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STUDY OF A COMPETITION BRIDLE

Javier Marqués Resano

Pablo Sanchís

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1. INTRODUCTION

The specific performance of the current engines has increased progressively, especially with the last advances so much in more light new and resistant alloys, since in the electronics and the employment of the overfeeding.

For it, the sports authorities like the FIA that there has between his principal aims implement the adoption of common regulations for all the engines and series sport of the whole world, have had to act to limit the presentations of the cars of competition applying measures to regulate between others, the power of the engines.

The thermal engines of combustion he hospitalizes that they possess the cars they obtain the mechanical energy from the heat energy that contributes the combustion of a mixture of fuel and air.

The power that provides the engine indicates the work that this one is capable of realizing to a certain speed of draft and during a certain time.

It is possible to express by means of the following formula:

$$N_e = p_{me} \cdot V_t \cdot n \cdot i \quad \text{Formula (1-1)}$$

According to this, the power that develops an engine depends fundamentally of:

- The average effective pressure of the chamber of combustion (p_{me})
- The maximum regime of revolutions capable of reaching the engine.

Therefore, the possibilities to reduce the above mentioned power are to act on someone of the previous factors.

The maximum revolutions can control by means of constrainers but they are slightly trustworthy and easy to manipulate.

On the other hand, the average effective pressure is defined as the average pressure that the gases exercise during the career of expansion of an engine.

This pressure depends principally on the air mass that gets in the phase of admission, since more air interferes during the admission, major pressure is reached in the phase of compression and as major consequence it is the power obtained in the phase of explosion.

The quantity of admitted air is directly related to the cylinder capacity, therefore limiting it might contain the "pme". But the application of the electronics has managed to optimize spectacularly the conditions of the combustion and to limit the maximum cylinder capacity of an engine it is not sufficient to contain the presentations of this one.

The best option consists of limiting of direct form the quantity of admitted air and to obtain it the bridle of admission is in use.

1.1 THE BRIDLE OF ADMISSION

A bridle is a metallic piece that reduces the diameter of the conduit of air inlet to the engine with the aim to limit the air flow that happens for the collectors. That way there is restricted the air quantity that enters the chamber of combustion and a limitation is obtained in the power of the engine.

The form and dimensions are variable and are subject to a regulation that changes depending on the cylinder capacity and on the type of engine.

The Figure 1 shows a bridle for cars with diesel engine.



Figure 1. Image of a bridle of admission. Ref.[1].

The bridle is of obligatory use for all the vehicles overfed with compressors or turbocompressors that overcome the power admitted according to his class, normally this when it excels itself in 10 % [2]. These must be equipped with a bridle fixed to the

framework of the compressor to take the power to the regulation values. According to the category and cylinder capacity of the cars there is in use a bridle or other one.

The tightening of the bridles is regulated so much in diameter as form, so that it supports his minimal throat along a measure.

If it does not expire with the form defined by the FIA, it cannot be considered validates since there would not be fulfilled the condition of strangled flow and there would not be reached the aim to limit the power looked by the sports authorities.

The bridle of admission is placed in the circuit of air admission so that all the air necessary for the supply of the engine must happen across her. According to the type of engine he places to a certain distance of the valve of admission (Figure 2) or at the entry of the turbocompressor (Figure 3) depending on the case.

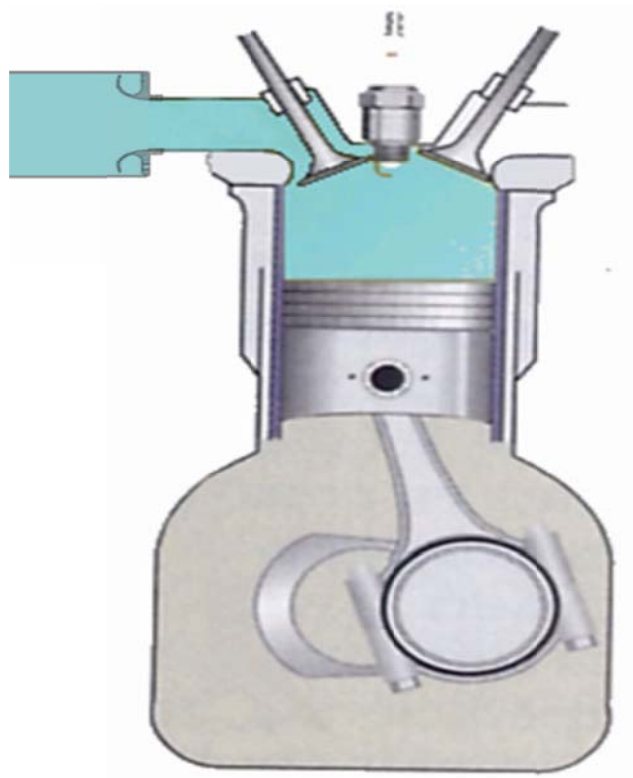


Figure 2. Bridle in air collector. Ref.[3].



Figure 3. Bridle in the entry of a turbocompressor. Ref.[3].

1.2 FUNCTIONING OF THE BRIDLE

The bridle bases his functioning on the concept of strangled flow or critical flow.

When a gas crosses an orifice (Fig.4), there is an occasion in which the speed of the orifice comes to sonic conditions, that is to say, the speed reaches the value equivalent to Mach 1.

This happens when the absolute pressure of exit is equal to 52.8 % of the absolute pressure of entry, or what is equal, when the quotient between the pressure of exit (P2) and the pressure of entry (P1) is equal or lower than 0.528 as expresses the equation:

—

Formula (1-2)

When this happens for much that we increase the absolute pressure of entry P1, the speed to the exit V2 does not increase.

One manages to strangle the speed of the flow so that this one remains constant.

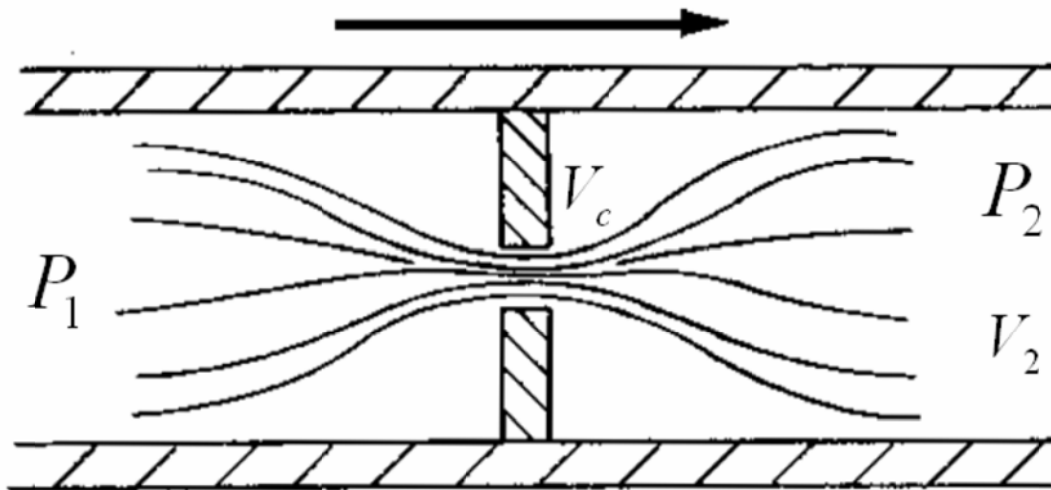


Figure 4. Scheme of flow crossing an orifice. Ref.[4].

But though it is named a strangled flow, it is a mistake to consider that due to this strangulation in the speed, a flow is obtained flow constant.

The flow remains constant providing that the pressure of entry P_1 is constant, if this pressure increases the density of the air (ρ) increases and also the flow does it (m) since it depends on the density (Formula. 2-3).

Formula (1-3)

The same thing happens with the bridles of admission. On having had convergent form or convergent - divergent (Figure 5), according to the model, when there reaches speed Mach 1 in the throat (the zone of minor diameter) of the bridle produces a strangulation to itself in the speed of the flow, that is to say that the speed to the exit of the bridle happens to be a constant.

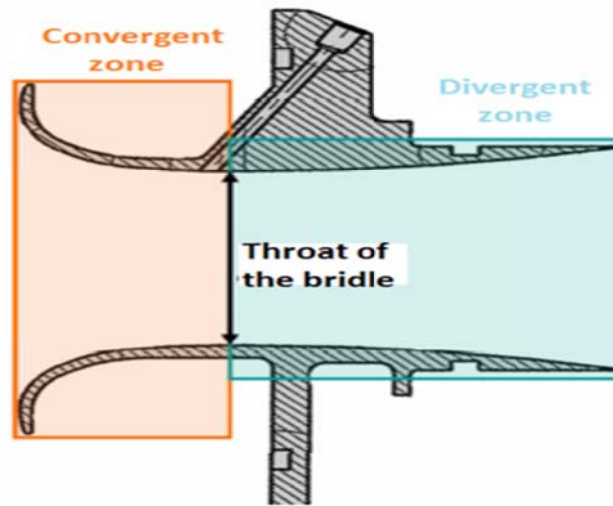


Figure 5. Scheme of a convergent - divergent bridle. Ref.[5].

When this happens, though the revolutions increase per minute (rpm) of the engine, the speed of the flow to the exit does not increase and the flow of air inlet to the engine does not increase, for a pressure of constant entry, and a loss of power takes place.

For it, it thinks that the employment of the bridle in the admission is an effective way of equalizing the presentations between very different engines.

2. AIMS OF THE PROJECT

The aim of the work is to analyze the air flow that crosses different bridles to see in what cases a major flow is obtained flow of air.

For it tells itself with 8 different models from bridles of admission provided by SEAT Sport and that they have used as base for the study.

From the geometries of these bridles and with the intention of increasing the flow of exit, modifications were realized in the convergent zone to verify if it is possible to increase the pressure of entry that, as is explained in the previous paragraph, it is the parameter that can increase the air flow of exit.

3. REVIEW OF LITERATURE

In this chapter the physical aspects of the flow are described, with the aim to provide the basic knowledge of the mechanics of necessary fluids to carry out this project.

3.1 FUNDAMENTAL EQUATIONS

The equations that govern the mechanics of fluids are obtained by the application of the beginning of conservation of the mechanics and of the thermodynamic one.

Three fundamental equations are:

- The equation of continuity
- The equation of the quantity movement
- The equation of the conservation of the energy

3.1.1. EQUATION OF CONTINUITY

The equation of continuity [5,6] expresses the conservation of mass. It is necessary for the analysis of flows across pipes or conduits with diameter variable. The speed of the flow changes due to the fact that the transverse area of conduit changes from a section to other one.

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \cdot \vec{V}) = 0 \quad \text{Formula (3-1)}$$

If it is considered to be a stable flow across a fixed volume as one tank with an entry and an exit, the reason with which the fluid enters in volume must be equal to the reason with which the fluid goes out of the volume for that fulfills the fundamental beginning of conservation of mass.

The flow of mass m and that goes out of the volume express by means of the following equation:

$$\dot{m} = \rho \cdot Q \quad \text{Formula (3-2)}$$

Where ρ is the density and Q the flow. If the area of exit of the volume perpendicular to the flow it is to and the fluid goes out to a speed V , at the time the flow of mass it expresses like:

$$\dot{m} = \rho \cdot V \cdot A \quad \text{Formula (3-3)}$$

3.1.2. EQUATION OF QUANTITY OF MOVEMENT

The equation of movement of a fluid is obtained applying the Newton's second law, according to which the variation of the quantity of movement of a portion of fluid is equal to the resultant one of the forces that acts on this portion.

$$\vec{F} = m \cdot \vec{a} \quad \text{Formula (3-4)}$$

Departing from the Newton's second law, the equation of quantity is established of linear movement for a volume of control.

$$\Sigma \vec{F} = \frac{\partial}{\partial t} \int_{VC} \rho \cdot \vec{V} dV + \int_{SC} (\rho \cdot \vec{V}) \vec{V} dS \quad \text{Formula (3-5)}$$

It is a question of a vectorial equation, in which the first term evaluates temporary variations of the quantity of movement inside the volume of control, whereas the second term studies the quantity of movement that enters and goes out for the surface of control.

These variations of quantity of movement between next and salient flow of the surface of control, (considering permanent flow) they give place to a force on the body submitted to study.

The quantity of movement obeys a law of conservation, which means that the quantity of total movement of any closed system (or one that not it is affected by exterior forces, and whose internal forces are not squandering) it cannot be changed and remains constant in the time.

3.1.3. EQUATION OF THE CONSERVATION OF THE ENERGY

The law of conservation of the energy [5,6] establishes that the value of the energy of a system isolated (without interaction with any other system) it remains invariable with the time.

The conservation of the energy of a system is tied to the fact of that equations of evolution are independent from the considered instant. It is to say, the fact that in his temporary evolution of a system all instants of time are equivalent, it does that the magnitudes of the same one change coordinated in such a way that certain magnitude called energy remain constant.

The equation of the conservation of the energy can express by means of equation:

$$\frac{\partial}{\partial t} \left[\rho \left(e + \frac{v^2}{2} \right) \right] + \nabla \left[\rho \left(e + \frac{v^2}{2} \right) \mathbf{V} \right] = \rho \cdot \dot{\mathbf{q}} - \frac{\partial(\mathbf{u}\mathbf{p})}{\partial x} - \frac{\partial(\mathbf{v}\mathbf{p})}{\partial y} - \frac{\partial(\mathbf{w}\mathbf{p})}{\partial z} + \rho \cdot \mathbf{f}$$

Formula (3-6)

3.2. BERNOULLI'S BEGINNING

Bernoulli's beginning [7] affirms that the mechanical total energy of a flow uncompressible and not viscous (without rubbing) it is constant along his path.

The energy of a flow can decompose in three types of energy:

- Kinetic Energy (E_c): energy of the fluid due to his speed.
- Potential gravitational Energy (E_p): it refers to the energy that it possesses mass of a fluid due to his elevation I concern the level of reference.
- Energy of pressure (E_{pr}): or energy of flow, it is due to the pressure of fluid capable of realizing work.

Therefore, the total energy of a fluid, considered the ideal case, will be the sum of three mentioned energies previously:

$$E_t = E_c + E_p + E_{pr} \quad \text{Formula (3-7)}$$

If it thinks that the mass is the product of the density for the volume, in addition, if it is supposed that during a pipe of variable section one passes ideal fluid, there is obtained the equation known as Bernoulli's Theorem:

Formula (3-8)

Where the subscripts 1 and 2 refer to points placed in the line of current of the fluid.

This theorem can be applied, for example, in pipelines where the flow it accelerates if we reduce the diameter of the pipe with the consequent falls of pressure.

According to the equation of continuity and Bernoulli's equation if it diminishes transverse area of a conduit, since it happens with the bridles, the air that it circulates along the above mentioned conduit suffers acceleration in speed and one decrease in pressure.

3.2.1. VENTURI'S PIPE OR EFFECT VENTURI

The effect Venturi [7] is based on a device that incorporates the simple one convergence and difference across a section and it uses the beginning of Bernoulli to relate the speed to the pressure of the fluid.

Venturi's pipe (Figure 6) it is used to measure the speed of the flow of one fluid. In the throat of the pipe, the area is reduced of A_1 to A_2 and his speed it increases of V_1 to V_2 . In the point 2, where the speed is maximum, pressure is minimal.

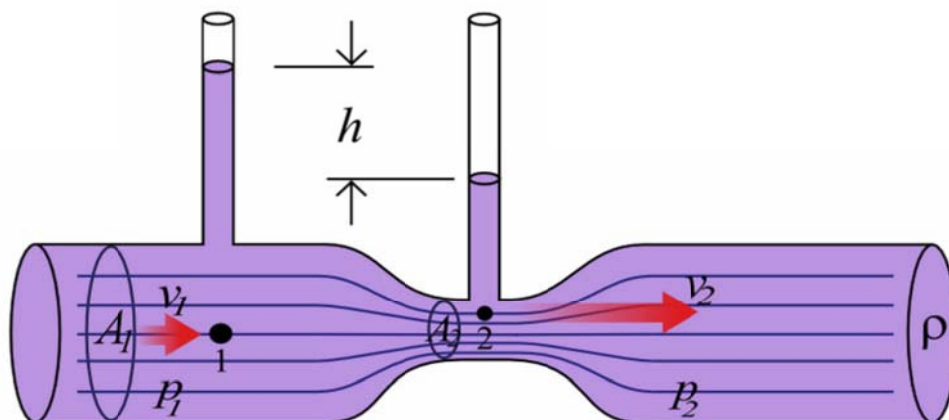


Figure 6. Representation of Venturi's pipe. Ref.[7].

This device is in use for measuring the flow of a pipeline. When the flow it crosses the throat of Venturi's pipe, the speed increases notably, and in consequence, the pressure diminishes; the expense transported by the pipeline in the case of an incompressible flow this one depending on the reading of the gauge.

The pressures in the entry (section 1) and in the throat of the pipe (section 2) they are real pressures, while the corresponding obtained speeds in Bernoulli's equation without a term of losses they are speeds theoretical. If they are considered to be the losses in the equation of the energy at the time it is a question of real speeds.

3.3. CONVERGENT - DIVERGENT TOWEL

The form of the bridges is alike that of a convergent towel or towel convergent - divergent, depending on the case.

Since one has seen in the previous paragraphs the air flow that circulates for bridge suffers acceleration in speed and a decrease in pressure when it approaches the throat and later when the throat spends the speed it diminishes and the pressure returns to increase.

Considering a stationary flow isentropic [5] that it circulates across one convergent and divergent towel like shows in the (Figure 7), if it is reached Mach's speed 1 in the throat of the conduit, the regime of the flow happens to be locally subsonic (low speed to $Mach=1$) in the section convergent, sonic in the throat (transverse minimal area) and supersonic (top speed to $Mach=1$) in the divergent section.

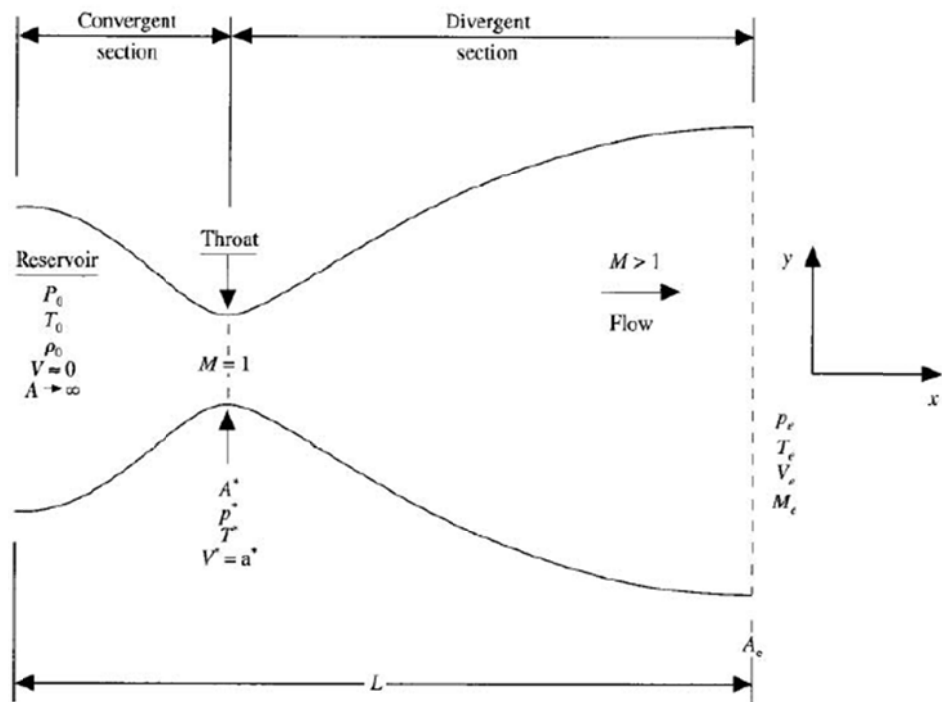


Figure 7. Scheme of the flow across a tewel convergent - divergent. Ref.[5].

It is possible to deduce that due to the fact that the flow behaves in an inverse way when it happens of subsonic to supersonic, the way of obtaining speeds of gone out superior to those of entry in a convergent - divergent tewel it is to come to sonic speeds in the throat of the tewel.

4. DESIGN PROCESS

4.1. WHAT IS THE DYNAMICS OF FLOW COMPUTATIONALLY?

The Computational Dynamics of Fluids (CFD) [8] is a branch inside the mechanics of fluids that uses the numerical methods and algorithms to analyze problems related to the flow of fluids.

CFD allows the accomplishment of detailed calculations of any system in which they control fluids, by means of the resolution of the fundamental equations of conservation of matter, energy and quantity of movement for the particular geometry of every considered system.

The obtained results are the values of all the variables that characterize the system (since it is speed, pressure, temperature, composition, etc ...) in each of the points of the same one.

These simulations allow a new perspective of the problem that is not possible by means of the traditional methods. In many problems the dynamics of the involved flow is decisive in the optimization of a technology. In our case, the way most adapted for the optimization of the bridles is the analysis CFD since his small size impedes the study by means of a wind tunnel.

The numerical simulation has been replacing gradually the experimental methods used for a long time in areas as the aerospace engineering. This growth owes principally to the creation and improvement of the computers of high speed, since the simulation CFD needs the manipulation of a great number of information, impossible to realize without the help of a computer.

Actualmente el CFD se aplica a prácticamente cualquier área de la ingeniería tanto en mecánica, como química o tecnología médica.

4.2. STAGES IN A SIMULATION CFD

A simulation CFD consists of 4 stages: generation of the model 2D or 3D, mesh of the domain, resolution of the equations and analysis of the results.

4.2.1. GENERATION OF THE MODEL

The generation of a two-dimensional model or three-dimensional CAD (Computer Aided Design) of the geometry of the fluid domain it is the first step and is in the habit of being done from the planes 2D.

The model must support the initial geometry and the relevant characteristics to capture the flow there being able to be overlooked details that to level of manufacture would be essential but from the point of view of the physical processes that happen they are considered of void importance. In case of the bridles, they interest those zones that have contact with the air by what there can be omitted some parts of the exterior geometry as the hollows for the screws, etc ...

4.2.2. MESH OF THE DOMAIN

To divide the domain of the fluid in small cells called elements or finite volumes that form a mesh is the second stage.

According to the characteristics of the geometry one is chosen or forms other one of the above mentioned elements to obtain a better mesh.

The complexity of the physics involved together with the size of the domain defines in outline the size of the problem and the necessary power of calculation. The density of nodes or elements can change a few regions to others must accumulate a major number of them in the zones where there are waited strong variations of some variable. It is important to know in what zones major gradients are waited and to determine there a thinner mesh. In case of the bridles, the interior zone and in I make concrete the throat of the bridle it is the one that a thinner mesh receives. The quality of the mesh determines partly the quality of the obtained results.

4.2.3. RESOLUTION OF THE EQUATIONS

The equations that govern the transfer of mass, quantity of movement, energy, etc..., they are solved in each of the elements of the mesh generated in the previous step. Since the equations that are in use are partial derivatives before it is necessary to turn them into algebraic equations (introducing numerical mistakes of divide and truncate) using the most suitable numerical schemes. This way it passes of having a set of equations in partial derivatives on a constant space (x, and, z, t) to a finite system of algebraic equations with independent discrete variables (x [i], and [i], z [i], t [j]). The number of equations to resolving depends on the system.

Associated with the quantification of mistakes they find the concepts of check and validation of the calculations. It is called a check of the model to the checking of which the equations are correctly decisive.

This little has to see with the physics and is a question purely of numerical calculation. The validation of the model, on the contrary, consists of determining adapted of using the equations that really are solved as approximation of the mathematical model of the physical process.

4.2.4. ANALYSIS OF THE RESULTS

Once solved the equations, he arranges of the values of the variables that define the problem in each of the elements of the mesh. If in addition the problem is not stationary, a set of information is obtained by every passage of time. Since it is of waiting there is obtained a great quantity of information, between which it is necessary to extract useful information.

To visualize the flow and related aspects is the best way of understanding the process and going directly to the ideal solution. This part is the most important or though the most interesting since the obtained results have to be interpreted and see if they fit with the awaited thing.

4.3. NECESSARY SOFTWARE

4.3.1. SOLIDWORKS

SolidWorks is a program of computer-aided design for shaped mechanic. He is a patternmaker of solid parametric, who uses the kernel of shaped geometrically.

The program allows to shape pieces and sets and to extract of them so much flat as another type of information necessary for the production. It is a program that works with base in the new technologies of shaped with systems CAD.

The process consists in export the mental idea of the designer to the system CAD, "constructing virtually" the piece or set. Later all the extractions (planes and files of exchange) are realized in an automated enough way.

4.3.2. GAMBIT

GAMBIT (Geometry And Mesh Building Intelligent Toolkit) is a program that allows to realize all the operations of pre-accused for the analysis CFD.

His more important usefulness is the creation of the geometries, the generation of the mesh, the possibility of examining the quality of the mesh and finally the assignment of the contour zones. With regard to the commented in the previous point, with this software the first two stages are realized.

4.3.3. FLUENT

FLUENT [9,10] a program that allows to realize the operations of accused for the analysis CFD. This one elaborated by the company Fluent Inc considered as the world leader in CFD's software. This software allows from a model mesh, to realize the stages of resolution of equations and the visualization of the obtained results.

4.4. PREPARATION OF THE SIMULATION

In this chapter there are detailed all the steps that have been realized to go to end the simulation CFD of the bridges.

4.4.1. CREATION OF THE GEOMETRIES WITH SOLIDWORKS

From the planes provided by SEAT Sport and that are attached in Annex A, the geometries of the bridges has been elaborated by means of the software SolidWorks.

Since it has been commented before, during this process it has been realized in everything details the design of the bridges in 3D though they are not necessary for the study of the same ones.

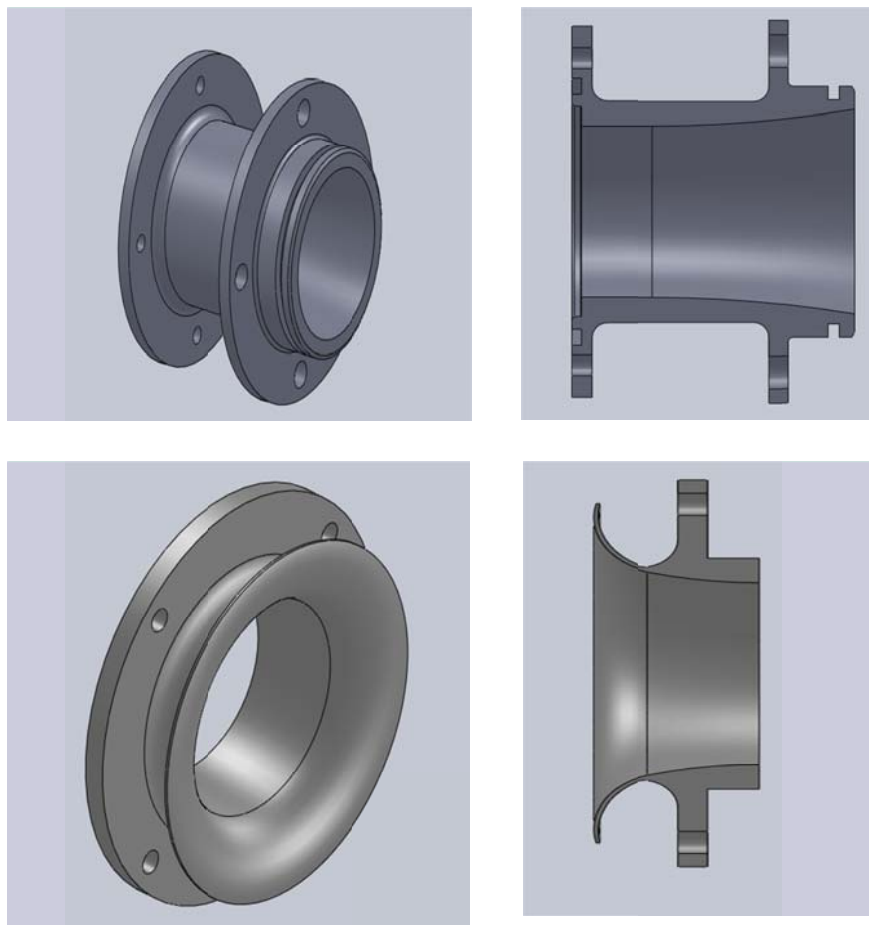


Figure 8. Bridges designed in SolidWorks.

4.4.2. CREATION OF THE GEOMETRIES WITH GAMBIT

Since already we have the bridles designed in SolidWorks, only we have to import the above mentioned bridles to Gambit by means of a type of file IGES.

4.4.3. MESH OF THE GEOMETRIES WITH GAMBIT

The following step is meshing the geometry. The process of mesh consists in to divide the geometry created in cells in those who later were calculated the variables of the problem.

A previous very important step before creating the mesh is the utilization of " Sizing Functions ", which serve to reduce the size of the mesh in those zones that we consider to be more important or in which we wait major gradients. Applying this tool we will realize a mesh of major quality and we will avoid a too small mesh in zones that not need.

In case of the bridles, knowing the behavior of the flow and after to prove different combinations has considered that the zones that they need q specific mesh they are the interior limits of the bridles.

This tool allows a direct control on the distribution of the size of the cells, being able to specify the following parameters:

- Start Size: it indicates the initial size of the mesh
- Growth rate: rate of growth of the mesh
- Size limit: maximum value allowed of the mesh

The concrete parameters chosen for the Sizing Function of all meshes appear in the table 1.

Start size	0,5 mm
Growth rate	1,1 mm
Size limit	2,5 mm

Table 1. Parameters of the used Sizing Functions.

Later the mesh of the geometries is realized.

Gambit offers many possibilities of mesh depending on the complexity of the geometry. For two-dimensional cases the cells can be square or triangular. The square cells form mesh easier to calculate, though they have the disadvantage of which they adapt badly to geometries that not be basically rectangular.

To be able to realize a mesh in pieces of 3D we have to create first a volume of mesh that will be that one that we are going to study. In our case it will be the whole interior part of the bridges.

The following images show the steps followed for mesh a bridge in 3D in Gambit, first where after having the designed bridge it is to create the interior volume (Figure 9) since better be convenient for us for the study since it will be the studied part. They show also the bridge totally mesh (figure 10) by means of a type of hybrid mesh with quadratic and triangular, like that elements like the cut of the same one (Figure 11) to observe it with more detail.

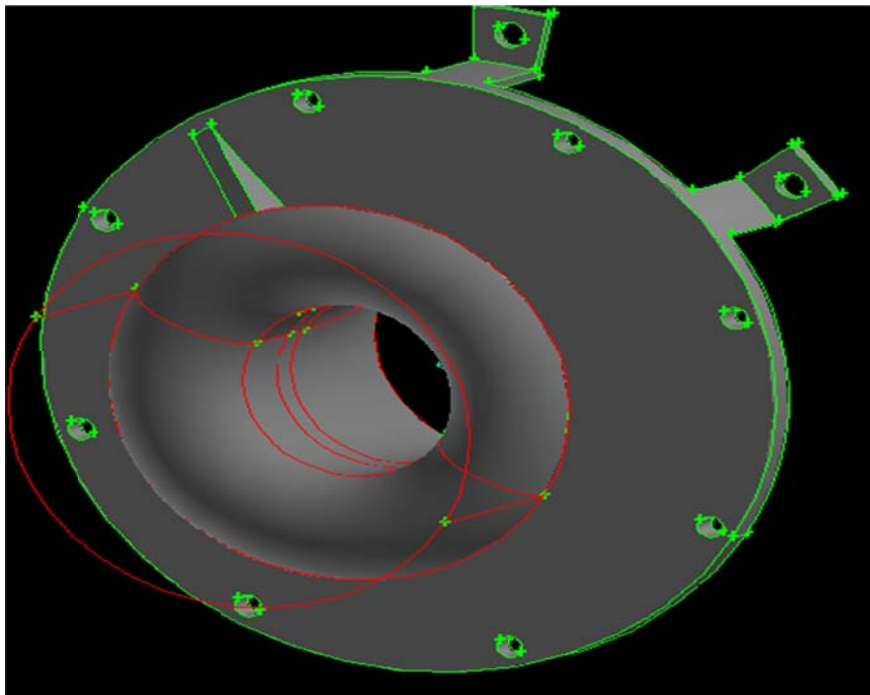


Figure 9. Creation of the interior volume for mesh later.

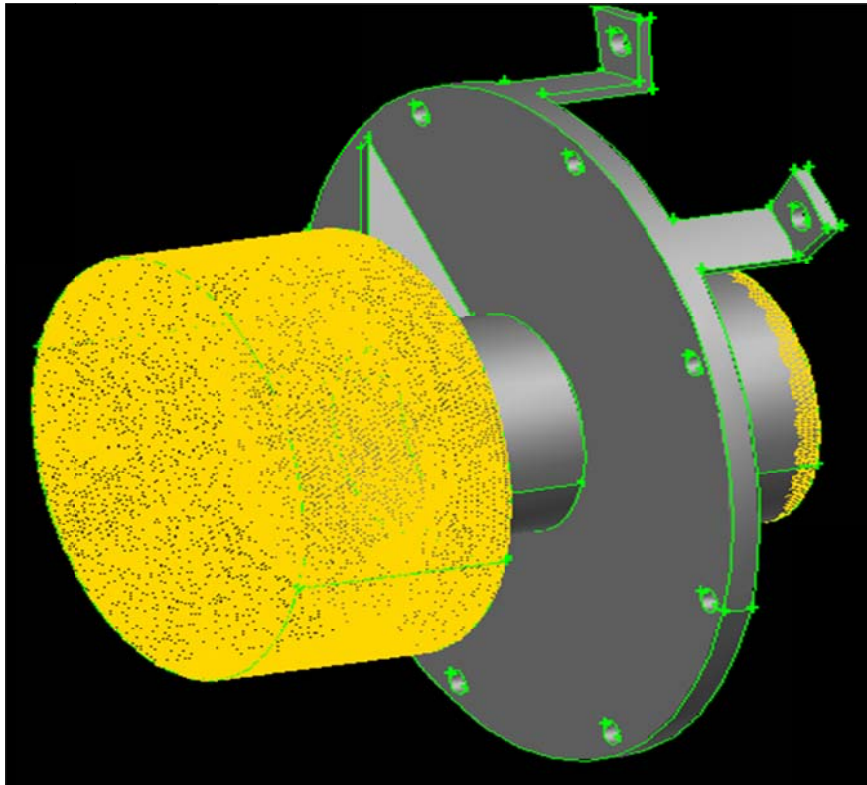


Figure 10. Bridle mesh in Gambit.

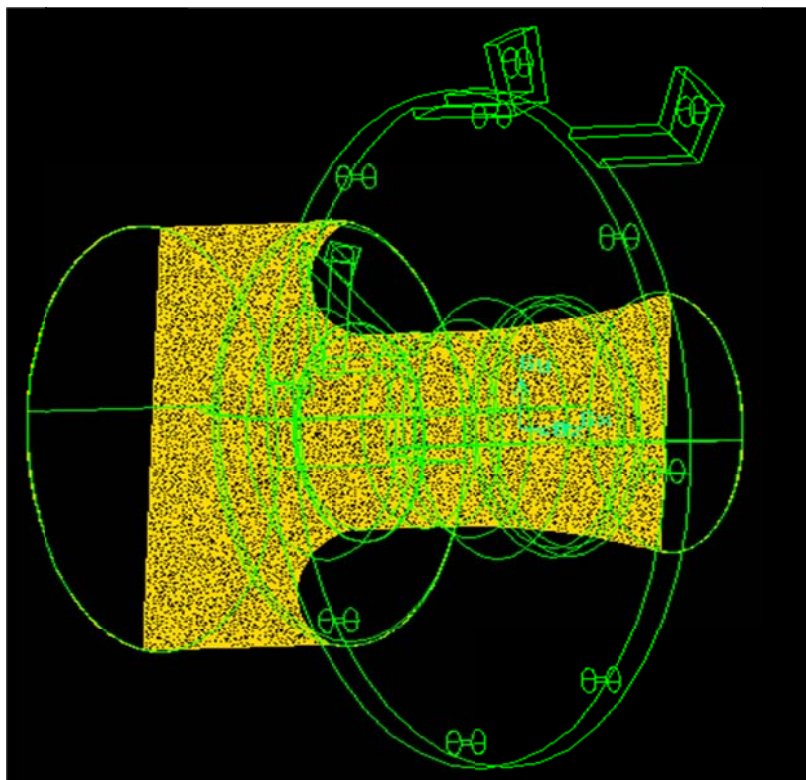


Figure 11. Court of the mesh volume.

There are cases in which to simple sight, it is possible to affirm that a mesh is not suitable for geometry, since it happens with the mesh of elements quadrangular where they appreciate irregularities in the mesh.

But it is necessary to examine held up the quality of the created meshes to be able to determine that type of mesh adapts better to the geometry.

Gambit has a tool that allows realizing this checking.

The skew is a measure of the quality of the cells, indicates the proportion between the sides of the elements that form the mesh. His value is near to 0 for regular cells and 1 for the deformed cells. In cases 3D it is suitable that the skew of the cells is below 0.6.

The quality criterion that has followed to consider a mesh as suitable, it consists of observing Skew's values of the created meshes and of verifying if this one below this value borders of 0.6.

In the Figure 12 and Figure 13 show themselves the results obtained of the calculation of skew of the mesh formed with triangular elements and of the mesh formed by hybrid elements.

In them is observed clearly that the hybrid mesh fulfills the requirements of quality, since it does not possess any element with a value superior Skew to 0.6.

On the other hand the mesh of triangular elements contains 10 elements with one value of Skew very near to the 1.

From value	To value	Count in range	% of total count (8582)
0	0.1	8334	97.11
0.1	0.2	211	2.46
0.2	0.3	18	0.21
0.3	0.4	2	0.02
0.4	0.5	1	0.01
0.5	0.6	0	0.00
0.6	0.7	0	0.00
0.7	0.8	0	0.00
0.8	0.9	0	0.00
0.9	1	16	0.19
0	1	8582	100.00

Measured minimum value: 2.01181e-007
Measured maximum value: 0.999949

Mesh of face face.1 contains 10 highly skewed elements (EQUISIZE SKEW > 0.97).

Total of 10 highly skewed elements encountered.

Figure 12. It reports of skew for the mesh of triangular elements

From value	To value	Count in range	% of total count (3732)
0	0.1	2484	66.56
0.1	0.2	659	17.66
0.2	0.3	272	7.29
0.3	0.4	301	8.07
0.4	0.5	14	0.38
0.5	0.6	2	0.05
0.6	0.7	0	0.00
0.7	0.8	0	0.00
0.8	0.9	0	0.00
0.9	1	0	0.00
0	1	3732	100.00

Measured minimum value: 0.00107438
Measured maximum value: 0.572894

0 out of 1 meshed face failed mesh check for skewed elements (EQUISIZE SKEW > 0.97).

Figure 13. It reports of skew for the mesh of hybrid elements

The quality of the mesh has a great importance, since a mesh with very deformed cells not only it can provide erroneous results about these cells, but it is possible to impede or prevent convergence of the calculation.

For it, if during the checking of the quality of the meshes, someone of them it does not expire with the minimal requirements cannot give well.

To solve a bad quality in the mesh the "Sizing can be modified Functions " assigned but generally the mistake relapses into the realized geometry by means of Gambit, by what it must be checked to seek and to correct the possible ones mistakes.

4.4.4. DEFINITION OF THE CONTOURS WITH GAMBIT

The last step that is realized by Gambit consists of specifying the zones of the geometry in that the contour conditions are going to be defined.

For it there is in use the tool of " Specify Boundary Types " that it allows to assign to specific zones of our geometry a name and a condition of contour.

The contour conditions that have been assigned to the bridles are practically the same ones for all of them and appear in the table 2.

Name	Zone	Contour condition
Entry	Zone of entry of the flow	Pressure inlet
Exit	Zone of exit of the flow	Pressure outlet
Bridle	Segments that define the bridle	Wall

Table 2. Boundary Types assigned to the bridles.

4.4.5. EXPOSITION OF THE PROBLEM IN FLUENT

Once realized the model 3D with the mesh and with the assignment of contour zones by means of Gambit, already it is possible to initiate the third stage of simulation CFD that consists of the exposition of the problem.

For it there is in use the software Fluent 6.2 that the mesh allows to import previously created to apply the equations and conditions that they define parameters of the simulation.

All the images showed from now on Fluent's images will prove in 2D since a shear plane has been created to be able to see perfectly what happens in the volume of control since it is in what we are interested as that the exterior part of the bridles does not have any influence in our study.

4.4.5.1. METHOD OF RESOLUTION

Fluent allows three types of formulations:

- Segregated "segregated"
- Connected implicit "coupled implicit "
- Connected explicit "coupled explicit "

All these formulations can provide precise results for one great variety of flows, but in certain cases a type is better than different.

The differences between the segregated way and the connected one relapse into the way in that the continuity, the moment, the energy are solved.

The algorithms of resolution segregated solve the equations of form sequential (segregated one of others), on the other hand the connected one solves them of simultaneous way. The methods implicit and explicit differ in way of linearizing the connected equations.

Both approximations are applicable to all the flows from incompressible up to the strongly compressible ones, though the method of formulation segregated normally is in

use for incompressible flows or moderately compressible and the connected one can provide the better one performance for the compressible flows of high speed.

In this case the type of formulation has been chosen connected implicitly.

4.4.5.2. EQUATION OF THE ENERGY

There offers the possibility of activating the resolution of the equation of the energy.

This equation must be in use when the temperature is a variable to having in it counts, already be for heat transfer or because the flow is compressible.

Since in our case the flow is a compressible debit to be activated the option of the equation of the energy in Fluent.

4.4.5.3. MODEL OF TURBULENCE

Fluent allows choosing the type of turbulence of the flow to studying.

The choice of the model of turbulence depends on diverse considerations as the physical characteristics of the flow, the level of precision necessary, capacity of IT resources which we have and the quantity of available time for the accomplishment of the simulation.

To know who of the models of turbulence adapts better to our case there must be known the capacities and limitations of the different options.

After studying the characteristics that the different models offer of turbulence, it thinks that better the one that adapts to this case is the model Spalart-Allmaras, turbulence used in the profile simulations trousers.

The model of Spalart-Allmaras is a model of an alone equation who can to predict with accuracy coefficients of pressure, dragging and sustentation. It resolves the equation of transport with viscosity. This designed turbulence especially for aerospace applications and for mechanical applications that involve closed flows and with the aim to show good results with conditions of contour you hold to gradients of adverse pressures.

The Figure 14 shows the parameters for fault of the model Spalart- that are the used ones in the simulation.

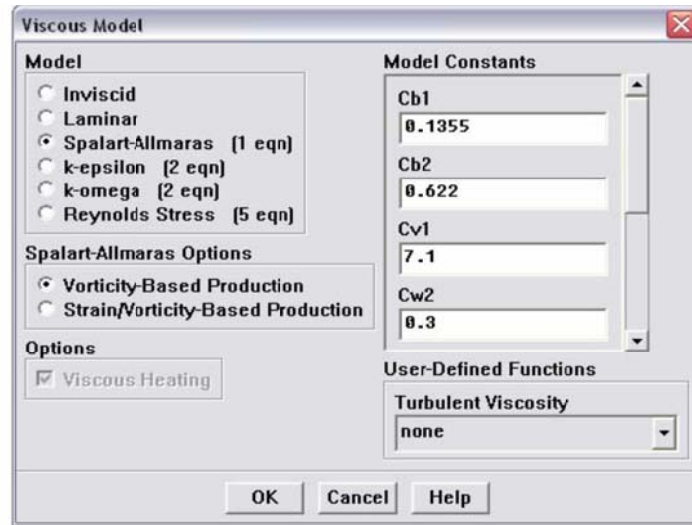


Figure 14. Parameters of the model of turbulence Spalart-Allmaras.

4.4.5.4. MATERIALS

The characteristics of the materials that form a part of the simulation have to be defined in Fluent.

The active materials for fault are an air as fluid and aluminium as solidly.

For this study we consider these materials to be appropriate.

As for the air, in the compressible flows or flows in which it intervenes temperature, it is necessary to have specially elegant with the definition of his density.

For fault it is constant, but in these cases it is in the habit of to being necessary to choose one in other available manners. For the simulation of the bridges we will define density of ideal gas.

The equation of ideal gas for compressible flows can express like:

$$\rho = \frac{p}{R T} \quad \text{Formula (4-1)}$$

On the other hand, the solid materials only are in use in the conditions of contour of wall or when there is a zone of the mesh that is defined like solid. The material in I make concrete and his properties only have importance if calculations of heat conduction want to be realized across it, and this one is not the case.

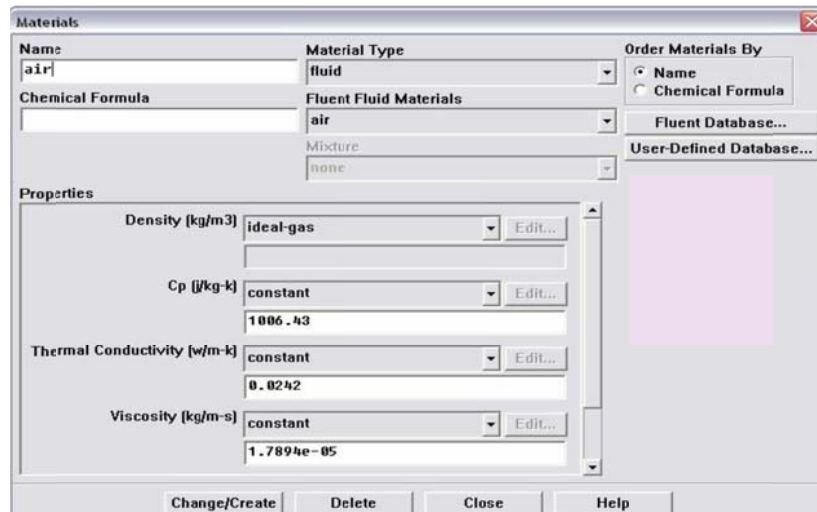


Figure 15. Parameters of the air.

4.4.5.5. CONTOUR CONDITIONS

There are defined the contour conditions that we have assigned in Gambit to some concrete zones of our geometry. For compressible flows available conditions of contour diminish basically to pressure and mass flow rate.

For this case the following conditions of contour have been defined:

- Pressure inlet: contour condition of entry, in which it owes to specify the total, supreme pressure of velocity head (that depends of the speed) and static pressure.

The total pressure in the entry is the atmospheric pressure that is equivalent to 101325 Pa, the static pressure in the entry costs approximately some 80000 Pa.

- Pressure Outlet: contour condition of exit, in which it is defined value of the total pressure in this edge.

The value of pressure of exit is an experimental value that it obtains by means of the formula of flow strangled (Formula. 2-2) and it is possible to bring near to approximately 50000 Pa.

Figure 16. Contour conditions in the entry.

Figure 17. Contour conditions in the exit.

These conditions of contour have been applied in the majority of simulations, though in some the values of pressure have been changed of entry and exit, in these cases it is indicated by that values have been replaced.

4.4.6. RELIABILITY OF THE RESULTS

After defining the parameters of simulation, we must impose a criterion of convergence that it indicates when it thinks that the simulation has come to stationary condition and it is stable.

The program Fluent has a criterion of convergence definite for fault, though it can be modified depending on the type of simulation.

In this case we have thought that the simulation converges when residual values of the involved parameters are below 0.001, since it shows the image Figure 18.

The residual values are the result of dividing the current value of a variable for that of his previous iteration. When this value is very small it means that he variations between iteration and iteration are minimal and therefore that the flow there goes way of being stable.

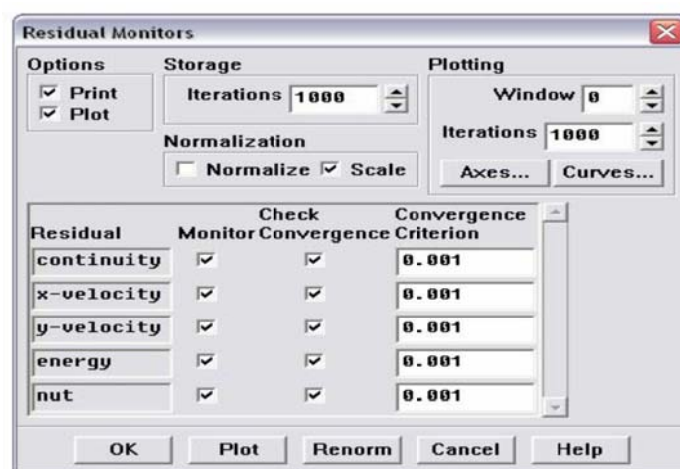


Figure 18. Criterion of convergence.

The Figure 19 it proves to be one of the graphic of residual values obtained in simulations. There is verified that the parameters are decreasing and being kept more or less stable below 10×10^{-3} .

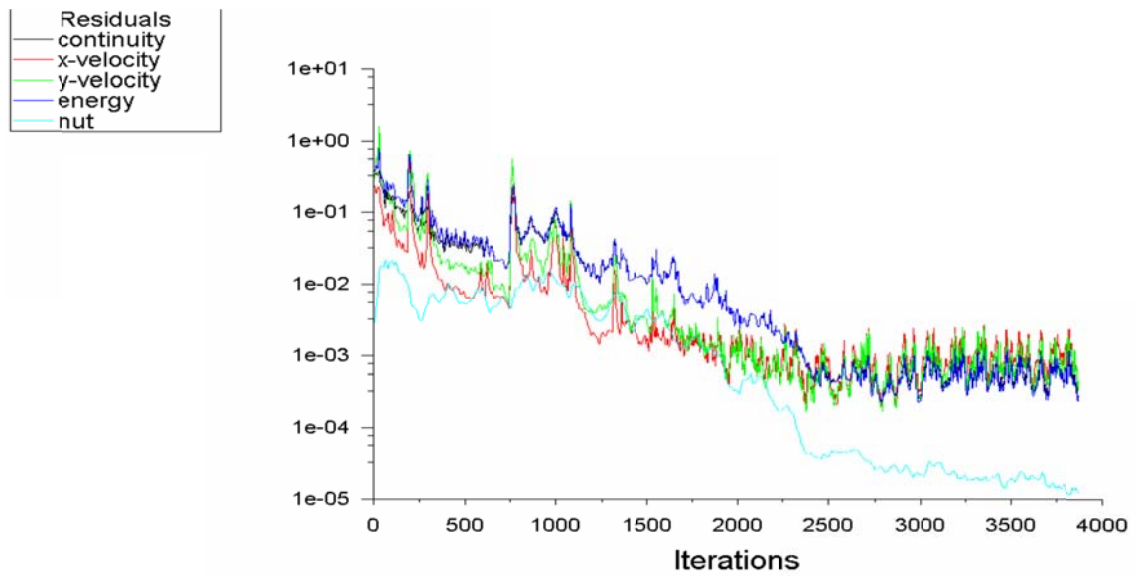


Figure 19. Graph of residual values.

The information that appears in the chapter 8 is the result of simulations CFD that have reached these values and that therefore have converged.

5. RESULTS AND DISCUSSIONS

In the latter chapter the analysis of the results is realized obtained in different realized simulations.

After verifying the conditions of strangled commented flow previously, of observing the geometries of the different bridles and of studying the possible conditions of contour offered by Fluent; the select bridle to realize the simulations is the bridle restrictor 35mm. of diesel type and his diverse modifications.

5.1. CHECKING OF THE EQUATION OF STRANGLED FLOW

The first simulations that are realized have as aim verify if the equation of flow strangled (Formula 8-1) it is fulfilled for the geometry of select bridle.

$$\frac{P_2}{P_1} \leq 0.528 \quad \text{Formula (5-1)}$$

Being P_2 the pressure of exit and P_1 the pressure of entry.

Considering the case of the bridle, where the pressure of entry is the pressure atmospheric (101325 Pa), the value of the pressure of exit must be:

$$P_2 \leq 0.528 \cdot P_1 \quad \text{Formula (5-2)}$$

$$P_2 \leq 53500 \text{ Pa} \quad \text{Formula (5-3)}$$

According to this, while the value of the pressure of exit (pressure outlet) is minor that 53500 Pa, there will take place the condition of strangled flow.

For this checking different simulations were realized changing the value of pressure of exit P_2 to observe that it happens with the flow.

Concretely simulations have been realized by the values of P_2 following:

- Pressure Outlet = 20000 Pa
- Pressure Outlet = 50000 Pa
- Pressure Outlet = 80000 Pa

The results obtained of the previous simulations are summarized in the Table 3. The values showed of speed and density is obtained ones in central zone of the bridle in the indicated surfaces:

Pressure Outlet (Pa)	Speed in the throat of the bridle		Speed in the exit of the bridle		Density in the exit (Kg/m³)	Mass flow rate of exit (Kg/s)
	m/s	Mach	m/s	Mach		
20000	311.86	1.0081	447.86	1.5588	0.4343	8.209661
50000	311.72	1.0122	448.97	1.5560	0.4362	8.209876
80000	311.85	0.9666	199.24	0.5947	0.9905	8.209863

Table 3. Proved for different pressures of exit.

We verify that for the pressures of exit (P2) lower than 53500 it fulfills the condition of strangled flow, there is reached Mach 1 in the throat of the bridle and the speed regime happens of subsonic to supersonic.

On the other hand in case of pressure of exit 80000 Pa, in spite of that it seems to there be reached the value very near to Mach 1 in the throat of the bridle, not it produces the change of regime and the speed of exit is low than her of throat.

On the other hand, the results of density to the exit in the cases of pressure low they are very seemed to 53500 I half-close to 0.4 Kg / m³. Though the pressure of exit is different, this does not concern the density due to the condition of flow strangled.

On the contrary, in case of pressure of exit of 80000 Pa the density is great higher (nearby to 1Kg/m³), due to the fact that the pressure of exit is top and in this case if it concerns the density because it has not taken place strangulation.

Finally, we verify that the value of the flow mesh (Mass flow rate) that it crosses the surface of exit, is very similar in the cases of flow strangled the variation is alone of 0.0026 % what confirms that though pressure of exit changes the flow it does not do it.

In the last case the value of Mass flow rate also is very similar to of two previous ones, though this similarity cannot be argued because it has not be produced the strangulation. Since in this case the density to the exit is superior but the speed is minor, the result looks like others, but since strangulation has not taken place, this value of flow is not constant if we change some parameter of the flow.

In the figures Figure 20, Figure 21 and Figure 22 it is possible to estimate the similarity in behavior of the flow of the first 2 cases and the difference of these with last.

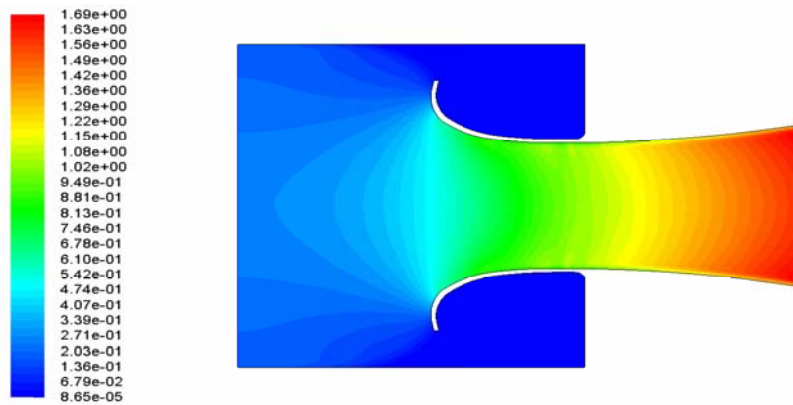


Figure 20. Contours of the number of Mach for the case $P_2 = 20000$ Pa.

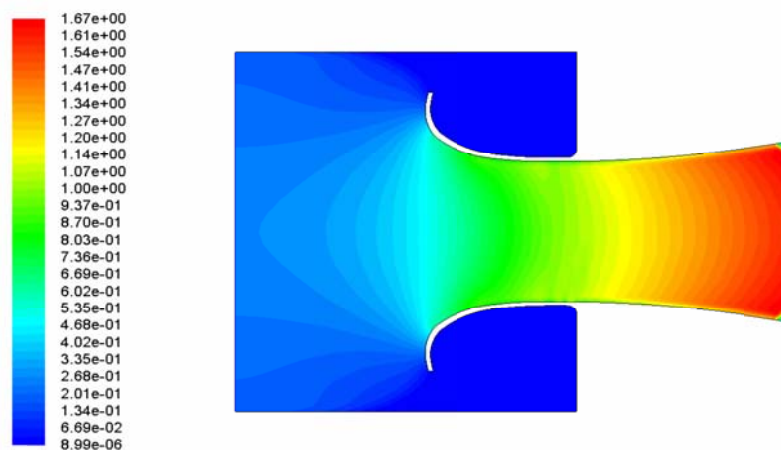


Figure 21. Contours of the number of Mach for the case $P_2 = 50000$ Pa.

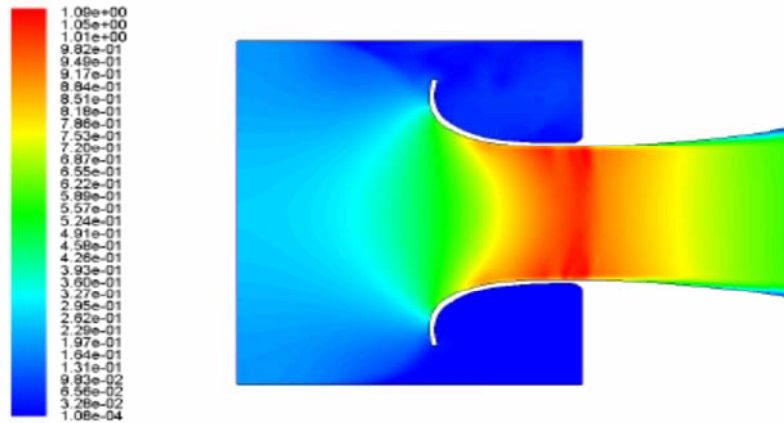


Figure 22. Contours of the number of Mach for the case $P_2 = 80000$ Pa.

In this, it is possible to affirm that while the relation between pressures should be defined by the Formula 8-1 there takes place the condition of strangled flow.

But it is necessary to verify if increasing the pressure of entry (P_1) can rise the mass flow of exit. For it the results of two are compared simulations that fulfill the previous relation of pressures, but that one of them has a value of P_1 top.

The parameters of the contour conditions (Boundary conditions) for raised simulations are the following ones:

Case A

- P_1 (Pressure Inlet) = atmospheric pressure = 101325 Pa
- P_2 (Pressure Outlet) = 50000 Pa

Case B

- P_1 (Pressure Inlet) = 121325 Pa
- P_2 (Pressure Outlet) = 60000 Pa

The obtained results summarize in the Table 4:

Case	Speed in the throat of the bridle		Speed in the exit of the bridle		Density in the exit (Kg/m ³)	Mass flow rate of exit (Kg/s)
	m/s	Mach	m/s	Mach		
A	311.72	1.0122	448.97	1.5560	0.4362	8.209876
B	314.77	0.9958	445.34	1.5645	0.5133	9.816819

Table 4. Results for different pressures of entry and exit.

The results of the Table 4 for of the obtained results there is verified that in the case B, which is that it has a pressure of entry (P1) top, the density in the exit is major that in the case to, whereas the speed in the exit is practically same in both, by it there is deduced that the increase in the pressure of entry several density of exit though not the speed since this parameter is that suffers strangulation and is kept practically constant is which it is the pressure of entry.

The results show a value of mass flow rate Superior in the case B, approximately 19.6 % more than the previous one. It was of waiting that this case it was top due to the fact that the density of exit is major while speed is kept similar to that of another case.

5.2. COMPARISON BETWEEN DIFFERENT DIAMETERS OF ENTRY

Looking for a geometry that provides a mass flow with top exit to that of the original bridle supporting the value of P1 as atmospheric pressure they have realized variations in the geometry modifying the diameter of entry of the pipe that connects with the bridle, to see in that way concerns the flow.

Two additional geometries have been realized to compare them with the original one. In they summarize the diameters of entry used are the following ones:

- 90 mm (original)
- 100 mm
- 150 mm

The Table 5 shows the values of speed, density in the central zone of bridle and the mass flow rate of exit:

Diameter of entry (mm)	Speed in the throat of the bridle		Speed in the exit of the bridle		Density in the exit (Kg/m³)	Mass flow rate of exit (Kg/s)
	m/s	Mach	m/s	Mach		
90	311.72	1.0122	448.97	1.5560	0.4362	8.209876
100	312.33	1.0407	445.19	1.5693	0.4274	8.205594
150	316.73	1.0546	450.77	1.5514	0.3965	8.214005

Table 5. Results for different diameters from entry.

The figures Figure 23, Figure 24 and Figure 25 show the contours of density to the long of the bridge in three previous cases:

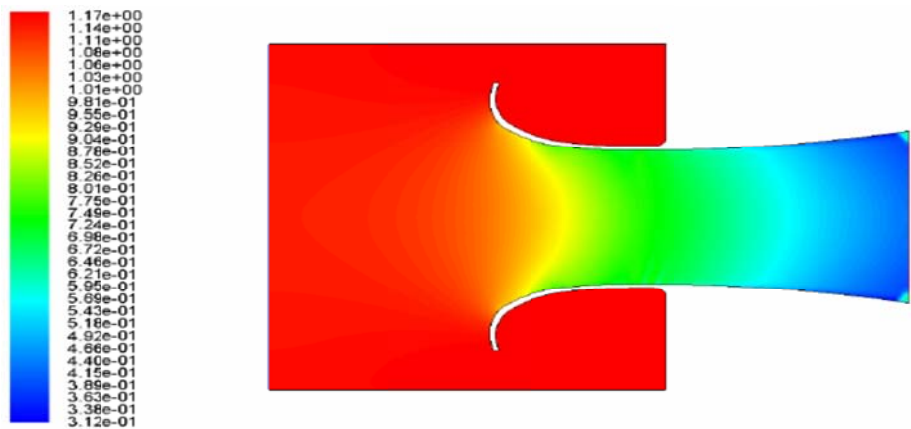


Figure 23. Contours of density (kg/m ³) for diameter of entry 90mm.

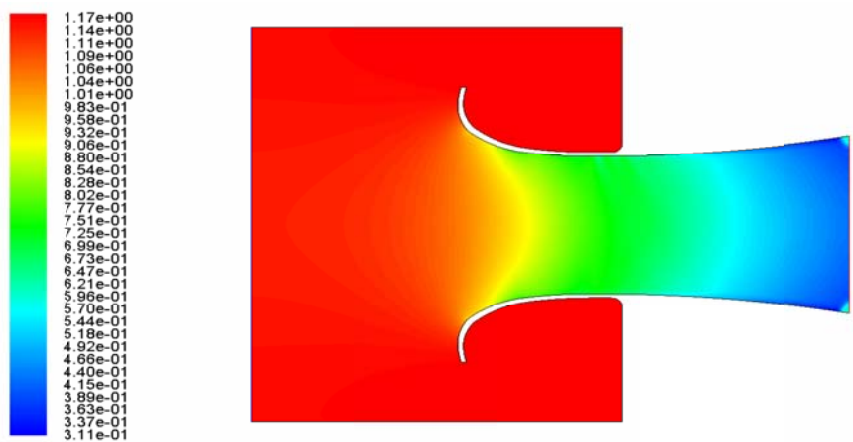


Figure 24. Contours of density (kg/m ³) for diameter of entry 100mm.

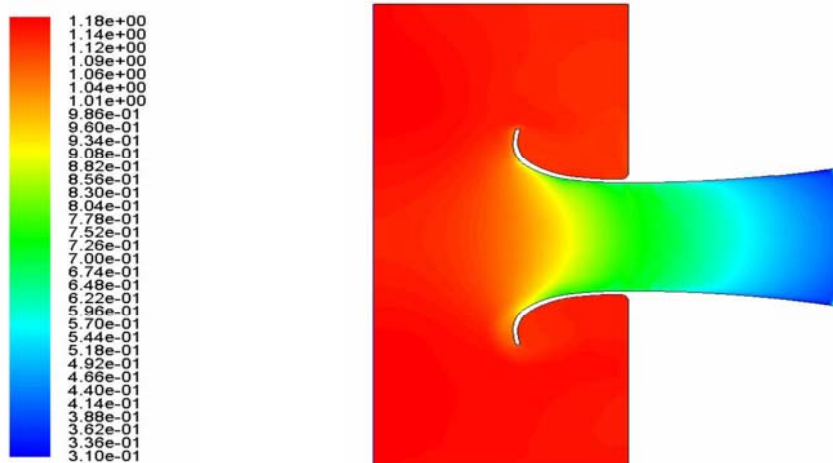


Figure 25. Contours of density (kg/m^3) for diameter of entry 150mm.

The previous figures show the value of density along the geometry, is observed that the behavior of the flow is very similar.

5.3. COMPARISON BETWEEN DIFFERENT LENGTHS OF ENTRY

It has wanted to be proved if the length of the conduit of entry can concern of some way to the flow inside the bridle. With this aim they have been elaborated two geometries with different lengths to the original one, concretely the double and the triple one.

The total lengths of the pipe of entry that have been in use sound:

- 70 mm (original)
- 140 mm
- 210 mm

The results obtained of show in the Table 6:

Length of entry (mm)	Speed in the throat of the bridle		Speed in the exit of the bridle		Density in the exit (Kg/m ³)	Mass flow rate of exit (Kg/s)
	m/s	Mach	m/s	Mach		
70	319.72	1.0122	448.97	1.5560	0.4362	8.209876
140	320.06	1.0157	447.62	1.5727	0.4315	8.209577
210	320.08	1.0222	449.53	1.5619	0.4324	8.202695

Table 6. Results for different lengths from entry.

It is observed that the density in the exit is practically the same for the three cases, with variations of 1.09% in the case of 140 mm with respect to the one of 70 and 0.87% in the case of 210 mm also with respect to the one of 70. With the speed of exit step the same, the differences of 1m/s only suppose a 0.3% less in the second case and 0.13 in the last. For that reason it is logical to think that with the mass volume it passed something similar. The values of mass flow rate of exit present/display variations of 0.0036% and 0.034% respectively. We can conclude that in agreement with the obtained results, the length of the entrance conduit seems not to modify the mass volume. The Figure 26 and Figure 27 shows to the values of density throughout the bridle in the cases of length 140mm and 210 mm:

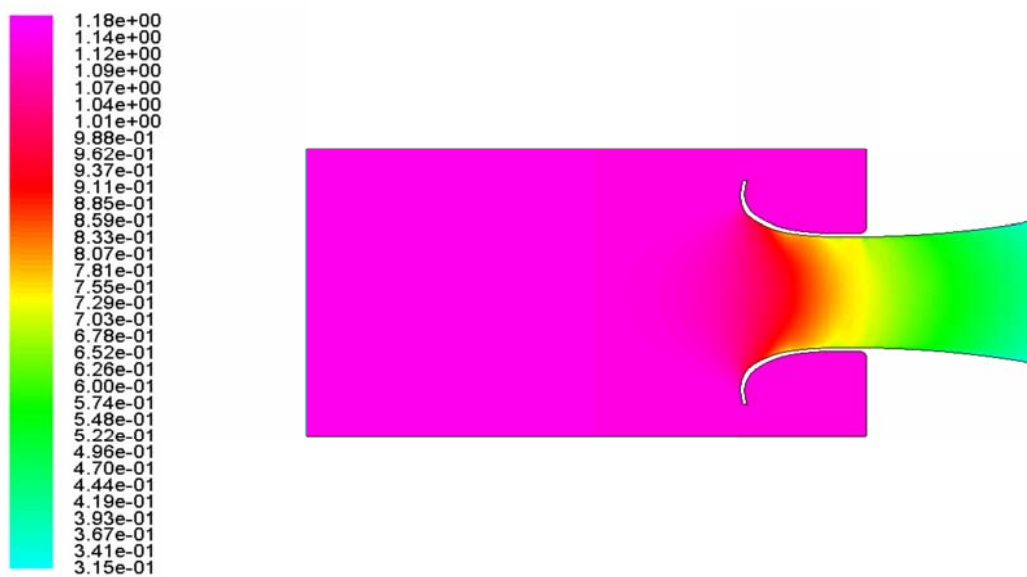


Figure 26. Contours of density (kg/m^3) for length of 140 mm.

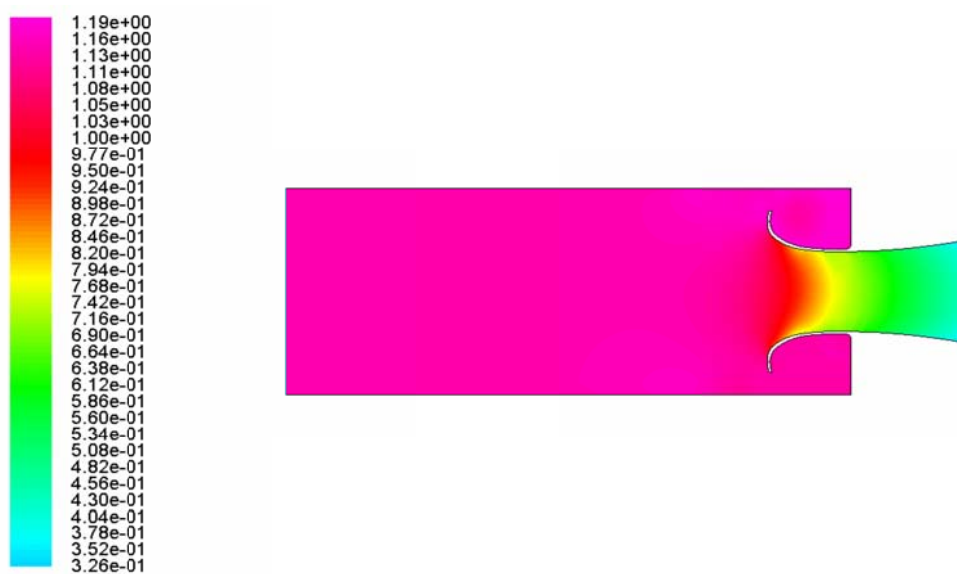


Figure 27. Contours of density (kg/m^3) for length of 210 mm.

5.4. COMPARISON BETWEEN DIFFERENT GEOMETRIES FROM ENTRY

Seeing the results of points 8.2 and 8.3 we can deduce that variations in the diameter or length of the conduit modify the values of flow rate of little significant form since they do not reach 1%. Another one of the possibilities to try to modify the exit volume is to modify the convergent zone of the bridle, that is the part that precedes to the throat of the bridle (the zone of smaller diameter). In order to prove this, modifications have been realized in initial geometry (the bridle restrictor 35mm) and 4 different geometries have been created that they differentiate with first in the convergence zone. The new geometries are denominated with abbreviations A (Figure 28), B (Figure 29), C (Figure 30) and D (Figure 31) and are variations from original geometry (Figure 32)

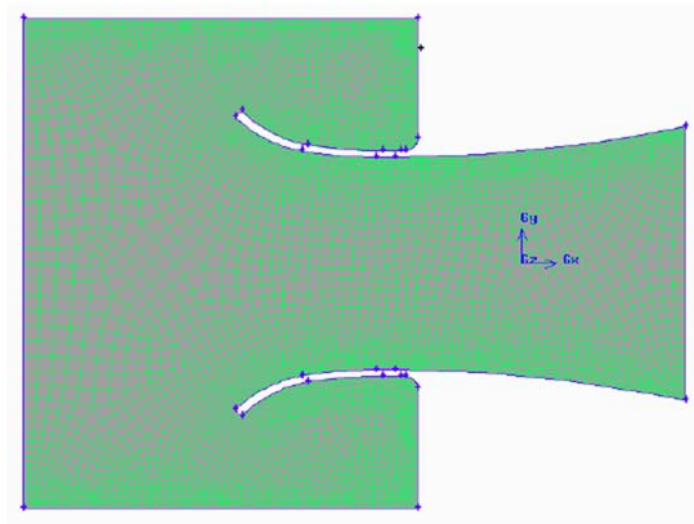


Figure 28. Geometry A.

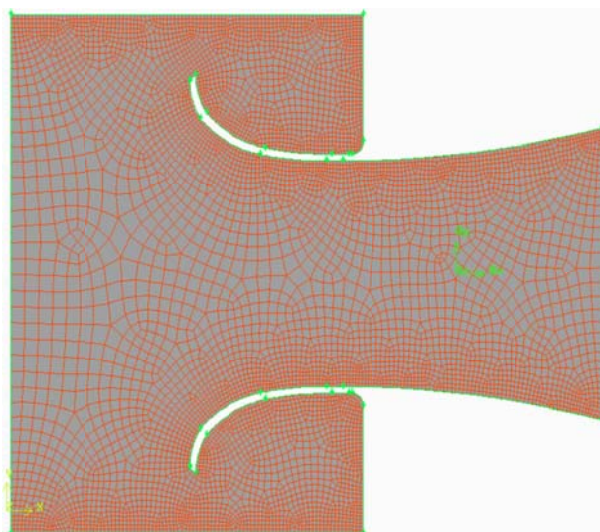


Figure 29. Geometry B.

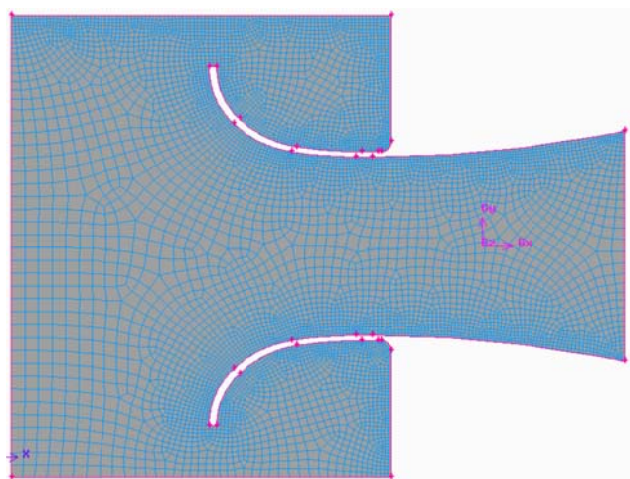


Figure 30. Geometry C.

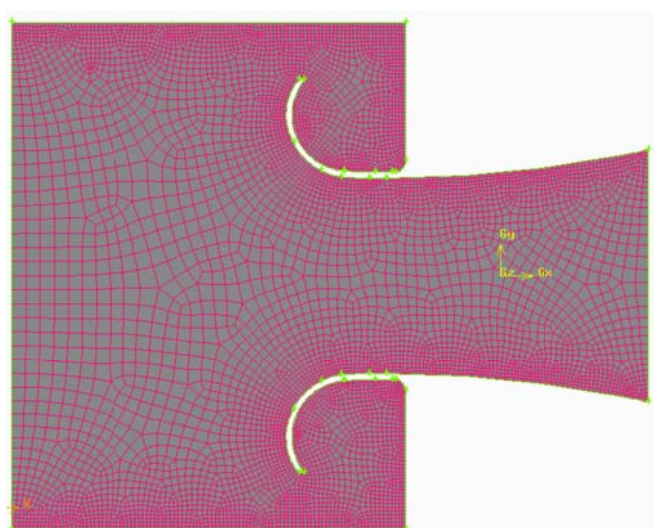


Figure 31. Geometry D.

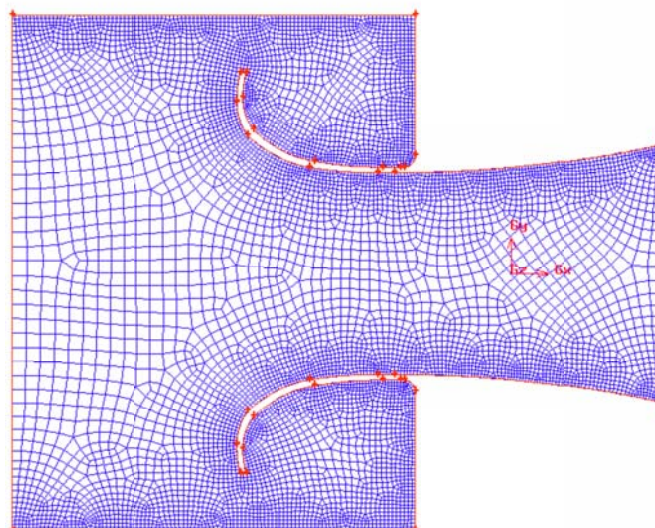


Figure 32. Original geometry.

In the Table 7 show themselves some of the parameters of the resultant bridges of the simulations of these geometries:

Model of geometry	Speed in the throat of the bridge		Speed in the exit		Density in the exit (Kg/)	Mass flow rate of exit (Kg/s)
	m/s	Mach	m/s	Mach		
Original	311.72	1.0122	448.97	1.5560	0.43616	8.209876
A	315.65	1.000	447.93	1.5753	0.4277	8.139819
B	315.86	0.9848	448.65	1.5508	0.4337	8.209714
C	310.83	0.9929	447.69	1.5744	0.4293	8.213228
D	337.10	1.0817	444.79	1.5718	0.4241	8.089943

Table 7. Results of the simulations of different geometries.

Though the values of speed and density of exit in the central point are very similar with a maximum difference of 2.8 % in density and of 0.28 % in speed.

The value of mass flow rate shows values seemingly more unlike overcoat in the geometries: To (Figure 29) with a difference of 0.07 kg/s that it supposes 0.85 % with regard to the original one and D (Figure 31) with it differs from 0.12 Kg/s that supposes 1.46 % with regard to the original one. Observing the geometries of these models, to simple sight one does not find any similarity unless they are the geometries that possess a length of the convergent minor zone.

Later the Figures 33, 34, 35, 36 and 37 show the evolution of the Mass Flow Rate in the surface of exit of different geometries.

The values of the vertical axis have negative sign because Fluent considers Mass Flow Rate to the exit negative, unlike that of entry that is positive.

The graphs show oscillations very declared in the first ones iterations that little by little are descending in extent until they turn in a constant line. This corresponds with the evolution of simulation, when the flow begins in transitory condition until it approaches to the convergence where it happens to be stationary and therefore stably.

A value of mass flow rate stable is also a sign that the simulation is reached the convergence. Depending on the geometry and on the parameters of the simulation this can happen with few iterations or on the contrary after many.

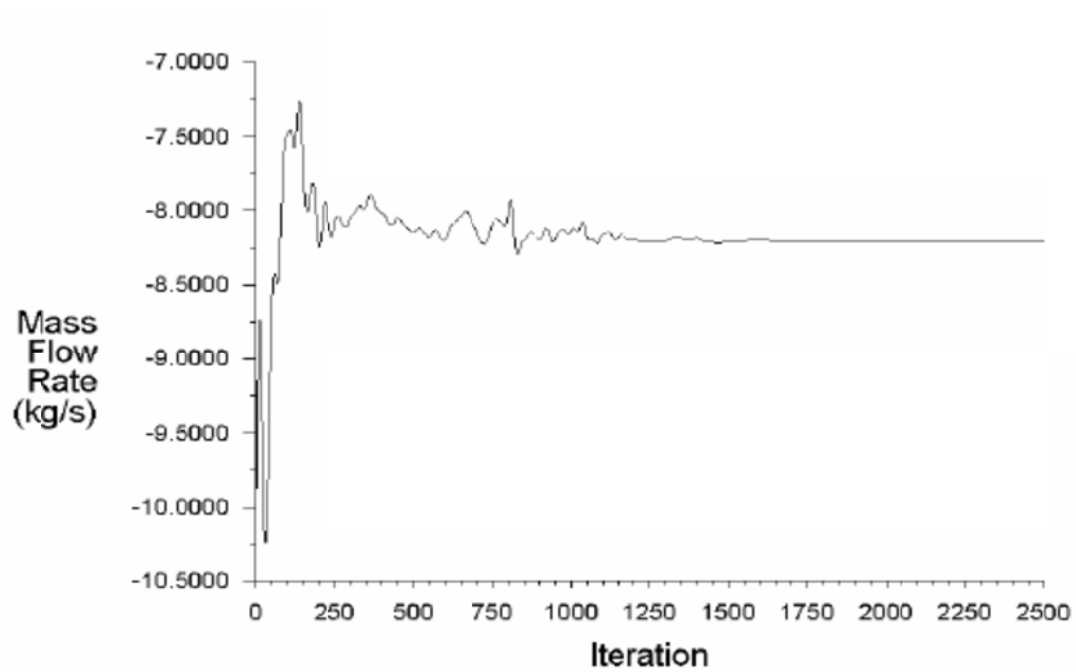


Figure 33. Mass flow rate of exit of the original geometry.

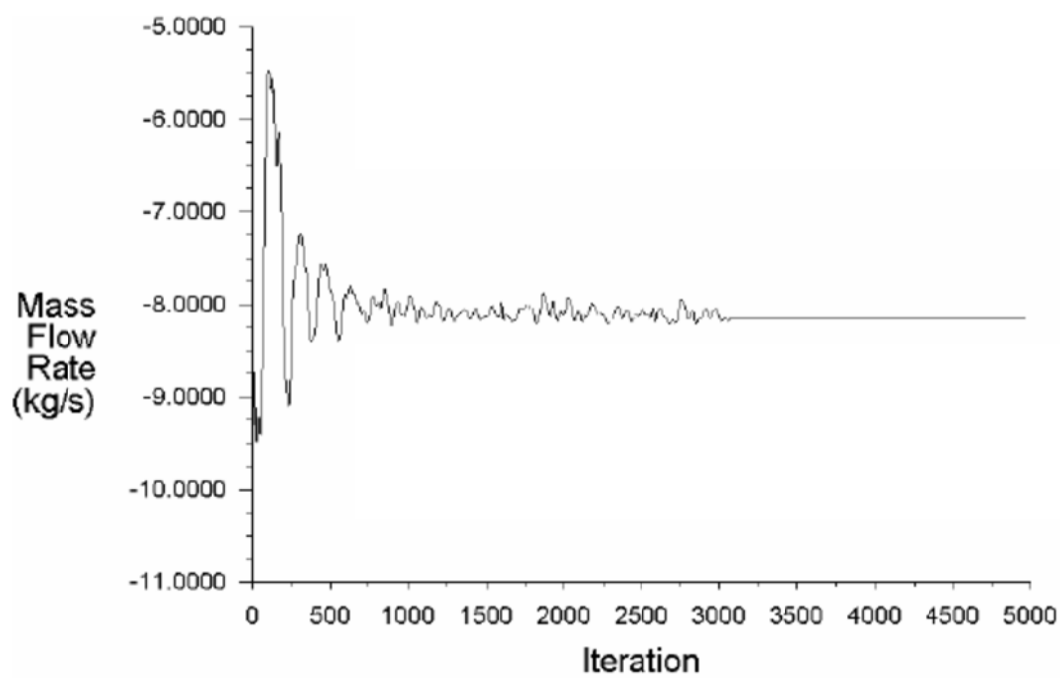


Figure 34. Mass flow rate of exit of the geometry A.

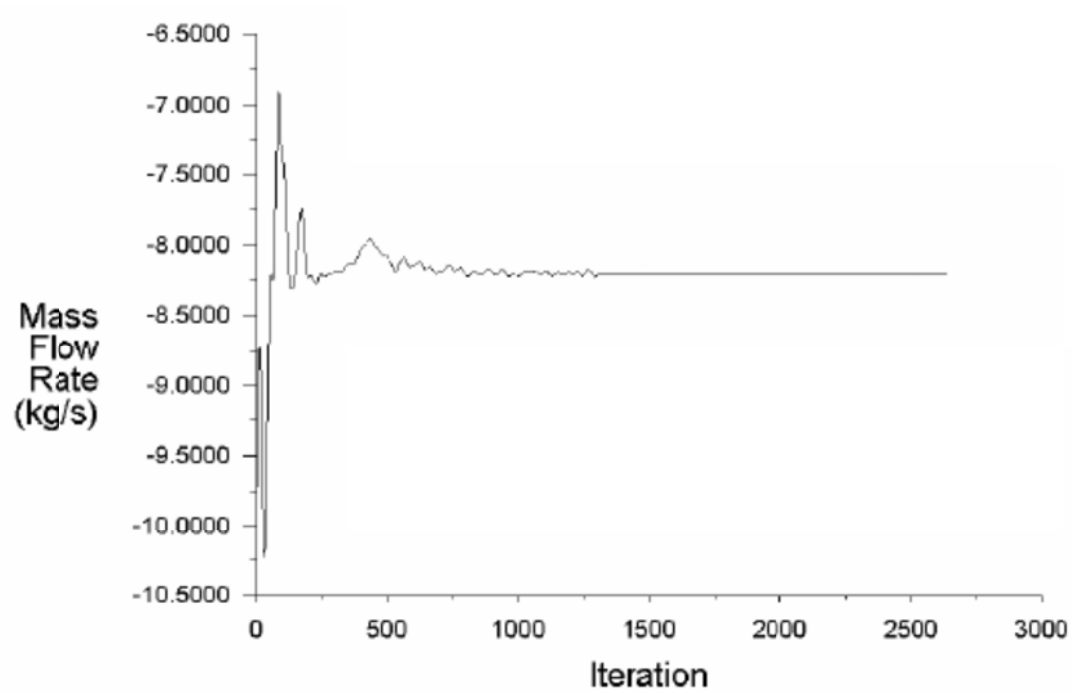


Figure 35. Mass flow rate of exit of the geometry B.

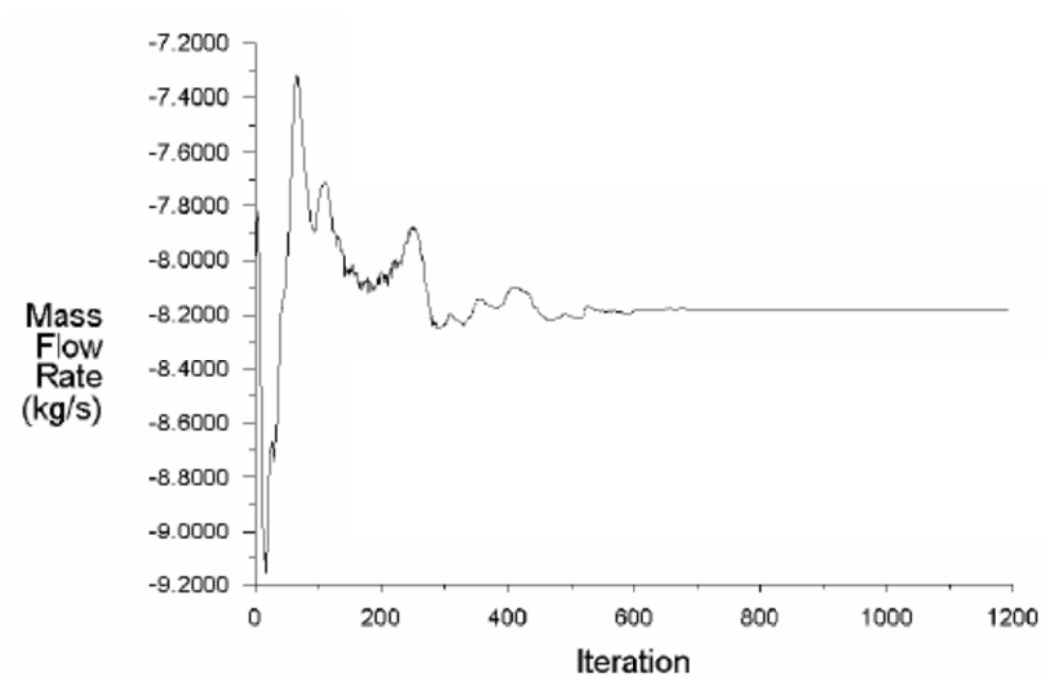


Figure 36. Mass flow rate of exit of the geometry C.

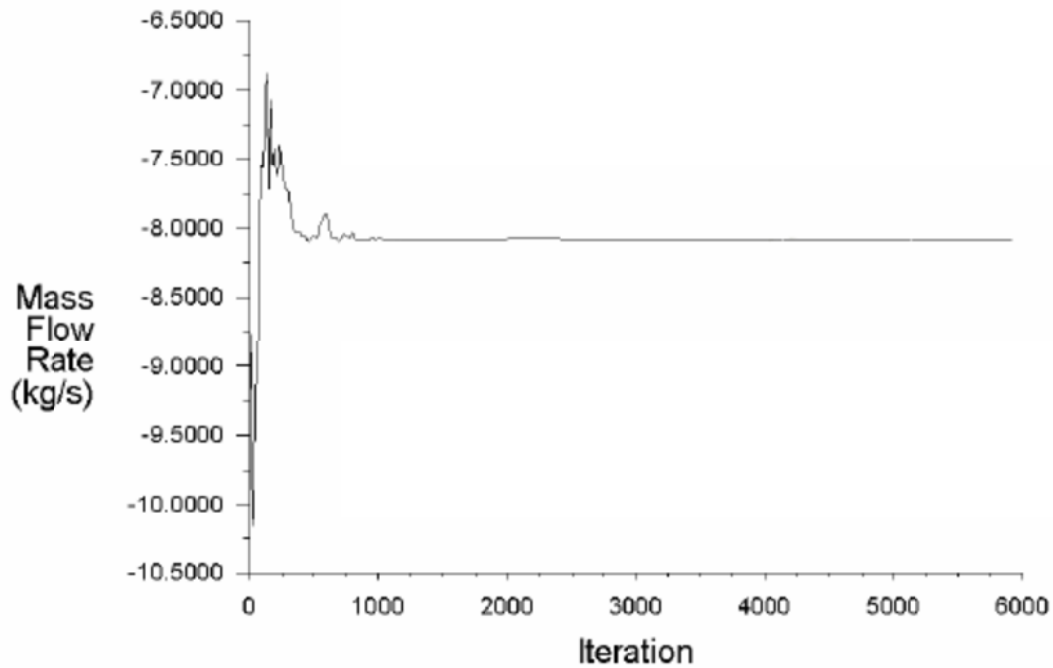


Figure 37. Mass flow rate of exit of the geometry D.

5.5. COMPARISON BETWEEN DIFFERENT DIAMETERS OF THROAT

There has wanted to be studied the influence of the diameter of the throat of the bridle, already that one of the parameters that defines the regulation for every type of engine.

A practically equal geometry has been realized to the original one with it differs in that the diameter of the throat of the bridle (D2) is low, though the diameters of entry (D1) and of exit (D3) they are equal. On having changed this one intermediate diameter and to support that of exit obtains also a variation in the divergent zone of the bridle.

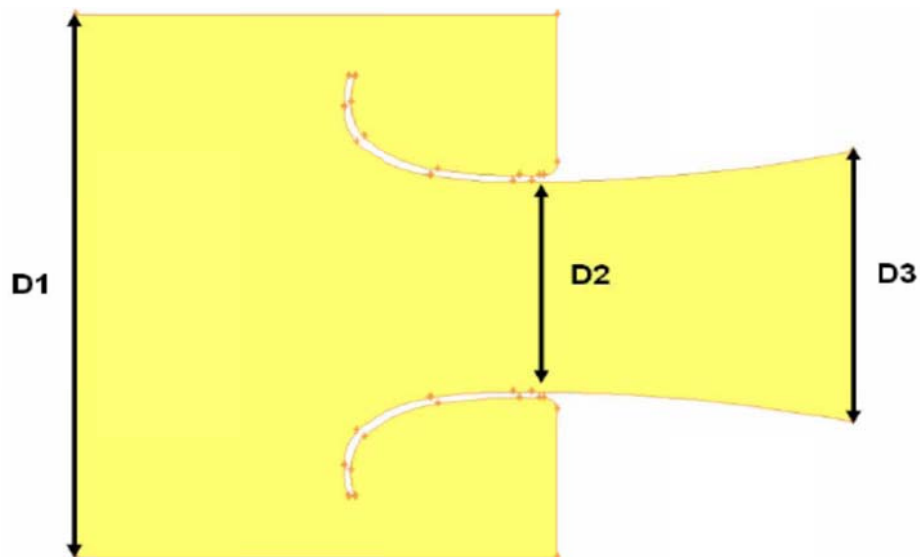


Figure 38. Diameters of the bridle.

The values of the diameters of throat of the simulated geometries are:

- 35mm (original)
- 30 mm

The variation of the diameter of throat has been minimal, of 5 mm. of difference but it has been this because the values of diameter of the bridles it is in the habit of ranging between them 30mm and 35 mm. And a royal case wanted to be simulated to see like it can modify this small variation.

The results of speed and density have taken in the central zone of bridle and appear in the Table 8 together with the mass flow rate of exit:

Diameter of throat (mm)	Speed in the throat of the bridle		Speed in the exit of the bridle		Density in the exit (Kg/)	Mass flow rate of exit (Kg/s)
	m/s	Mach	m/s	Mach		
35	311.72	1.0122	448.97	1.5560	0.43616	8.209876
30	311.83	1.0016	447.49	1.7522	0.34562	7.017468

Table 8. Results of the simulations with diameter of different throat.

In this case we observe like in case of diameter of throat of 30 mm. the value of the mass flow rate is almost 15% lower than that of the case of diameter of equal throat to 35mm.

The speed of exit is 6.35% top in case of minor diameter already that the flow flows with major speed due to the fact that the diameter of throat is minor. On the contrary the density is 20.76 % low in case of minor diameter due to his direct relation with the pressure that is inverse to speed.

The small difference of 5mm. in the throat he supposes a difference in mass flow of exit of 1.19 Kg/s that is the biggest variation of all the realized ones during the project.

The Figure 39 and Figure 40 show the graphs of density and the Figure 41 and Figure 42 the speed graphs of the bridles of 30mm. and 35mm.

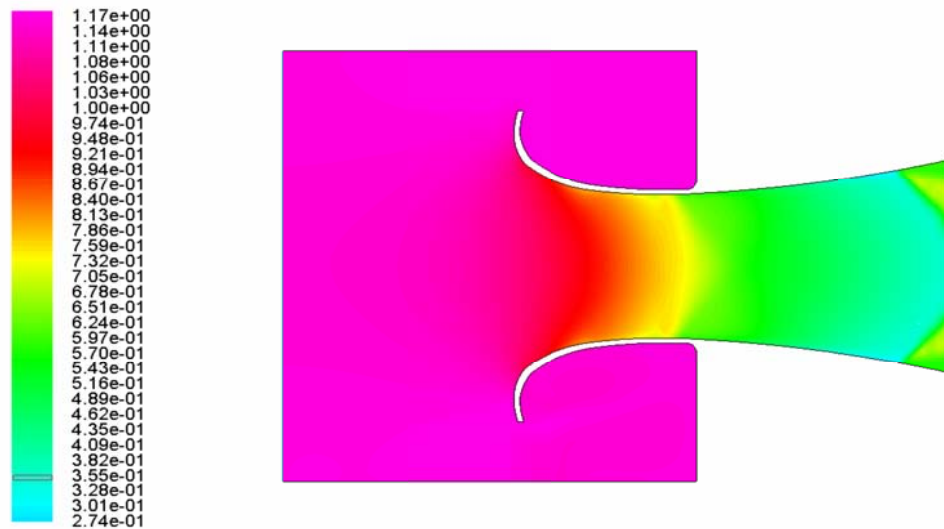


Figure 39. Contours of density (kg/m^3) of the bridle of throat 30 mm.

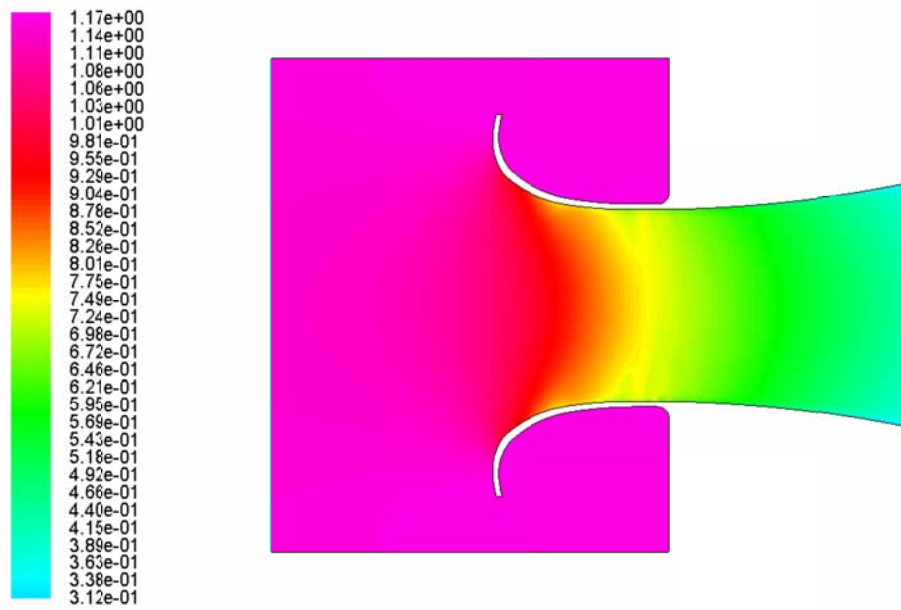


Figure 40. Contours of density (kg/m^3) of the bridle of throat 35 mm.

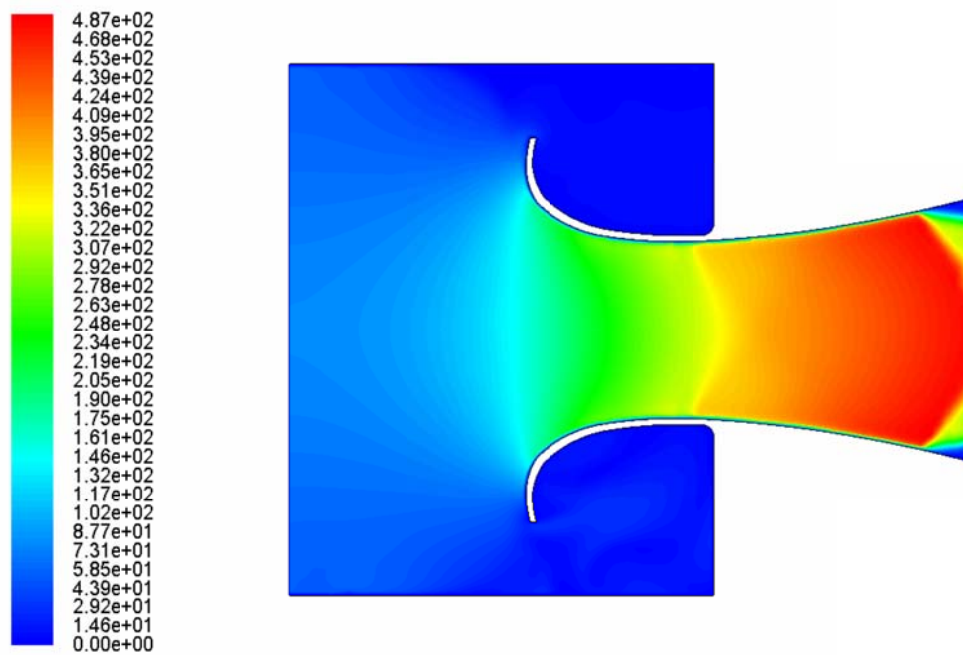


Figure 41. Speed contours (m/s) of the bridle of throat of 30 mm.

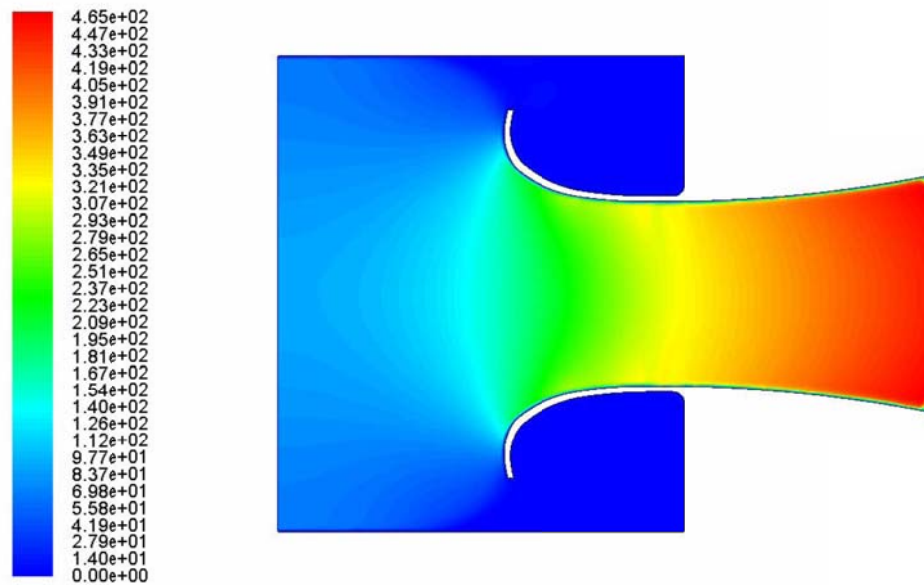


Figure 42. Speed contours (m/s) of the bridle of throat of 35 mm.

In the previous graphs it is possible to estimate the difference of diameters in throats of both geometries.

In the speed graphs it is estimated as the changes gear they are one little more declared in the geometry of 30 mm. Due to the fact that the speed it increases with more rapidity, because of it the speed value in the exit is top in this case.

6. DISCUSSION AND CONCLUSIONS

The aim of the project is the optimization of a bridge of admission of one car. For it the analysis CFD has been in use for realizing a series of simulations changing different parts of the geometry of the bridge for to observe that it happens with the air flow that it crosses it.

After verifying that for the select geometry the condition was fulfilled of strangled flow given the parameters of condition of border defined in Fluent, modifications have been realized in the convergent zone searching to increase the pressure of entry provided that it is the one that influences directly in mass flow of exit once has obtained the strangled flow.

The results of these simulations have showed variations little significant I concern the original bridge. By what there is deduced that not even the diameter not even the length of the conduit they modify or alter the flow of exit.

On the other hand, the simulations changing the convergent zone of the bridge, they have showed more unlike results in the geometries that less they look alike to the original one. Observing the values of mass flow from the geometries A and D and seeing that is in them in which there takes place a flow of minor exit, we can suppose that the bridges with a shorter convergent zone, it is to say, which have a convergent zone of fewer horizontal distance, they provide a flow of minor exit that other long billiard cues.

The last simulations comparing geometries with diameters of throat low, they show a flow to the original mass one of low exit, for what we can affirm that to major diameter of throat, major mass flow of exit.

This project and his results confirm the efficiency of the bridges of admission since there is demonstrated that given the condition of strangulation, it turns out to be difficult to increase the mass flow of exit.

Finally it can use as base for another project that studies more variations in the convergent zone to confirm if it is the length of this one the one that reduces flow. Another interesting serious option to realize variations in the diameter of throat climbs minor to try to find a direct relation between this one diameter and the flow of exit.

7. REFERENCES

[1] Templates, J. 2009, *Virtual Mecanic* (online), retrieved via Mozilla Firefox.

<http://www.mecanicavirtual.org/>

[2] Sports Associations of the Top Advice of Sports, 2010, *Royal Spanish Federation of driving* (online), retrieved via Mozilla Firefox.

<http://www.rfeda.es/>

[3] Bridles of admission, determined air, 2010, *Royal Spanish Federation of driving* (online), retrieved via Mozilla Firefox.

<http://www.rfeda.es/docs/infor/52/Pag3638.pdf>

[4] O'Keefe Control Co., 2000, *Precision Orifices and Fluid Control Products* (online), retrieved via Mozilla Firefox.

www.okcc.com

[5] Anderson, J.D., *Fundamentals of aerodynamics*, Boston, McGraw- Hill 2006.

[6] NASA, T. Benson, 2001, *Navier-Stokes Equations* (online), retrieved via Mozilla Firefox.

<http://exploration.grc.nasa.gov/education/rocket/nseqs.html>

[7] Dynamic of fluids, Marhl M., 2005, *Drop formation in a falling stream of liquid* (online), retrieved via Mozilla Firefox.

<http://www.sc.ehu.es/sbweb/fisica/fluidos/dinamica/bernoulli/bernouilli.htm>

[8] Anderson, J.D., *Computational Fluid Dynamics*, New York, Dover cop.

[9] Fluent Inc., 2003, *Fluent 6.1. Users Guide* (online), retrieved via Mozilla Firefox.

http://jullio.pe.kr/fluent6.1/help/html/ug/main_pre.htm

[10] Fluent Inc., 2005, *Guide for Fluent and Gambit* (online), retrieved via Mozilla Firefox.

www.fluentusers.com

[11] FIA, 2008, *International federation of the Car* (online), retrieved via Mozilla Firefox.

<http://www.fia.com>

8. APPENDICES

8.1 APPENDICE A. DESIGNATION OF THE EQUATIONS

Ne:	The effective power of the engine
pme:	The average effective pressure
vt:	The total cylinder capacity
n:	The regime of shaft or number of revolutions per minute
i:	The number of cycles for every return
ρ:	Density
P:	Pressure
\dot{m}:	Mass flow
v:	Volume
Q:	flow rate
V:	Velocity
F:	Force
m:	Mass
t:	Time
vc:	Volume of control
sc:	Surface of control
S:	Surface
h:	Height
R:	Constant of ideal gas
T:	Temperature

Ec:	Kinetic energy
Ep:	Potential graviational energy
Epr:	Energy of pressure
1:	Inlet section
2:	Outlet section

8.2 APPENDICE B. FIA

The International Federation of the Car, usually recounted as the FIA, [11] It is the entity that regulates the principal car competitions. It has his principal headquarters in Paris and it is shaped by 157 organizations natives affiliated in 118 countries in the whole world. His current president is Max Mosley.

The aim of the FIA is to establish an union between his members, principally with the sight in:

- 1) To support a world organization defending the interests of his members in all the international relating matters to mobility of the car and the sport of engine.
- 2) To promote the freedom of mobility across an attainable way, sure, and clean, and to defend the rights of the consumers on having travelled in car.
- 3) To promote the development of the sport of engine, delivering a judgment, interpreting and making fulfill the common rules applicable to the organization and to functioning of the events of engine.
- 4) To promote the development of the facilities and of the services of clubs members, associations and federations of the FIA and coordination of reciprocal services between the members in benefit of his individual members on having travelled abroad.
- 5) To exercise jurisdiction regarding the conflicts between his members, or in what concerns that some member has counter come obligations written in the bylaws, in the Sports Code International and in the regulations.
- 6) To preserve and to preserve all the documents relating to the world of car to remember his history.

Nowadays the FIA regulates, between others, the following events:

- World Championship of Formula 1
- World Championship of Rally
- International Championship of Formula 3000
- Championship GT
- World Championship of Go-cart CIK-FIA
- World Championship of Tourisms
- European Glass of Trucks
- World Cup of Rally Cross-Country
- Championship of Careers Drag
- European Championship of Autocross-country race

8.3 APPENDICE C. PLANES OF THE BRIDLES

In the following pages the planes of the bridles are provided for SEAT. The planes are not to scale since the dimensions were overcoming size DIN-A4 and it has not been considered to be necessary for his observation said dimensions.

The bridles that appear are the following ones:

1. Key: PTDI 145 563

Name: Bridle restrictor 35 mm.

Car: diesel

2. Key: PTDI 145 563 To

Name: Bridle restrictor 35 mm.

Car: diesel

3. Key: V131 129 550

Name: Bridle restrictor 34 mm.

Car: WRC

4. Key: V131 129 520

Name: Trumpet admission

Car: WRC

5. Key: V2GT 145 183

Name: Trumpet admission I disturb

Car: GT

6. Key: V2GT 145 563 To

Name: Bridle restrictor 31.9 mm.

Car: GT

7. Key: V2GT 145 563 B

Name: Bridle restrictor 30 mm.

Car: GT

8. Key: V2GT 145 563 C

Name: Bridle restrictor 29.3 mm.

Car: GT

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S:	Surface
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Name: Bridle restrictor 35 mm.

Car: diesel

2. Key: PTDI 145 563 To

Name: Bridle restrictor 35 mm.

Car: diesel

3. Key: V131 129 550

Name: Bridle restrictor 34 mm.

Car: WRC

4. Key: V131 129 520

Name: Trumpet admission

Car: WRC

5. Key: V2GT 145 183

Name: Trumpet admission I disturb

Car: GT

6. Key: V2GT 145 563 To

Name: Bridle restrictor 31.9 mm.

Car: GT

7. Key: V2GT 145 563 B

Name: Bridle restrictor 30 mm.

Car: GT

8. Key: V2GT 145 563 C

Name: Bridle restrictor 29.3 mm.

Car: GT

ANEXOS

ANEXO A. FIA

La **Federación Internacional del Automóvil**, usualmente referida como la FIA, [12] es el ente que regula las principales competencias automovilísticas. Tiene su sede principal en París y está conformada por 157 organizaciones nacionales afiliadas en 118 países en todo el mundo. Su actual presidente es Max Mosley.

El objetivo de la FIA es establecer una unión entres sus miembros, principalmente con la vista en:

- 1) Mantener una organización mundial defendiendo los intereses de sus miembros en todos los asuntos internacionales concernientes a la movilidad del automóvil y el deporte de motor.
- 2) Promover la libertad de movilidad a través de una manera asequible, segura, y limpia, y defender los derechos de los consumidores al viajar en automóvil.
- 3) Promover el desarrollo del deporte de motor, decretando, interpretando y haciendo cumplir las reglas comunes aplicables a la organización y al funcionamiento de los acontecimientos de motor.
- 4) Promover el desarrollo de las instalaciones y de los servicios de los clubes miembros, asociaciones y federaciones de la FIA y la coordinación de servicios recíprocos entre los miembros en beneficio de sus miembros individuales al viajar al extranjero.
- 5) Ejercer jurisdicción en lo que se refiere a los conflictos entre sus miembros, o en lo referente a que algún miembro haya contravenido las obligaciones redactadas en los estatutos, en el Código Deportivo Internacionales y en las regulaciones.
- 6) Preservar y conservar todos los documentos referentes al mundo del automóvil para recordar su historia.

Actualmente la FIA regula, entre otros, los siguientes eventos:

- Campeonato Mundial de Fórmula 1
- Campeonato Mundial de Rally
- Campeonato Internacional de Fórmula 3000
- Campeonato GT
- Campeonato mundial de Karting CIK-FIA
- Campeonato Mundial de Turismos
- Copa Europea de Camiones
- Copa Mundial de Rally Cross-Country
- Campeonato de Carreras Drag
- Campeonato Europeo de Autocross

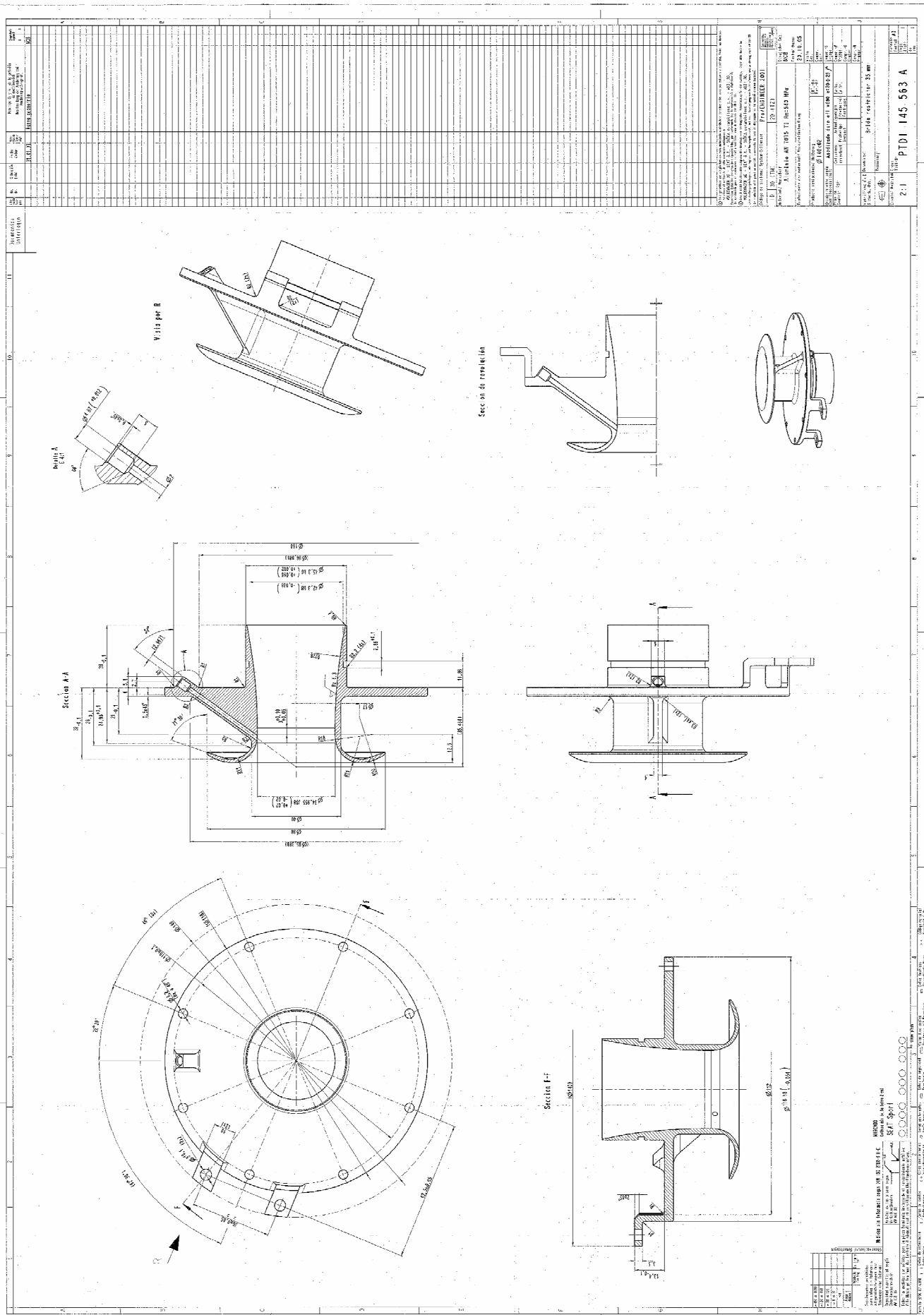
ANEXO B. PLANOS DE LAS BRIDAS

En las páginas siguientes están los planos de las bridas proporcionados por SEAT. Los planos no están a escala ya que las dimensiones superarían el tamaño DIN-A4 y no se ha considerado necesario para su observación dichas dimensiones.

Las bridas que se muestran son las siguientes:

1. Clave: PTDI 145 563
Denominación: Brida restrictor 35 mm.
Automóvil: diesel
2. Clave: PTDI 145 563 A
Denominación: Brida restrictor 35 mm.
Automóvil: diesel
3. Clave: V131 129 550
Denominación: Brida restrictor 34 mm.
Automóvil: WRC
4. Clave: V131 129 520
Denominación: Trompeta admisión
Automóvil: WRC
5. Clave: V2GT 145 183
Denominación: Trompeta admisión turbo
Automóvil: GT
6. Clave: V2GT 145 563 A
Denominación: Brida restrictor 31.9 mm.
Automóvil: GT
7. Clave: V2GT 145 563 B
Denominación: Brida restrictor 30 mm.
Automóvil: GT
8. Clave: V2GT 145 563 C
Denominación: Brida restrictor 29.3 mm.
Automóvil: GT





A		B		C		D		E		F		G		H		I		J		K		L		M		N		O		P		Q		R		S		T		U		V		W		X		Y		Z																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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1:1	Escala/ Maßstab		Denominación/ Benennung	Brida restrictor 34mm	Identificación D. Stempel-Dk.	Formato A2 Hoja Blatt 1 1
1:1	Escala/ Maßstab		Denominación/ Benennung	Brida restrictor 34mm	Identificación D. Stempel-Dk.	Formato A2 Hoja Blatt 1 1

Section A-A

Detalle S
Escala 2:1

Detalle R
Escala 2:1

Medidas sin tolerancias según DIN ISO 2768-M

Section A-A

Detalle S
Escala 2:1

Detalle R
Escala 2:1

Medidas sin tolerancias según DIN ISO 2768-M

Section A-A

Detalle S
Escala 2:1

Detalle R
Escala 2:1

Medidas sin tolerancias según DIN ISO 2768-M

Section A-A

Detalle S
Escala 2:1

Detalle R
Escala 2:1

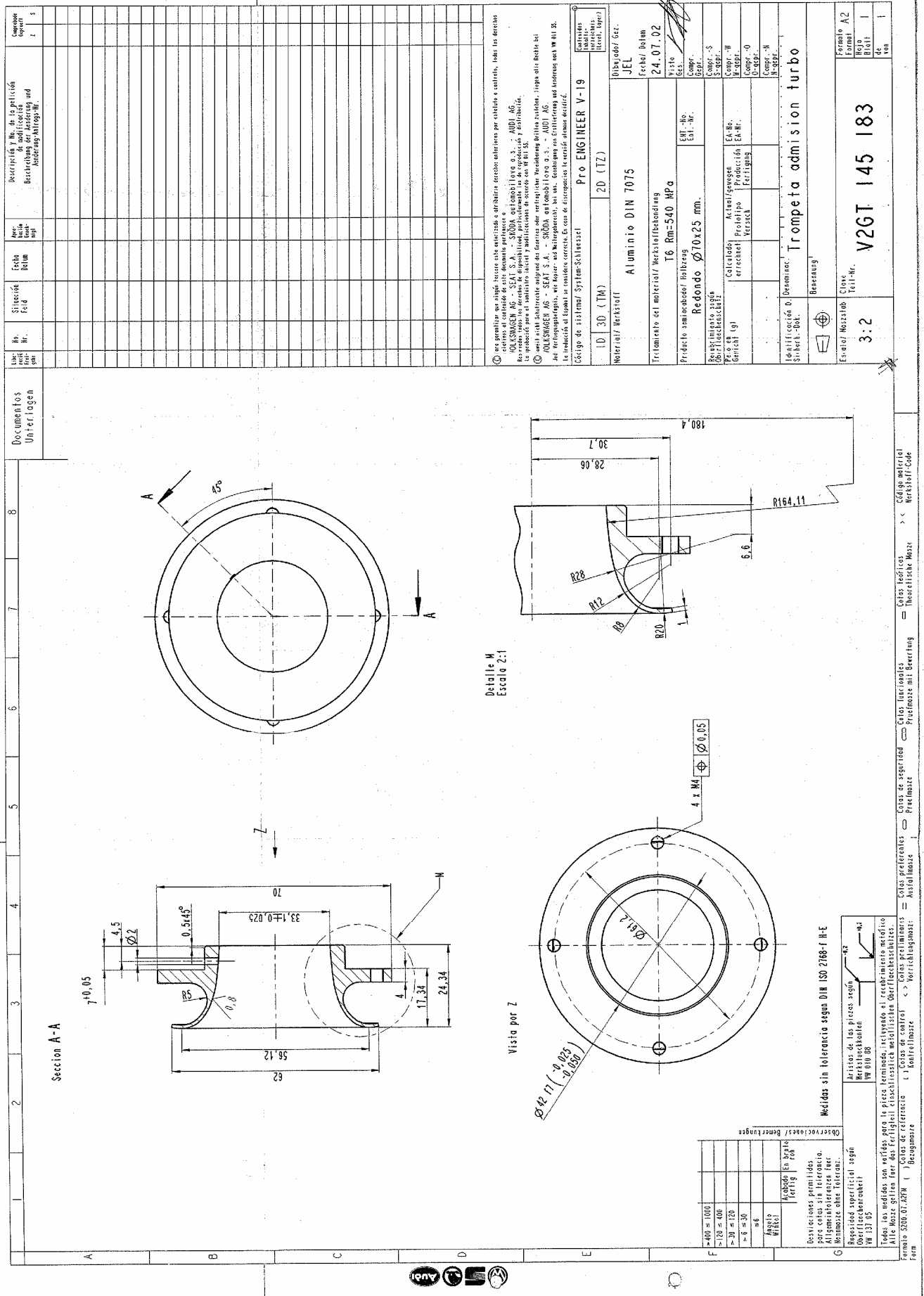
Medidas sin tolerancias según DIN ISO 2768-M

Section A-A

Detalle S
Escala 2:1

Detalle R
Escala 2:1

Medidas sin tolerancias según DIN ISO 2768-M



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