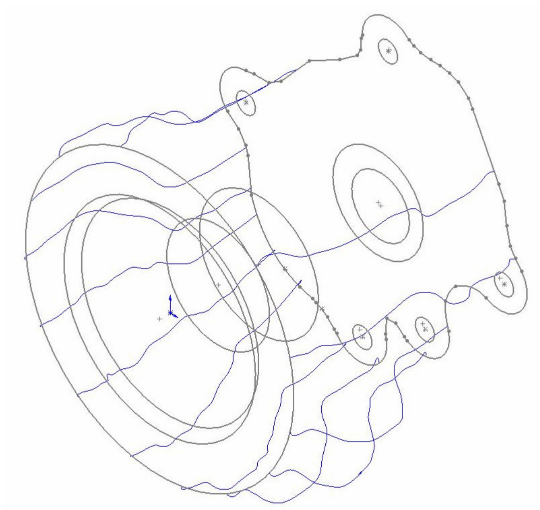

Figure 8: Curves of the region's external box spiral for the generation of surfaces and volumes

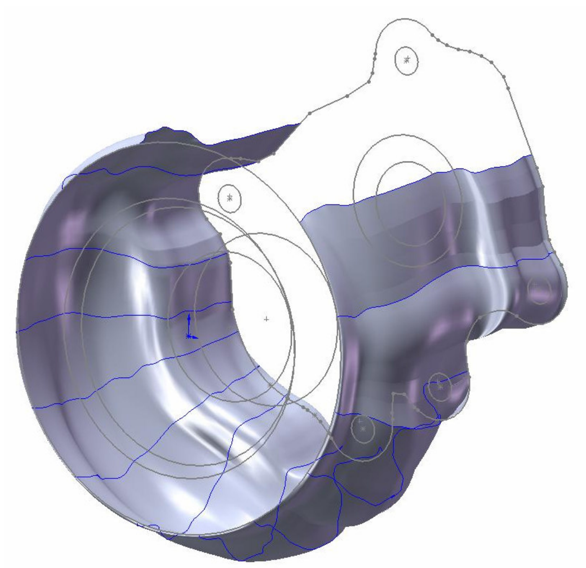

Figure 9: Area of the region's external box spiral

Using the curves found by the machine to measure by coordinates, redrawing up the curves for the virtual reconstruction of the region's foreign box spiral, which can be seen in Figure 8. From the curves redrawed, figure 8, you can create the surface of the region's foreign box spiral, as Figure 9, and may, in future, creating the volumetric field for the simulation.

From the previous drawings and curves built up the field of simulation for the box spiral. This area can be seen in Figure 10 below. This is indicated, too, the points of entry and exit of the fluid used in simulation.

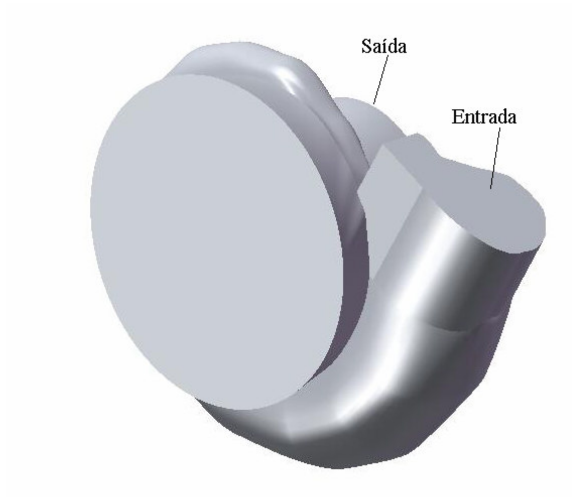


Figure 10: Field to simulate the spiral

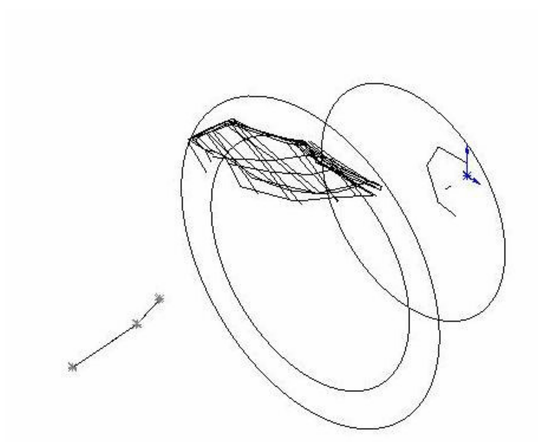

Figure 11: Curves obtained in measuring the rotor

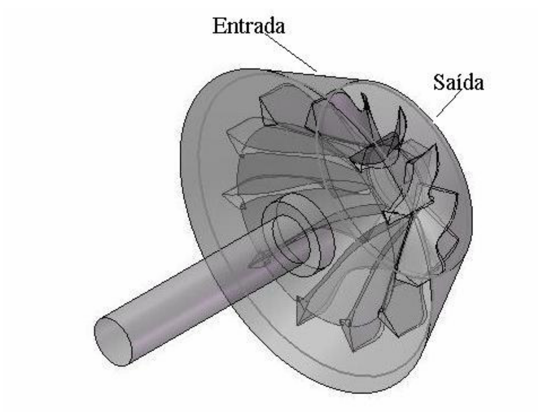


Figure 12: Field to simulated the rotor

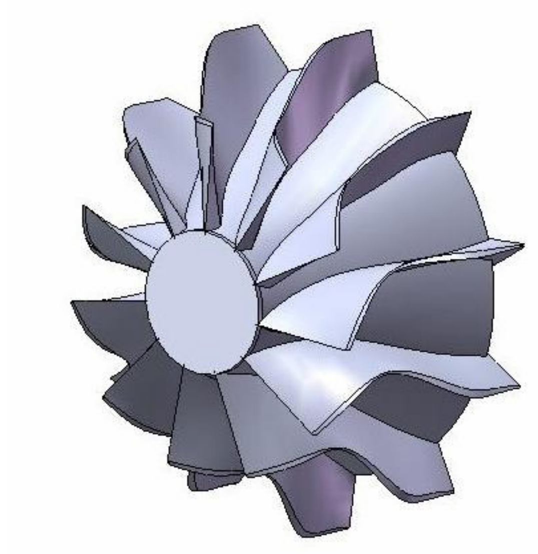

Figure 13: Rotor

The curves obtained in measurements of the rotor were for a single bucket, but with the help of SolidWorks software you can draw the wheel in full. This can be seen in Figures 11, 12 and 13 above.

For those areas was created the corresponding meshes, using the software Ansys CFXMesh. These meshes can be seen in Figures 14 and 15 below. Once created the mesh was carried out on the numerical simulation, Ansys CFX 11.0, in which some results can be seen below (Figures 16 and 17).

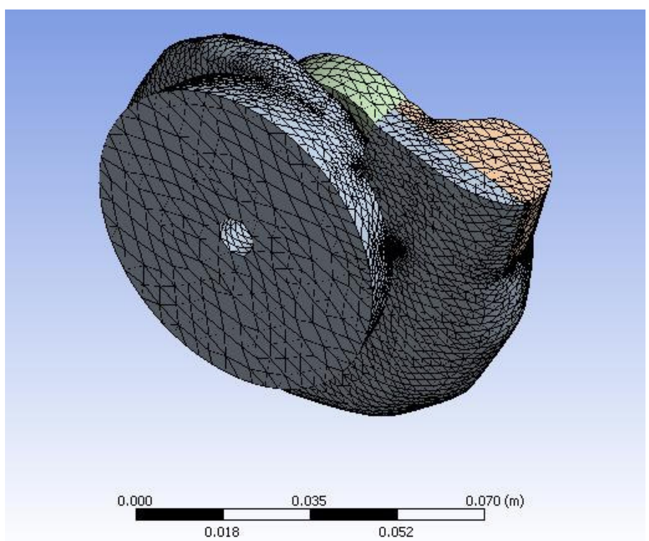


Figure 14: Loop field for the simulation of the box spiral

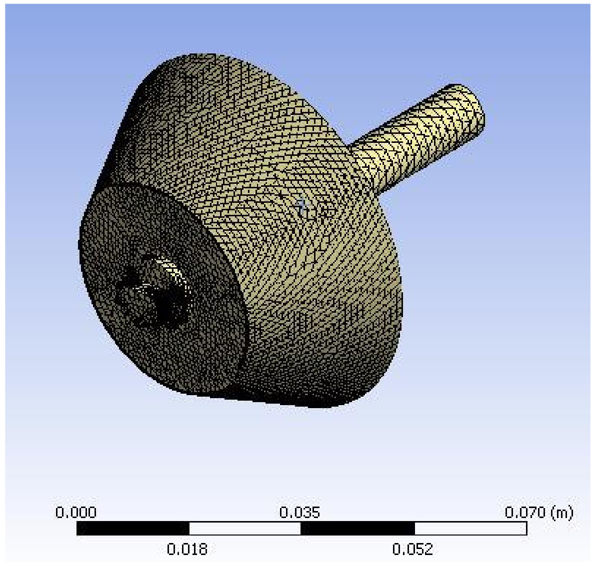


Figura 15: Loop field for the simulation of the rotor

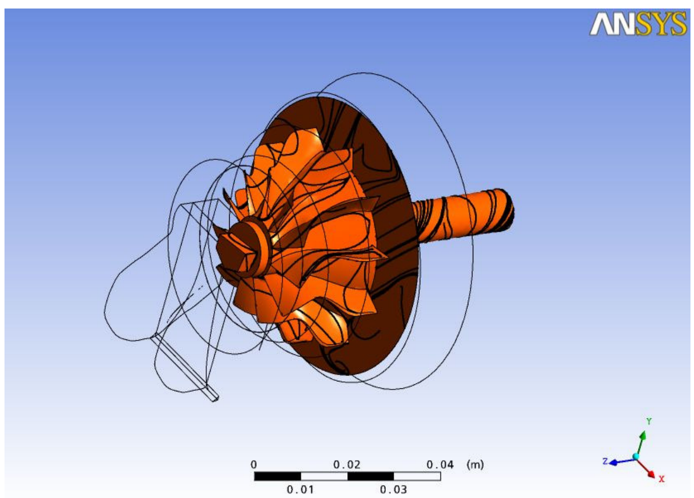


Figure 16: Surface Streamlines

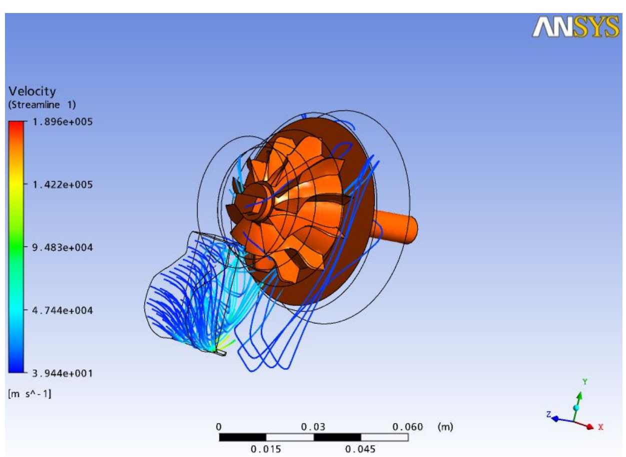


Figure 17: Streamlines

## 3. CONCLUSION

The methodology developed and described in this work, for the measurement of the region's foreign box spiral of turbo - compressor was implemented, allowing the creation of the model in CAD, through commercial software SolidWorks.

The strategy involved the measurement developed since the establishment of the model, so that does not happen with the difficulty of measuring machine, by measuring coordinates. The demarcation lines in the model with internal and external surfaces of the box spiral and the rotor. And the definition of the average number of points to be measured in each line, in addition to the sequence and direction of the acquisition of points on the lines.

You can see that after the numerical simulations it was found very different results than expected, this is because of lack of data. In spite of these data are from the boiler used in testing, does not have precise data, they fluctuate.

Future work may be directed to the acquisition of more precise data and which were not purchased.

## 4. ACKNOWLEDGEMENTS

The authors acknowledge the support of technical Tarsis de Oliveira Queiroz, Claudio and Marcos Pereira of the University of Brasilia, which contributed to the achievement of the experimental part of this work. Besides, participation of the Federal University of Para, who proposed this interesting project.

## 5. REFERENCES

Albuquerque, L. A. and Motta, J. M. S. T., “3D Reconstruction of Free-Form Objects from Range Images Acquired by Laser Scanning”, University of Brasilia, Brasília, Brasil.

Bardell, R., Sivayoganathan, K., Balendra V. and D. Al-Dabass, 1992, “The Analysis and Decomposition of Free-Form Surface Models”, Faculty of Computing and Technology, Nottingham Trent University, England.

Bronnikov, A. V. and Killian, D., 1999, “3D Tomography of Turbine Blades”, International Symposium on Computerized Tomography for Industrial Applications and Image Processing in Radiology, Berlin, Germany.

Dumoulin, Ch. et al., 1994, “Geometry Recovery of a Francis Runner Prototype at Site”, 17$^{th}$ IAHR Symposium, Beijing, China.

Piratelli Filho, A., Araújo, J. A., Brasil Junior, A. C. P., Gonçalves, C. and Horta, C. A., 2005, “Reconstrução Virtual de Rotores de turbinas Hidráulicas usando Máquina de Medir por Coordenadas”, SNPTEE - Seminário Nacional de Produção e Transmissão de Energia Elétrica, Curitiba, Paraná, Brasil.

Soares Neto, G. G., 2005, “Estudo da Reconstrução de Peças com Superfícies de Forma Livre Utilizando Máquina de Medição por Coordenadas (MMC)”, Universidade de Brasília, Brasília, Brasil.

## 6. RESPONSIBILITY NOTICE