People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
University M'Hamed Bougara Boumerdes
Faculty of Engineering

Department Of Industrial Maintenance
Engine's Dynamics and Vibroacoustics Laboratory

In Partial Fulfillment
of the Requirements for the Degree
Master in Mechanics and systems engineering

TOPIC

THERMAL AND MECHANICAL STUDY OF NIIGATA 6MG28BX PISTON ENGINE

Submitted by:

BOUROUIS Athmane.

DERICHE Mohamed amine.

Under the supervision:

Mr DJEDDID Toufik.

PROMOTION: 2016/2017

Abstract:

The main objective of this study is to appreciate the material choice in the Diesel engine piston head with direct injection on the mechanical and thermal stresses. We focused our study on the 6MG28BX engine type NIIGATA.

For this study, the simulation is done applying the finite elements method using ANSYS software. Then, an analysis of deformations on each material was made. The obtained results were compared to obtain the best characteristics.

Résumé :

L'objectif principal de cette étude est d'apprécier le choix du matériau du piston d'un moteur diesel à injection directe en se basant sur les contraintes mécaniques et thermiques. Nous avons axé notre étude sur le piston du moteur NIIGATA de type 6MG28BX.

A cet effet, la simulation a été faite par la méthode des éléments à l'aide du logiciel ANSYS, conçu pour les calculs des structures. Par la suite, une analyse des déformations pour chaque matériau a été faite. Les résultats obtenus ont été comparés pour choisir le piston qui ayant les meilleures caractéristiques.

الملخص

الهدف من هذا العمل هو اختيار معدن المكبس الخاص بمحرك ديزل NIIGATA ذي الحقن المباشر من نوع 6MG28BX. و هذا من خلال دراسة الاجهاد الميكانيكي و الحراري.

لهذا الغرض, استعملنا طريقة العناصر المنتهية وفق برنامج ANSYS المصمم لحساب الهياكل الميكانيكية. يليه تحليل شامل للتشوهات الخاصة بكل مادة من المواد المستعملة. قارنا النتائج المتحصل عليها لاختيار المكبس ذي الخصائص الجيدة.

ACKNOWLEGMENTS

In the Name of Allah, the Most Merciful, the Most Compassionate all praise is to Allah, the Lord of the worlds; and prayers and peace be upon Mohamed His servant and messenger.

First, we must acknowledge our limitless thanks to Allah, the Ever-Magnificent, the Ever-Thankful, for His help and bless. We are totally aware that this work would have never seen the light without Him saying so.

We owe a deep debt of gratitude to our university for giving us an opportunity to complete this work. We are grateful to some people, who worked hard with us from the beginning till the completion of the present research particularly our supervisor **Mr. DJEDDID Toufik,** who has been always generous during all phases of this work.

We are grateful for all teachers of laboratory of dynamics and vibroacoustics ,we want to say thank you it was a good experience being your students, and it makes us sad that it comes to its end, but, life goes on, and with Allah help we`ll make you proud of us.

We would like to express our wholehearted thanks to our parents and families for their generous support they provided us throughout our entire life and particularly through the process of pursuing the master degree. Because of their unconditional love and prayers, we have the chance to complete this thesis.

Finally ,We also would like to take this opportunity to say warm thanks to our friends, who supported us and comrades who are now most like family, beside our differences, we want to say to each one apart that we are lucky to meet someone like you on this journey it is always better sooner than later

Dedication

I dedicate this modest work to my parents.

And all my family and all my friend

For my dears brothers and sister

BOUROUIS Athmane

Dedication

I dedicate this modest work to my parents.

And all my family and all my friend

For my dears brothers ANIS and RACHID

For my dear sister: RAYAN.

DERICHE Med Amine.

CHAPTER I : Generalities on diesel engine

1 Introduction 1
2 HISTORY 1
3 The theory of Diesel 2
4 Definition of diesel engine 2
5 Principle of operation 2
5.1 Intake 3
5.2 Compression 4
5.3 Combustion 4
5.4 Exhaust 5
6 The different types of diesel engines 5
6.1 Direct injection engines 5
6.2 Indirect injection engines 6
7 description of the naval engine (NIIGATA “6MG28BX”) 7
7.1 Introduction 7
7.2 Type of machine 7
7.3 The main characteristic of the engine 8
8 Organic description of the Naval engine (Niigata "6MG28BX ") 8
8.1 The fixed bodies 8
8.1.1 The cylinder block 8
8.1.2 The cylinder head 9
8.1.3 The cylinders 9
8.1.4 The cylinder liner 10
8.1.5 The cylinder head gasket 11
8.1.6 The casing 12
8.2 The mobile bodies 13
8.2.1 The crankshaft 14
8.2.2 The camshaft 14
8.2.3 The bearing shells 15
8.2.4 The valves 15
8.2.5 The rocker arms 16
8.2.6 The connecting rod 16

8.2.7 The piston 17
8.2.7.1 Introduction 17
8.2.7.2 The piston rings 19
8.2.7.3 Axis of piston...21
9 Conclusion 22

CHAPTER II : thermodynamic study of cycle

1 Generalities 23
2 Theoretical cycles of internal-combustion engines.. 24
3 Diesel cycle 25
4 Thermodynamic calculation of the engine cycle Niigata..................................... 27
4.1 Study of the cycle 27
4.2 Geometrical characteristics of diesel engine 29
4.3 Case study with data practice 31
4.3.1 The mean effective pressure Pm 32
4.3.2 Determination of the Net Work... 33
4.3.3 The four processes 33
4.3.4 The Network: 34
4.3.5 The efficiency: 34
5 Conclusion 35

CHAPTER III : Thermal and Mechanical Simulation of the piston

1 Introduction.. 36
2 The used software 36
2.1 The SolidWorks software 36
2.2 The ANSYS 16.0 software 37
3 Simulation methodology of the piston 37
3.1 Objectives 37
3.2 Assumptions of simulation 37
3.2.1 Geometrical assumptions 37
3.2.2 Assumptions of physical behaviors 40
3.3 Construction of the geometric model 41

3.4 Meshing 42
3.5 Boundary Conditions 43
3.6 Conditions of thermal loading of the piston 44
3.7 Conditions of mechanical loading of the piston 44
4 Results and Discussion 45
4.1 Introduction 45
4.2 Distribution of fields of thermal in the piston 45
4.3 Distribution of fields of mechanical stress in the piston 50
4.4 Choice of specific points to consider 55
6 Conclusion 57

LIST OF TABLES

Table 1.1 characteristic of engine …………………………………………..08

Table 2.1: real data………………………………………………………..31

Table 3.1 Characteristics of the materials used in the manufacture of the Piston……………………………………………………..40

Table 3.2 Values of the temperatures and stress for the selected points…………………………………………………56

Chapter I

Figure 1.1: Four strokes of the diesel engine…………………………………….03

Figure 1.2: intake………………………………………………………………03

Figure 1.3: compression………………………………………………………… 04

Figure 1.4: combustion…………………………………………………...……04

Figure 1.5: exhaust……………………………………………………………… 05

Figure 1.6.a: Sloping injector………………………………………………… 06

Figure 1.6.b: Upright injector………………………………………………… 06

Figure 1.7.a: pre-chamber system …………………………………………… 07

Figure 1.7.b: whirl-chamber system……………………………………….. 07

Figure 1.8.a: The cylinder head…………………………………………..... 09

Figure1.8.b: The cylinder head separate …..……………………….……..09

Figure 1.9: cylinder ………………………………………...……..…..10

Figure 1.10: cylinder liner………………………………………………..11

Figure 1.11: cylinder head gasket……………………………………...…12

Figure1.12: the casing…………………………………………………...…12

Figure 1.13: mobile hitch ……………………………………………..…13

Figure 1.14: crankshaft……………………………………...………14

Figure 1.15: bearing shells…………………………………………………15

Figure 1.16: valves……………………………………………………….…15

Figure 1.17: rocker arms…………………………………………...………16

Figure 1.18: Connecting Rod………………………………………………..17

Figure 1.19: piston…………………………………………………………..18

Figure 1.20: ring firewall……………………………………………………20

Figure 1.21: ring of sealing…………………………………………………20

Figure 1.22: scraper ring of oil…………………………..……….........21

Figure 1.23: Piston axis………………………………...……………22

Chapter II

Figure 2: schematic representation of a heat engine…………………………..23

Figure 2.2.a: thermal machine ……………………………………………….. 24

Figure2.2.b: cycle of Carnot …………..……………………………………...24

Figure 2.3.a: DIAGRAM P-V..26

Figure 2.3.b: DIAGRAM T-S…………………………………………..…..26

Figure2.3.c: diagram P-V of the diesel cycle theory…………………………26

Figure 2.4: schematic representation of an internal combustion engine alternative…………………………………………………………30

Figure 2.5: curve demonstrating the values of β……………………………..32

Chapitre III

Figure.3.1: photo of the piston………………………………………………36

Figure.3.2.a: dimensions of the piston head…………………………………38

Figure.3.2.b: dimensions of the skirt…………………………………………39

Figure.3.2.c: dimensions of piston (assembly)………………………………39

Figure.3.3: The head of the piston……………………………………………41

Figure 3.4: The piston skirt…………………………………………………..42

Figure.3.5: 3D view of the piston……………………………………………..42

Figure.3.6: mesh of the piston of study………………………………………43

Figure.3.7: Boundary condition of the piston…………………………………43

Figure3.8: Application of the temperature of the combustion gas…………44

Figure.3.9: Application of the pressure of combustion gases………………45

Figure.3.10. (a).(b): Distribution of temperature field.
The piston head to steel (Cr-Mo)………………………..46

Figure.3.11.(a).(b): Distribution of temperature field.
The piston head made of austenitic steel………………47

Figure.3.12. (A).(b): Distribution of temperature field.
The piston head in AS 12 UNG reinforced by fiber……48
Figure 3.13: (A).(b): Distribution of temperature field.
The piston head in as 12 UNG…………………………..49
Figure.3.14: Distribution of the pressure of combustion gases
on the piston head……………………………………………….50
Figure.3.15.(a).(b): Distribution of fields of mechanical stress.
The piston head to steel (Cr-Mo)………………………51
Figure.3.16.(a).(b): Distribution of fields of mechanical stress.
The piston head made of austenitic steel……………….52
Figure.3.17.(a).(b) : Distribution of fields of mechanical stress.
The piston head in AS 12 UNG reinforced by fiber……53
Figure.3.18.(a).(b) : Distribution of fields of mechanical stress.
The piston head in AS 12 UNG…………………………54
Figure .3.19: Selected Points…………………………………………………55
Figure 3.20: Values of temperature distribution on the selected points
in the piston…………………………………………………..56
Figure 3.21: Values of mechanical stress on the selected points
in the piston…………………………………………………57

Nomenclature

Mechanical:

N	Speed in revolution	[rpm]
W	Network	[J]
M	Masse	[kg]
D	cylinder diameter	[m]
L	length of stroke	[m]
V	volume	[m^3]
$\mathcal{P}$	power	[kW]
K	Number of cylinder	-
$\overline{Sp}$	Mean speed of piston	[m/s]

Chemical:

C_p	specific heat at constant pressure	[J/kg.K°]
C_v	specific heat at constant volume	[J/kg.K°]
E	Young's modulus	[MPa]
T	Temperature	[K°]
Q	heat quantity	[kJ/kg]
η	Efficiency	-
P	pressure	[bar]
r	compression ratio	-
CC	total capacity	[ℓ]
P_m	Mean effective pressure	[bar]
γ	isentropic coefficient	-
α	Thermal coefficient of dilatation	[K^{-1}]
ν	Poisson's ratio	-
ρ	Density	[kg/m3]
σ_{mec}	Mechanical stress	[N/mm2]

Chapter I

Generalities on Diesel engine

1 Introduction

The engine is a body which transforms into mechanical work a source of energy that is provided to it.

The names given to different engines are often used to refer to the source of energy used:

- Gasoline engine,
- Steam engine, or steam machine,
- Gas engine,
- Electric motor.

They can also be designated:

- By the name of their inventor: **diesel engine**, invented by **Rudolf Diesel** in1883

The diesel engine owes its name to its inventor, that he had the idea to achieve an engine to which the cycle is closer to the cycle of Carnot, the latter has presented this new engine as an internal combustion engine in which has been used the heat due to the compression of the air to cause the ignition of the fuel.

The types of training most commonly used in vehicles are internal combustion. They develop their power by converting the chemical energy into heat contained in the fuel, and then transforming this heat into mechanical work.

The diesel engine is an internal combustion engine whose ignition is not controlled but Spontaneous by self-ignition phenomenon (auto-ignition). Pressure and temperature during of such an engine reach such high levels that the fuel ignites spontaneously.

The Diesel engine is renowned for presenting one of the best energy a remarkable flexibility of use. Its performance, whether its power, and polluting emissions, are particularly sensitive to the quality of combustion this is mainly linked to the choice of the combustion system, the shape of the Combustion chamber or pre-chamber and the manner in which the fuel is introduced.

2 HISTORY

Diesel, a name or an adjective past in the current language, a name attached to never in the principle of engine to injection of diesel fuel which he has laid the bases. Rudolf Diesel, born in Paris, parent Germans, undertaken as early as 1887 the study of the engine that bears his name. Ten years later, the company MAN has produced the first diesel engine to fuel injection.

Five (05) tons, twenty (20) liters of displacement, this enormous vertical single cylinder developed 20 hp to 170 rpm. A special feature: its performance: 26%. It is the Best of all heat engines. As a comparison, the gasoline engines gave at the time 20% and the steam engines to barely 10 %.

3 The theory of Diesel

Based on the principle of operation of the engine in explosion at four (04) strokes with gasoline, the diesel engine is distinguished by the fact that at the intake stroke, the engine aspirates air only when the inlet valve opens, otherwise to the gasoline engine, which sucks in air and the fuel in its version carburetor. In the second strokes, the air is compressed; the pressure can reach 40 bars at 600°C. At the end of compression and a load of diesel fuel is injected at high pressure. The high temperature prevailing then in the combustion chamber is enough to cause the auto-ignition of the fuel. The third and fourth strokes, Combustion expansion, Exhaust -, are identical in all respects in their conduct to those of the four motor gasoline stroke.

4 Definition of diesel engine

The diesel engine is an internal combustion engine to spontaneous ignition, using fuels such as diesel fuel, the fuel or the granary. [1]

5 Principle of operation

The diesel engine operates on the following four strokes: intake, compression, expansion and exhaust.

The fuel is injected into the air which has been compressed meadows of the neutral high between the stroke of compression and expansion, causing an auto-ignition.

The engines are of the type called type with compression ignition. [2]

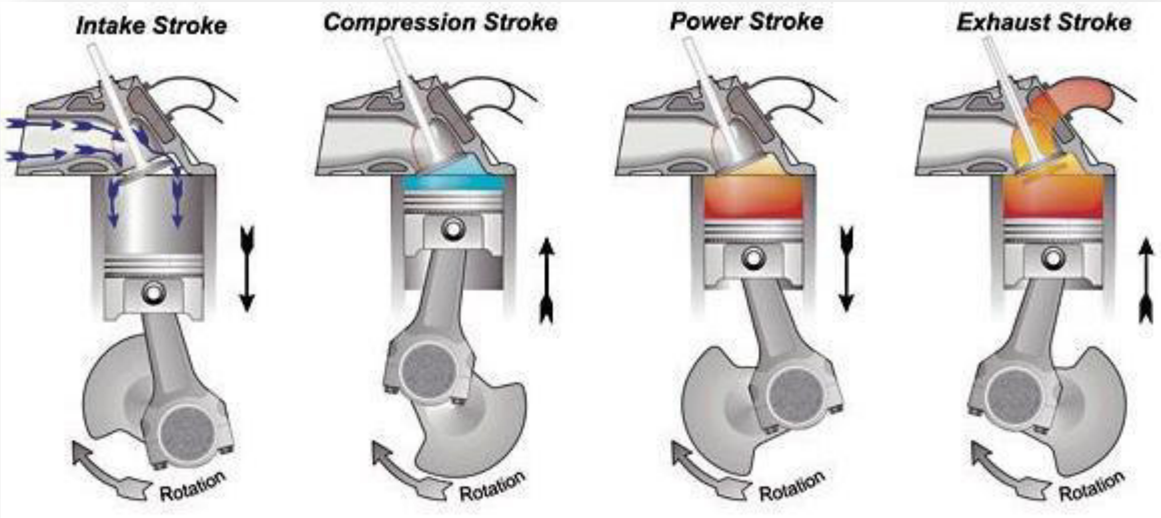


Figure 1.1: Four strokes of the diesel engine

5.1 Intake

The exhaust valve is closed, the piston goes down, the inlet valve opens and the turbo compressor makes pass the air which was compressed through the inlet valve.

When the piston reaches the bottom dead center (BDC), the inlet valve does not close immediately and the compressed air passes into the cylinder.

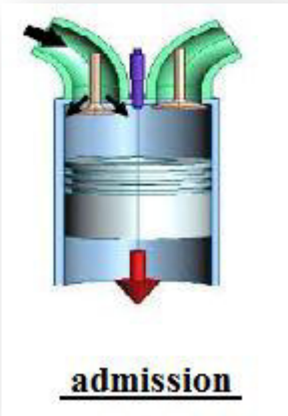


Figure 1.2: intake

5.2 Compression

The inlet and exhaust valves are closed, and while the piston goes up, the air contained in the cylinder is compressed which makes the temperature rise.

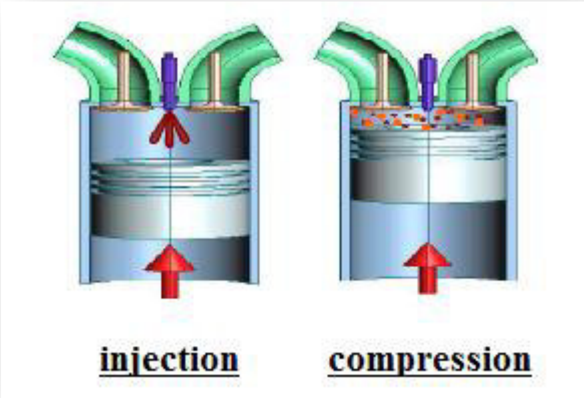


Figure 1.3: compression

5.3 Combustion

Just before the piston reaches top dead center (TDC), the mastering your sprayed is injected inside the cylinder by a jet; when he between in contact with the air at high temperature, a spark is produced and the combustion is performed.

The high pressure gas as well product moves toward the bottom of the piston and fact turn the crankshaft.

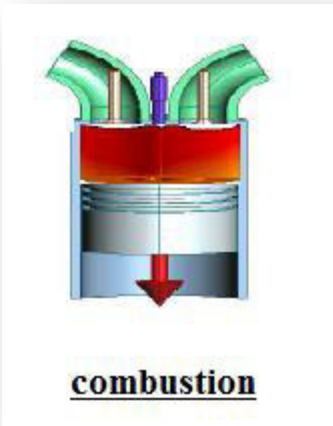


Figure 1.4: combustion

5.4 Exhaust

Just before the piston is at bottom dead center (BDC), the exhaust valve opens, the exhaust gas flows to the outside and the pressure in the cylinder falling.

The piston goes up in expelling the burned gas remaining in the cylinder.

As well, the four (04) strokes corresponding to two turns of each of the cylinders, the engine is still running, repeating this operation. [2]

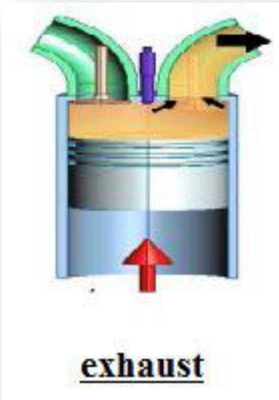


Fig 1.5: exhaust

6 The different types of diesel engines

Depending on the mode of injection of the fuel, we class the diesel engines in two categories: direct injection engines and indirect injection engines.

6.1 Direct injection engines

On this type of engine, the injector, equipped with several holes of spray pattern, leads directly in the combustion chamber. The piston can be flat or contain a cavity according to that one wishes to give the mixture a movement of turbulence. The turbulence of the compressed air but also of injected diesel fuel promotes then the combustion of the diesel fuel.

The volumetric ratio is very high as well as the injection pressure. The instant combustion of the Diesel Mixture/air generates a maximum pressure high. It results in a brutal operation. In return, the specific consumption is low and the startup of this type of engine requires no auxiliary system starting aid.

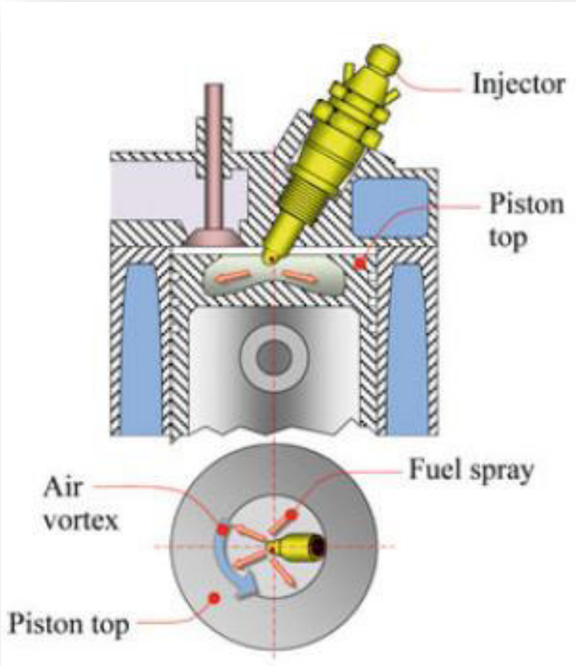


Figure 1.6.a: Sloping injector

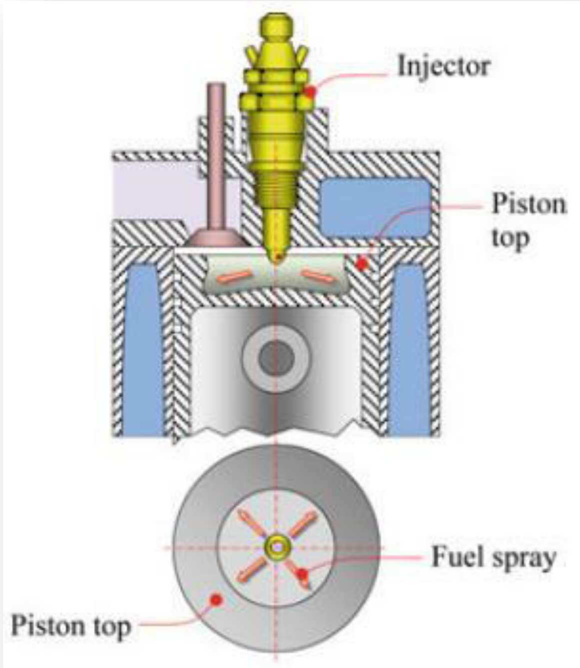


Figure 1.6.b: Upright injector

6.2 Indirect injection engines

In order to remedy the defects of the diesel engine related to the direct injection namely: brutality, knocking, lack of flexibility the manufacturers have been led to conceive an indirect injection engine. The injector leads in a pre-combustion chamber whose volume represents a part of the combustion chamber. This provision allows you to use a volumetric report lower as well as the injection pressure more lowly. The engine is much more flexible than an engine with direct injection. The knocking are mitigated which makes its use more pleasant. Its only defects: a consumption slightly higher than that of an engine with direct injection, and the requires the use of glow plugs when starting the engine because the volumetric ratio employee does not allow the auto-ignition temperature of the diesel fuel when the engine is cold.

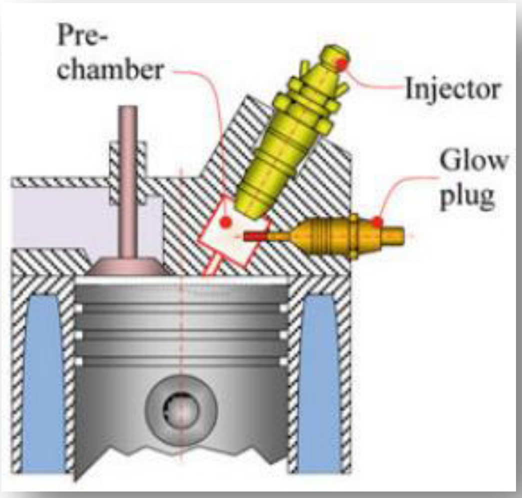


Figure 1.7.a: pre-chamber system

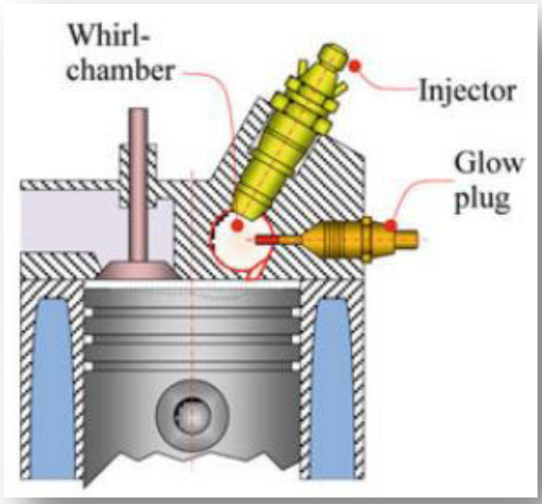


Figure 1.7.b: whirl-chamber system

7 DESCRIPTION OF THE NAVAL Engine (Niigata "6MG28BX")

7.1 Introduction

In our project it was takes the thermo-mechanical study of piston of a naval engine NIIGATA type 6MG28BX of port side of a boat tug which this name MAZAFRAN " 4 ".

This boat contains two motors a port side (left) and the other on the side starboard (right).

7.2 Type of machine

6MG28BX

→ **BX**….Classification Code (4 valves with turbo compressors and coolers of compressed air).

→ **28**……..The diameter of the cylinder: 280 mm.

→ **MG**….Classification of use (main engine with gear Marin)

→ **6**………Number of cylinder.

7.3 The main characteristic of the engine

Table 1.1 characteristic of engine [2]

Model	Unit	6MG28BX
Type		Diesel engine to 4 time to vertical cylinder and simple effect
Number of cylinders		6
Combustion system		Direct injection
Maximum power continues	hp	1700
Speed in revolution	rpm	720
Diameter of the cylinder	mm	280
Length of the stroke	mm	320
Mean piston speed	m/s	7.68
Compression rate		22
Firing order		1-3-5-6-4-2
Direction of rotation		Clockwise, facing the flywheel
Supercharging system		With Turbo-compressor and air coolers Tablet
The starting system		Start has the compressed air
The lubrication circuit		Pressure lubrication, completely closed
Cooling system		Cooling to fresh water or the sea water
Fuel Injection Pump		Bosch type
Injector		Automatic valve type to multiple holes

8 Organic description of the Naval engine (Niigata "6MG28BX ")

8.1 The fixed bodies

8.1.1 The cylinder block

An engine with, most of the time, several cylinders, they are often gathered in the same room: the cylinder block, which the envelope. It is also generally a piece of foundry, it is the master piece of engine. It is usually sunk in cast of a single piece. The cylinders can be machined or hollowed out to receive the cylinder liner. A circulation of water ensures their cooling.

The cylinder block must fulfill several functions:

- To resist the pressure from the gauze, which tend to dilate and to push the cylinder head.
- Guide the piston.
- Contain the cooling water while resistant to corrosion.
- As, a support, which receives the engines assemblies of cylinders liner

8.1.2 The cylinder head

This is the fixed bottom of the cylinder. It contains the more often the bodies intake, exhaust and injection. It has also the function to evacuate in the ambient air as part of the heat produced by the combustion, by water or directly by air. Its shape can therefore vary according to the geometry of the engine and its cooling mode. As it is a piece of complex form which must be able to withstand a pressure and a high temperature, it is more often cast in aluminum, cast iron or steel. It contains, in addition, when there is one, the combustion chamber, the form of which significantly affects the performance of the engine and on its maximum power. In the engine NIIGATA 6MG28BX it was 6 cylinder head separates for each of the cylinders.

Figure 1.8.a: The cylinder head

Figure1.8.b: The cylinder head separate

8.1.3 The cylinders

In addition to that they constitute the fixed walls of the combustion chamber, the cylinders are used to guide the pistons, which is transmitted the mechanical energy created by the combustion. This function leads to a number of constraints.

As the cylinder head, in effect, the liners should resist the pressure and heat. They must be able to evacuate a part of this heat for that their surface temperature remains lower than that of the carbonization of the oil, because they must ensure a shift without binding of moving parts.

These constraints require thus materials with qualities of resistance, conductivity and landslide. With regard to the circular shape, it was adopted because it is the only one which allows to keep the seal during the large variations in temperature to which it is subject and because it is the only to be machined in a precise manner. [4]

Figure 1.9: cylinder

8.1.4 The cylinder liner

The cylinders to ensure the slipping of the piston rings of the pistons and the cylinder block being an important piece and costly, in some cases, it fills the cylinder walls in contact with the piston of a material with good qualities of resistance to friction: special cast iron alloy or particular. This trim and removable sometimes which allows to replace at a lower price after wear.

Figure 1.10: cylinder liner

8.1.5 The cylinder head gasket

The cylinder head is applied and fixed on the cylinder block. The contact surfaces must ensure a perfect seal. To obtain the latter, we insert generally between the cylinder head and the cylinder block a special room: the cylinder head gasket.

This seal must also withstand the heat, while being more malleable as the parts with which it is in contact. Its tightening is particularly important. Its maximum torque, different for each, is given in a manner that is sufficient to ensure the sealing, without risking distorting the cylinder head or the cylinder block.

Figure 1.11: cylinder head gasket

8.1.6 The casing

It is a kind of metal tray attached to the underside of the cylinder block. Its function is to contain the oil necessary to lubrication of the engine. The housing is also separated from the cylinder block by a gasket ensuring the sealing. This part is often carried out in sheet metal or aluminum alloy. A pump takes oil from the oil sump and the distributed.

Figure1.12: the casing

8.2 The mobile bodies

The transmission of engine torque is ensured by a dynamic system with three main elements: the piston, the con rod and the crankshaft. The whole constitutes the mobile hitch.

The very high mechanical and thermal stresses, engendered by a diesel engine, impose components more robust, able to withstand pressures higher than in the gasoline engine. The hitch mobile (Piston, Connecting Rod, crankshaft) is clearly oversized. A condition of never solicit the engine beyond the capabilities provided by the manufacturer, the diesel engine has therefore logically a longer life than a petrol engine of the same power. [4]

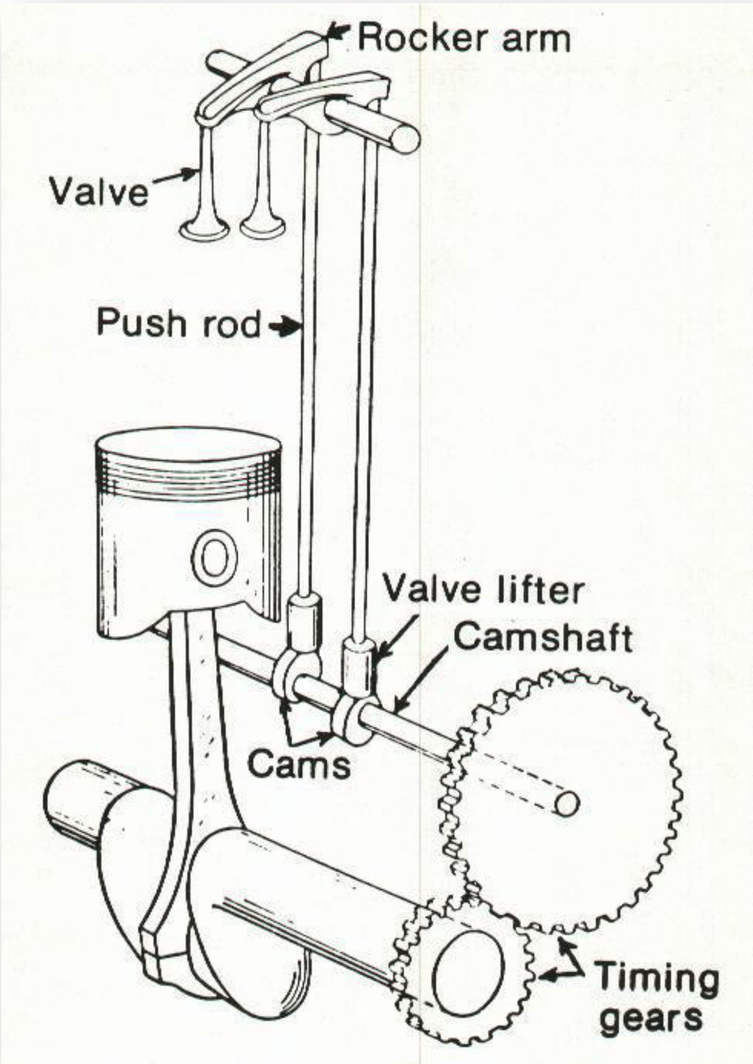


Figure 1.13: mobile hitch [4]

8.2.1 The crankshaft

Constitutes the crankshaft and engine flywheel, it transmits in the form of a torque the energy developed during the combustion. The regularization of the operation of the engine the balancing of the rotation of crankshaft is carried out firewall the engine flywheel. The crankshaft is realized with a particular care, steel to Nickel Chrome, precision machining of rotating parts, thermal treatment, balancing, font that the crankshaft, the centerpiece of the engine, it constitutes one of the most expensive.

Figure 1.14: crankshaft

8.2.2 The camshaft

The camshaft is driven by the crankshaft and with as much of cams that the valves according to the design of the distribution, its location within the motor varies. The solution most answered on the engines of the major powers is the distribution knocked her .**Figure 1.13**

It is following in the block and its drive is provided by a set of gears in which the report of multiplication is a half (1/2). The connection camshaft valves are ensured by a set of tappets, push rods and rocker arms.

Helical springs, housed around the valves, automatically close those, when the pressure communicated by the cams of the camshaft ceases.

When the camshaft is located in the cylinder head, it is said in the head. This solution, allows to reduce the number of elements thus to alleviate the distribution system, the tappets, the rods, rocker arm assemblies. The connection camshaft crankshaft is then carried out by a toothed belt.

This design of modern distribution benefits from several advantages:

- Reduction of the masses in movement.
- Lubrication of the liaison system non-existent.
- Silent operation.

8.2.3 The bearing shells

Constitutes half-cowlings removed, covered with a layer of anti-friction metal, they realize the contacts between the bearing of the crankshaft and the head of the rod.

Figure 1.15: bearing shells

8.2.4 The valves

Depending on the design, the power of the engine, the number of valves per cylinder generally varies with the number of two, one of admission, the other the exhaust. Some engines, with a view to improve the cylinder filling, can be equipped with three or four valves per cylinder. Each valve consists of a head fitted with a conical scope and a tail, allowing the guidance.

There are two kinds of valves: The inlet valves, and the exhaust valves.

Figure 1.16: valves

8.2.5 The rocker arms

Sometimes also called dumpers, rocker arms shall transmit the movement of the cams to the valves by the intermediary of the rocker arm rods. The end is in contact with the rod of rocker arm is fitted with a screw system allow nut adjustment of the valve rocker clearance [1]

Figure 1.17: rocker arms

8.2.6 The connecting rod

The connecting rod ensures the connection between the crankshaft and the piston. It transforms the movement alternative straight of the piston in rotary movement of the crankshaft to which it is connected. This part must be slight (always to minimize the effort of inertia, as for all mobile parts), and able to withstand cyclical efforts important. Made in steel ally, it must be able to withstand the efforts of compression very high. Has this title the manufacturers have generally adopted a section in H.

The connecting rod includes:

- The foot connected to the axis of the piston;
- The body whose section is generally in the form the;
- The head, which is connected to the crankshaft.

Figure 1.18: Connecting Rod

8.2.7 The piston

8.2.7.1 Introduction

In mechanical, a piston is a rigid piece of section usually circular sliding in a cylinder with a complementary form. The movement of the piston causes a variation in the volume of the room, part located above the piston, between the latter and the cylinder. A piston allows conversion of a pressure in a job, or vice versa.

The pistons are present in many mechanical applications. The most common is the internal combustion engine, in particular in the automobile. There are also one or several pistons in compressors, pumps, cylinders, valves, regulators, the distributors, the valves, shock absorbers, but also the medical syringes or the instruments of music to the pistons.

Most of the pistons are of a simple design (a flat piston is pushed or pulled by a rod), except in the engines, where they know an extensive study. These differ by their shape, their functions and their dimensions, their range is unlimited. Nevertheless, "Major Classes" can be distinguished according to the type of engine (shape of the head, materials used, etc.)

In a heat engine, the pistons are subjected to mechanical constraints resulting from the pressure of combustion of gases and of the dynamics of displacement cyclic, and thermal constraints, due to the difference in temperature between the piston and the burned gases. These constraints explain the choice, in general, of the steel. [3]

Figure 1.19: piston

The piston is the body which, by moving in the cylinder or the shirt, transmits the thrust of the gas to the crankshaft by the intermediary of the connecting rod.

The piston supports four (04) different kinds of efforts:

- Gas pressure and temperature of the explosion.
- Reaction of the axis of the connecting rod (piston pin).
- Reaction of the wall of the cylinder.
- Force of inertia.

In general it is molded in a lightweight material and a good thermal conductivity as aluminum alloys.

The head and the support of axis, to transmit the mechanical energy, are particularly strengthened.

It consists of:

- A head diameter must be less than the cylinder bore whatever the dilations.
- The sealing is ensured by segments located in the gorges practiced on the periphery of the piston.
- The skirt must ensure the Guidance hot and cold with a minimum of friction. [5]

8.2.7.2 The piston rings

The rings are of broken rings, section parallelepiped, working in extension. They must ensure the Radial pressures uniform on the walls of the cylinder.

In the marine engine **Niigata 6MG28BX** we have six (06) piston rings:

a) The ring firewall

It ensures the sealing of the combustion chamber. It must take to temperature, lack of lubrication, to the pressure and to the corrosion. It is generally in the Nodular graphite cast iron hardened and chrome.

Figure 1.20: ring firewall

b) The ring of sealing

There are three (03) rings, that they ensure the sealing and avoid the consumption of oil. They can be in gray cast iron to lamellar graphite. [5]

Figure 1.21: ring of sealing

c) The scraper ring of oil

There are two (02) rings that prevent the oil to prevent the lifts while leaving a certain film for enables the lubrication. They have grooves or notches authorizing the return of oil.

It may be in gray cast iron or steel treaty. [5]

Figure 1.22: scraper ring of oil

8.2.7.3 Axis of piston

The gudgeon pin is a cylindrical part that binds the piston to the connecting rod. It allows the oscillatory motion connecting rod/piston during the rotation of the engine. It transmits to the connecting rod the force of pressure that receives the piston during the phase expansion of gas.

It is manufactured in steel case hardened tempered, then rectified.

Figure 1.23: Piston axis

9 Conclusion

In this first chapter, we have presented the principle of operation of a compression ignition engine and the physical processes involved. We have described the constitution of the Engine NIIGATA 6MG28BX as well as the movable and fixed parts of the engine.

Chapter II

Thermodynamic study of the cycle

1 Generalities

A heat engine vehicle an engine fluid in a cyclic process during the what engine fluid absorbs the energy of a source of energy to a high temperature, a work is done by the engine, and the energy is evacuated by the engine toward a source at low temperature.

It is useful to represent a heat engine schematically as in Figure 2.1

The engine absorbs a quantity of energy$Q_c$of the hot source, produces a job *w*, and then emits an amount of energy $Q_f$toward the source of cold. Since the fluid engine performs a cycle, its internal energies to the initial and final states are equal, as well $\Delta Ein = 0$.

Therefore, in considering the first Principle of Thermodynamics, in the absence of variation of the internal energy , $\Delta Ein = Q - W$ ***the network produced by the engine is equal to the net energy which the cross member***.

As can be seen on the Figure 2.1 $Q_{net} = Q_c - Q_f$;

Therefore:$W = Q_C - Q_f$

Q_c: Energy provided by the hot source

Q_f: Energy released toward the cold source

W: Mechanical Work obtained

T_c: The temperature of the hot source

T_f: The temperature of the cold source

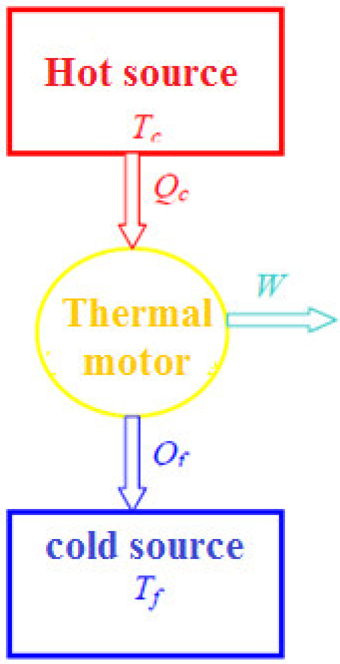


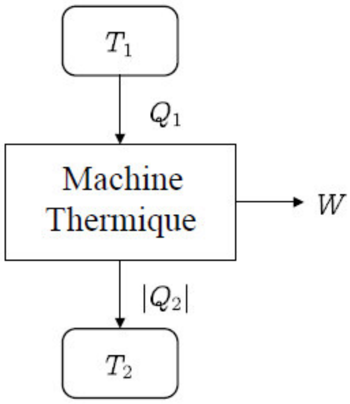
Figure 2.1: schematic representation of a heat engine.

The thermal performance η of a heat engine is defined as the ratio of the network produced by the engine during a cycle to the energy absorbed to the high temperature during the cycle:

$$\eta = \frac{W}{Q_{23}} = \frac{Q_{23}+Q_{41}}{Q_{23}}$$

In practice, all engines transform only a part of the absorbed energy into mechanical work and therefore the yield is always less than 100%.

2 Theoretical cycles of internal-combustion engines



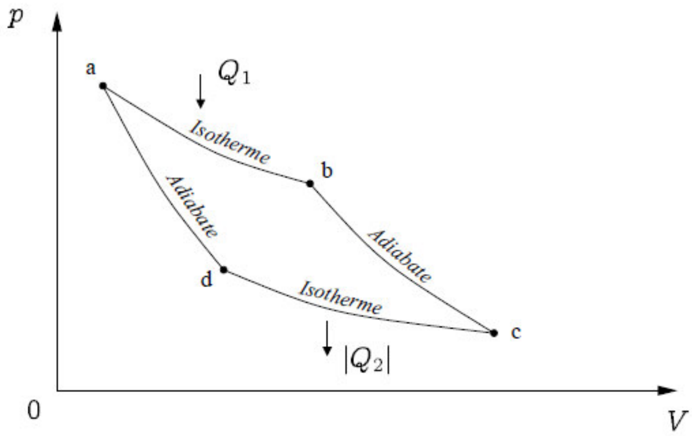


Figure 2.2.a: thermal machine **Figure2.2.b: cycle of Carnot**

It is to Sadi Carnot that must be the formulation of the ideal conditions of the operation of thermal machines: he considered the performance of a machine running with a hot source to the temperature T_1 and a source of cold temperature T_2 (Figure 2.2.a). The thermodynamic cycle ideal it then gets (Figure 2.2.b) is composed of two (02) Developments reversible isotherms (*ab* and *cd*) and two (02) Developments reversible adiabatic, i.e., isentropic (*bc* and *da*). A quantity of heat *Q1* is borrowed from the source following hot the isotherm *ab* and a quantity of heat Q_2 is transferred to the cold source following the isothermal *cd* .By convention, the heat received by the system is positive and that transferred is a negative sign, just as the work product:

$$w < 0 \quad , Q_1 > 0 \quad et \quad Q_2 < 0 \qquad (2.1)$$

According to the Carnot theorem, the performance of the cycle corresponds to the report of the work carried out by the quantity of heat received, either:

$$\eta_{th} = \frac{|W|}{Q_1} \tag{2.2}$$

The work of the cycle is given by the first principle:

$$|W| = Q_1 - |Q_2| \tag{2.3}$$

And finally, the performance of the cycle is written

$$\eta_{th} = \frac{Q_1 - |Q_2|}{Q_1} = 1 - \frac{T_2}{T_1} \tag{2.4}$$

3 Diesel cycle

While the cycle of Carnot is not applicable to internal combustion engines, Rudolf Diesel is inspired and adapted in order to limit the maximum pressure reached during a cycle. Diesel has first replaced the isothermal evolution *ab* (Fig. 2.2.b.) by an isobar: the heat input was then held at constant pressure. Then, to reduce the compression ratio and at the same time the stroke of the piston, he substituted to the evolution *cd* an isochors. The phases of the theoretical cycle of diesel (Fig. 2.3.a) are the following:

0 → 1 : Admission to constant pressure;

1 → 2: Isentropic compression of the gas

2 → 3 : Contribution of a quantity of heat, Q_{23}, at constant pressure by combustion of the load in the cylinder

3 → 4 : Isentropic relaxation of gas up to the initial volume;

4 → 1: Exhaust gases at constant volume up to return to the initial pressure;

1 → 0 : Exhaust gases at constant pressure. [7]

According to the first principle of thermodynamics, the work product W during this cycle is equal to the difference between the heats received, Q_{23}, and the heat transferred, Q_{41}, by the fluid, either:

$$|W| = Q_{23} - |Q_{41}| = C_P(T_3 - T_2) - C_V(T_4 - T_1) \tag{2.5}$$

The performance is written:

$$\eta_{th} = \frac{|W|}{Q_{23}} \tag{2.6}$$

It then comes: $$\eta_{th} = 1 - \frac{1}{\gamma}\frac{T_4 - T_1}{T_3 - T_2} \tag{2.7}$$

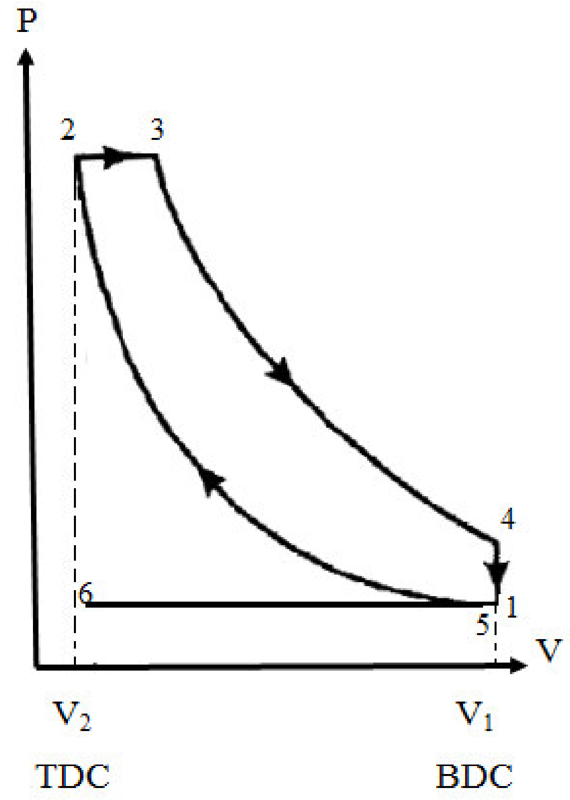


Figure 2.3.a: Diagram P-V

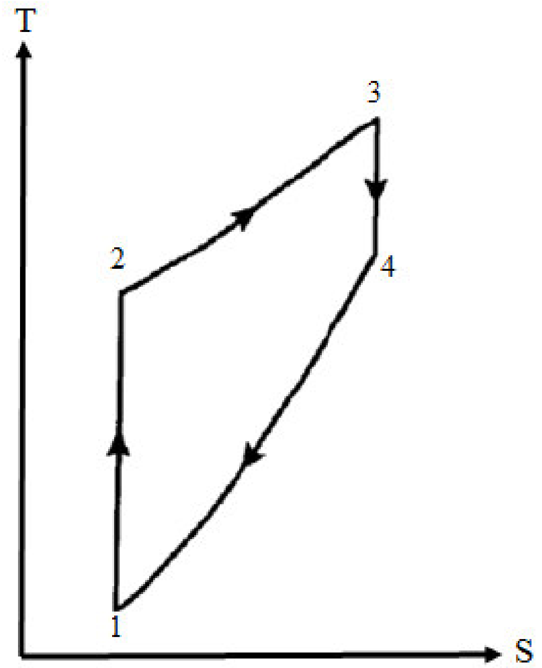


Figure 2.3.b: Diagram T-S

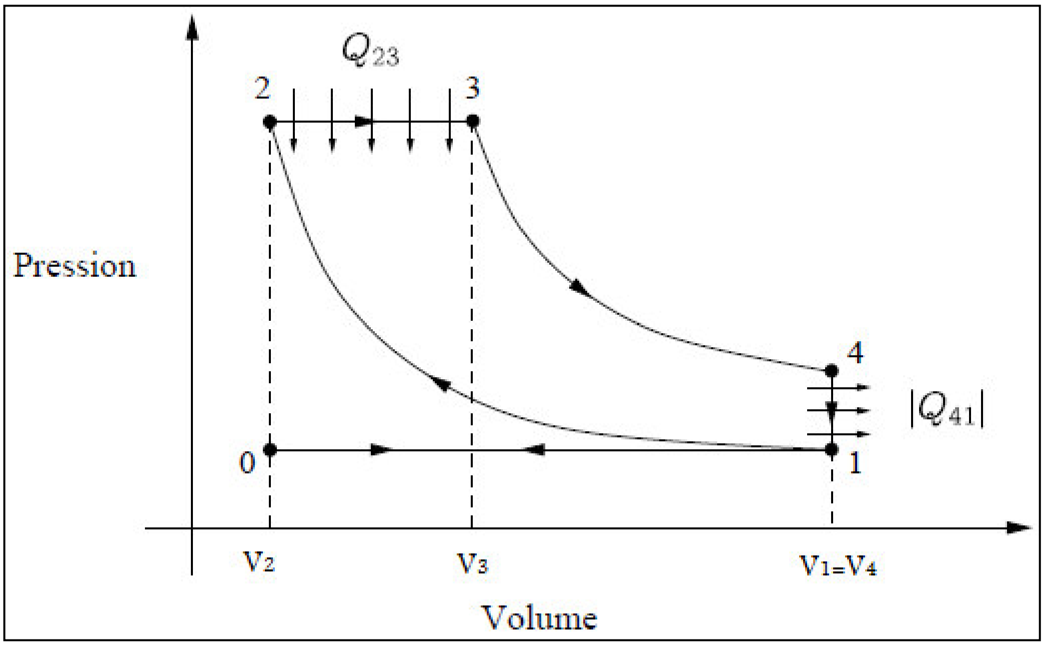


Figure2.3.c: diagram P-V of the diesel cycle theory

4 Thermodynamic calculation of the engine cycle Niigata

4.1 Study of the cycle

The thermodynamic study consists in studying the various transformations that undergoes the fuel in the cylinder during a complete cycle which corresponds to a cycle 720° rotation of the crankshaft.

To make the thermodynamic calculation we need certain data and some pre-requisite. The manufacturer of the engine gives, in general, the total displacement CC, the number of cylinders *K* and the report of volumetric compression *R,* report between the maximum volume of the cylinder and its minimum volume. ($r = V_1 / V_2$). Of these three (03) values one draws:

Given the air:

In the intake: One defines the pressure and the temperature of the air which enters the cylinder.

The inlet pressure *(P1)* is equal to the atmospheric pressure "0.95 bar".

In the exhaust: it is almost always done with the free air thus the exhaust pressure is equal to the atmospheric pressure always for this air, it defines two thermodynamic quantities:

The constant mass (or of Meyer) $R = C_p - C_v$ (2.8)

This constant is the difference of the mass heats applied to transformations with constant pressure (C_p) and constant volume (C_v).

For the air $R = 287 J/kg.K$ (2.9)

-The isentropic coefficient $\gamma = C_P / C_V = 1{,}4$ for the air (2.10)

Before embarking in the numerical values on the various points of the cycle it could necessary to measure the mass of air entering the cylinder and the mass of the gas participating in the transformations.

For a diesel engine, the phenomenon of scanning fact that at the end of the admission there is no longer that of the air. One is thus led to consider, for a diesel engine, that the mass of air entering is equal to the mass of the gas participating in the transformations:

$m = (P_1.V_1) / (R.T_1)$ According to the Act of Marriot. (2.11)

The parameters characterizing the cycle are:

- Compression ratio $r = \frac{V_1}{V_2}$ (2.12)

-The rate of relaxation Prerequisite: $\beta = \frac{V_3}{V_2}$ (2.13)

-Heat Quantity:

$$Q_{23} = c_P(T_3 - T_2) \quad (2.14)$$

$$Q_{41} = c_V(T_1 - T_4) \quad (2.15)$$

Process 1-2: isentropic transformation

It is governed by the Act:

$$P_1.V_1{}^{\gamma} = P_2.V_2^{\gamma} \quad (2.16)$$

As we know P_1, T_1, r and γ you can calculate $P_2 et\ T_2$

- $\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = r^{\gamma} \rightarrow P_2 = P_1\ .r^{\gamma}$ (2.17)

- $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = r^{\gamma-1} \rightarrow T_2 = T_1\ .r^{\gamma-1}$ (2.18)

Process 2-3: isobaric transformation

As the pressure remains constant: $P_3 = P_2$ and we have T2

We can calculate T3 but first there is the rate of relaxation of prior β after the formula of the average pressure

It was $P_m = P_1 r\left[\frac{\gamma.r^{\gamma-1}.(\beta-1)-(\beta^{\gamma}-1)}{(r-1)(\gamma-1)}\right]$ (2.19)

Therefore it calculates T_3 as the next

- $\frac{T_3}{T_2} = \frac{V_3}{V_2} = \beta \rightarrow T_3 = \beta.T_2$ (2.20)

Process 3-4: isentropic transformation

One finds the same law that for the transformation **1-2**. And as $V_4 = V_1$ we can calculate $P_4\ et\ T_4$

$$P_3.V_3^{\gamma} = P_4.V_4^{\gamma} \rightarrow P_4 = P_3\left(\frac{V_3}{V_4}\right)^{\gamma} \quad (2.21)$$

$$\rightarrow P_4 = P_3.\left(\frac{V_3/V_2}{V_4/V_2}\right)^{\gamma}$$

We have: $\beta = \frac{V_3}{V_4}$ $\quad , r = \frac{V_4}{V_3}$

Moreover: $P_4 = P_3\left(\frac{\beta}{r}\right)^{\gamma}$ (2.22)

- $T_3.V_3^{\gamma-1} = T_4.V_4^{\gamma-1} \rightarrow \; T_4 = T_3.\left(\frac{V_3}{V_4}\right)^{\gamma-1} = T_3\left(\frac{V_3/V_2}{V_4/V_2}\right)^{\gamma-1}$

Moreover: $T_4 = T_3.\left(\frac{\beta}{r}\right)^{\gamma-1}$ (2.23)

For process 4 → 1: **isochore transformation**$V_4 = V_1$

No calculation is necessary since it falls on the point (1) of which we already know the characteristics.

4.2 Geometrical characteristics of diesel engine

The design of a reciprocating engine has a fundamental character since some geometrical parameters have a preponderant influence on the operating range of the engine in terms of speed, power, torque and consumption. On the other hand, combustion in an engine is in part governed by aerodynamic phenomena which depend directly on the geometry of the combustion chamber. [7]

This section presents the main elements of geometry and kinematics necessary for the description of a reciprocating engine (Figure 2.4). The diameter of the cylinder is also called bore, the power of the engine is linked to this parameter since it depends on the surface of the piston. The movement of the piston is bounded by two points limits: the top dead center (TDC) and the bottom dead center (BDC). When the piston is at TDC (respectively to the BDC), then the volume of the combustion chamber is minimum (maximum, respectively). The race represents the distance the travelled by the piston between these two points of reference. Note that the report between the race and the radius of the connecting rod R, is a parameter invariant of the engine, the following relationship is virtually always respected:

$$L = 2R \tag{2.24}$$

The swept volume or unit volume vs corresponds to the volume swept by the piston between the TDC and the BDC:

$$V_S = \frac{\pi . D^2}{4} . L \tag{2.25}$$

When the piston is at the TDC the volume of the chamber is not zero, it remains a minimum volume describes mainly by the clearance between the piston and the top of the cylinder, is the clearance volume *Vc*. Also includes the housing of the injector and the bowl machined in the head of the piston and possibly the volume of the pre-combustion chamber in the case of an indirect injection engine. The total volume of the combustion chamber V_T is equal to the sum of the volume moved swept volume V_S and of the clearance volume *Vc* : [7]

$$V_T = V_S + V_C \tag{2.26}$$

The total capacity of an engine is given by: $cc = k. V_S$ (2.27)

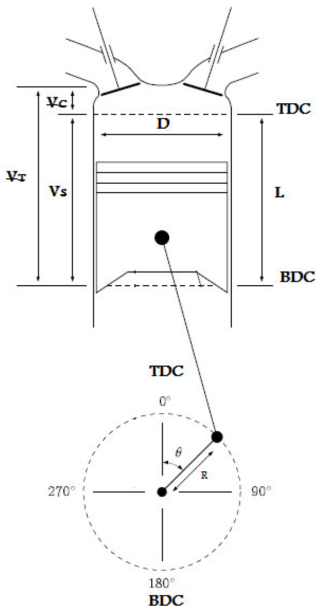


Figure 2.4: schematic representation of an internal combustion engine alternative.

4.3 Case study with data practice

Table 2.1: real data

Real Data	Symbol	Value	Unit
Power	$\mathcal{P}$	1700 1267,689	hp kw
Speed in revolution	N	720	rpm
Number of cylinder	K	6	
Diameter of cylinder	D	280 0.28	mm m
Lengh of the stroke	L	320 0.32	mm m
Mean speed piston	$\overline{Sp}$	7.68	m/s
Compression ratio	r	22	
	γ	1.4	
Initial pressure	P_1	0.95	bar
Initial temperature	T_1	300.15	K

- **Swept volume V_S**

$$V_S = \frac{\pi d^2}{4} L = \frac{3{,}14\,.\,0{,}28^2}{4}.\,0{,}32 = 0{,}0196\, m^3$$

$$\boxed{V_S = 19{,}6\,\ell}$$

- **Clearance volume V_C**

$$r = \frac{V_T}{V_C} = \frac{V_C+V_S}{V_C} = 1 + \frac{V_S}{V_C}$$

$$V_C = \frac{V_S}{r-1} = \frac{0{,}0196}{22-1} = 9{,}33\,.\,10^{-4} m^3$$

$$\boxed{V_C = 0{,}933\ell}$$

- **Total volume of cylinder:**

$$V_T = V_C + V_S = 0{,}0196 + (9{,}33\,.\;10^{-4}) = 0{,}020533\, m^3$$

$$\boxed{V_T = 20{,}533\,\ell}$$

- **Total capacity** CC

$CC = k\ V_S = 6\ .\ 0{,}0196 = 0{,}11816\ m^3$

$\boxed{CC = 118{,}16\ \ell}$

- **The mass of air entering:**

$$m = \frac{(P_1.V_1)}{r.T_1} = \frac{0{,}95\ .0{,}020533}{22\ .\ 300{,}15} = 2{,}95\ kg$$

It is known that the mass of air entering and the mass of the gas taking part in the transformations are equal

4.3.1 The mean effective pressure P_m

$$P_m = \frac{p}{L\ .A\ .\frac{N}{2}\ .k} = \frac{1267{,}689}{0{,}32\ .\ \pi\ .\frac{0{,}28^2}{4}.\frac{720}{60\ .\ 2}.6} = 1{,}787\ .\ 10^6\ N/m^2$$

$\boxed{P_m = 17{,}87\ bar}$

$\boxed{\beta = 3{,}465}$ = = = = = = = = = = = = = (this value has been concluded from a graph)

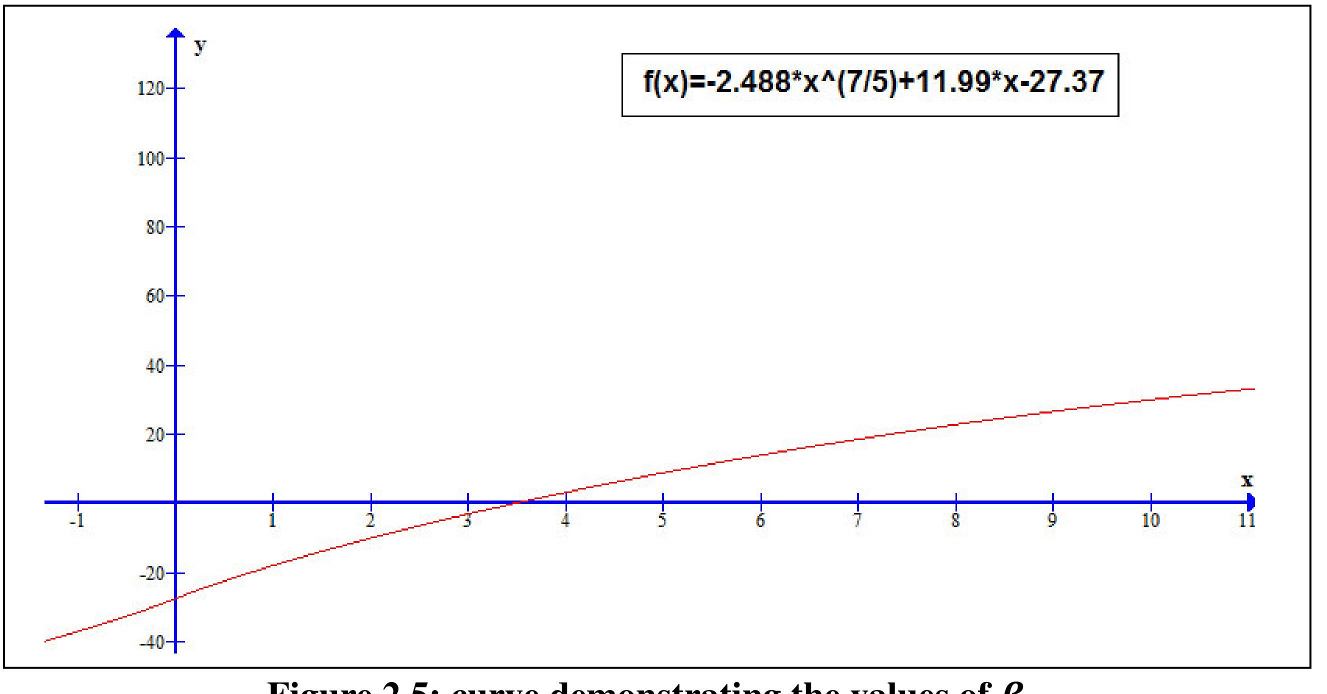


Figure 2.5: curve demonstrating the values of β

4.3.2 Determination of the Net Work

$W = Q_{23} + Q_{41}$

$Q_{23} = C_p(T_3 - T_2)$

$Q_{41} = C_V(T_1 - T_4)$

4.3.3 The four processes

Process: isentropic 1 → 2 transformation

- $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = r^{\gamma-1} \rightarrow T_2 = T_1 . r^{\gamma-1} = 300{,}15 \ . \ 22^{0,4}$

  $\boxed{T_2 = 1033{,}492\ K}$

- $\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = r^{\gamma} \rightarrow P_2 = P_1 . r^{\gamma}$

  $P_2 = P_1 . r^{\gamma} = 0{,}95 \ . \ 22^{1.4}$

  $\boxed{P_2 = 71{,}964\ bar}$

Process: isobaric transformation 2 → 3 $P_3 = P_2$

- $\boxed{P_3 = 71{,}964\ bar}$
- $\frac{T_3}{T_2} = \frac{V_3}{V_2} = \beta$

  $\rightarrow T_3 = \beta . T_2 = 3{,}465 \ . 1033{,}492$

  $\boxed{T_3 = 3581{,}049\ K}$

Process: isentropic transformation3 → 4 V4=V1

- $P_3 . V_3^{\gamma} = P_4 . V_4^{\gamma} \rightarrow P_4 = P_3 \left(\frac{V_3}{V_4}\right)^{\gamma}$
- $P_4 = P_3 . \left(\frac{V_3/V_2}{V_4/V_2}\right)^{\gamma}$
- We have: $\beta = \frac{V_3}{V_2}$, $r = \frac{V_4}{V_2}$

Moreover: $P_4 = P_3 \left(\frac{\beta}{r}\right)^{\gamma} = 71.964 \,.\left(\frac{3{,}465}{22}\right)^{1{,}4}$

$\boxed{P_4 = 5.397\ bar}$

$$T_3 . V_3^{\gamma-1} = T_4 . V_4^{\gamma-1} \rightarrow \ T_4 = T_3 . \left(\frac{V_3}{V_4}\right)^{\gamma-1} = T_3 \left(\frac{V_3/V_2}{V_4/V_2}\right)^{\gamma-1}$$

Moreover: $T_4 = T_3 . \left(\frac{\beta}{r}\right)^{\gamma-1} = 3581{,}049 \,.\left(\frac{3{,}465}{22}\right)^{0{,}4}$

$\boxed{T_4 = 1708{,}160\ K}$

4.3.4 The Network:

Heat quantities:

$Q_{23} = C_p . (T_3 - T_2) = 1{,}005 \,.\ (3581{,}049 - 1033{,}492)$

$\boxed{Q_{23} = 2560{,}294\ kJ/kg}$

$Q_{41} = C_V (T_1 - T_4) = 0{,}718 \,.\ (300{,}15 - 1708{,}160)$

$\boxed{Q_{41} = -1010{,}951\ kJ/kg}$

$W = Q_{23} + Q_{41} = 2560{,}294 - 1010{,}951$

$\boxed{W = 1549{,}343\ kJ/kg}$

4.3.5 The efficiency:

$$\eta_{diesel} = \frac{W}{Q_{23}} = \frac{1549{,}343}{2560{,}294}$$

$\boxed{\eta_{diesel} = 0{,}6051 = 60{,}51\%}$

5 Conclusion

We have presented in this chapter a thermodynamic analysis of a Diesel standard cycle, with numerical application on our engine taking into account the available data from **ERENAV** Company.

Chapter III

Simulation

Thermal and Mechanical of the piston

1 Introduction

This study is made on the piston of the Niigata engine type 6MG28BX fitted to the towing vessel which this name MAZAFRAN "4", the real form is presented (Figure 3.1)

Figure.3.1 Photo of the piston

2 The used software

2.1 The SolidWorks software

The Solid Works software is an application of mechanical design that takes advantage of the graphical user interface of Microsoft Windows.

Using this software, designers can sketch quickly an idea, experiment with functions and coasts and produce models and put in specific plan.

2.2 The ANSYS 16.0 software

ANSYS is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers. So ANSYS, which enables to simulate tests or working conditions, enables TB test in virtual environment before manufacturing prototypes of products. Furthermore, determining and improving weak points, computing life and foreseeing likely problems are possible by 3D simulations in virtual environment. With its modular structure it gives an opportunity for taking only needed features. ANSYS can work integrated with other used engineering software on desktop by adding CAD and FEA connection modules.

ANSYS can import CAD data and also enables to build geometry with its pre-processing abilities. Similarly in the same pre-processor, finite element model (a.k.a. mesh) which is required for computation is generated. After defining loadings and carrying out analyzes, results can be viewed as numerical and graphical.

3 Simulation methodology of the piston

3.1 Objectives

The work of simulation is divided into two (02) Parts:

- The first part concerns the determination of the field of temperature in the 3D model of the piston and the thermal distribution.

- The second part concerns the determination of the field of mechanical stresses due to the load pressure of the combustion gases.

The study is based on a static analysis of stresses and strains corresponding to the case of maximum load on the piston at the time of the combustion.

3.2 Assumptions of simulation

3.2.1 Geometrical assumptions

A). System of Units Used

We will work in the system of units "kg, m, s, N, °C".

B). Assembly and Configuration

We work here with two parts, two defeated the materials Head and skirt which assembles our piston configuration. The assembly is therefore imported.

C) Dimensions characteristics

For information, the characteristic quantities of the work piece are data in the (Figure3.2):

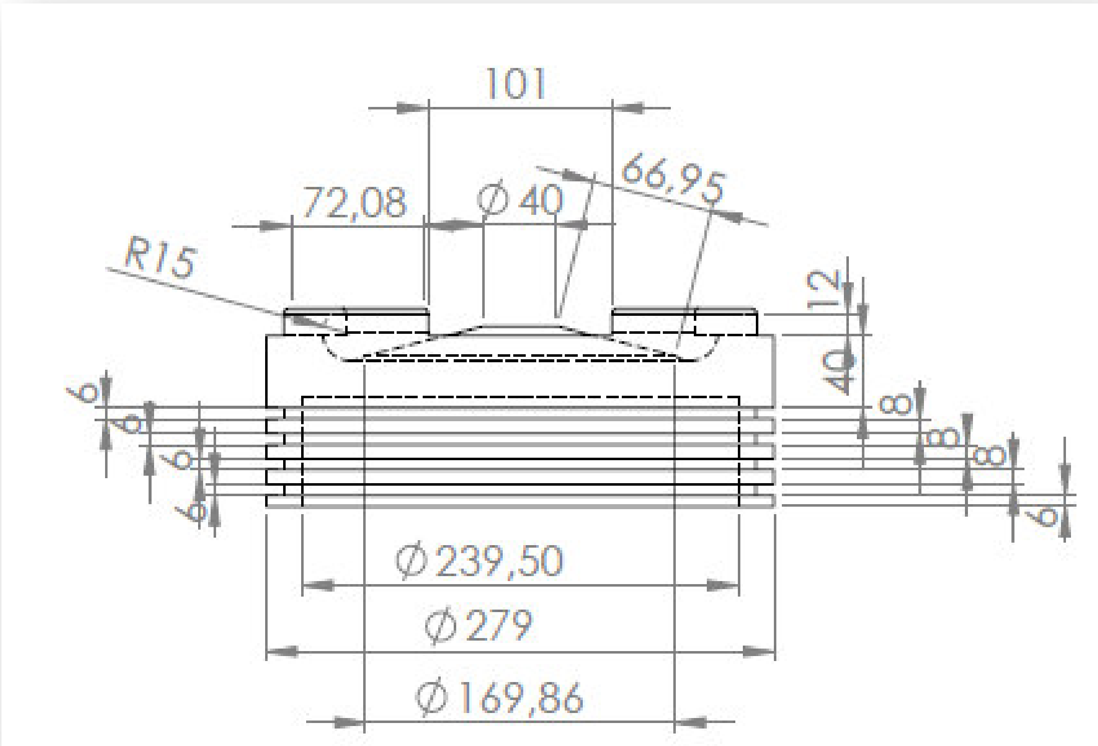


Figure.3.2.a. dimensions of the piston head

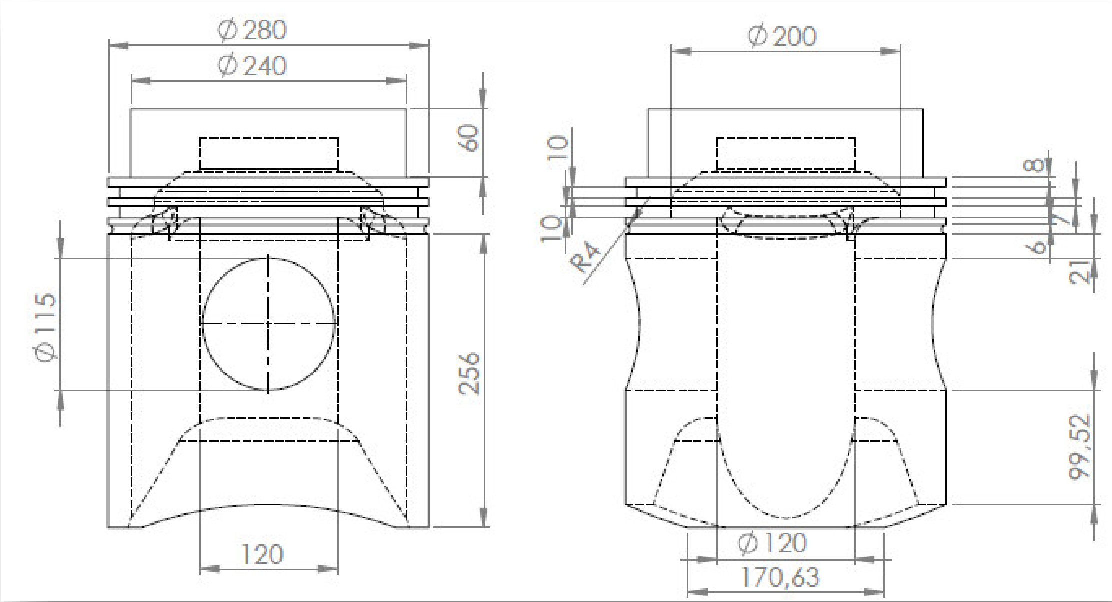


Figure.3.2.b dimensions of the skirt

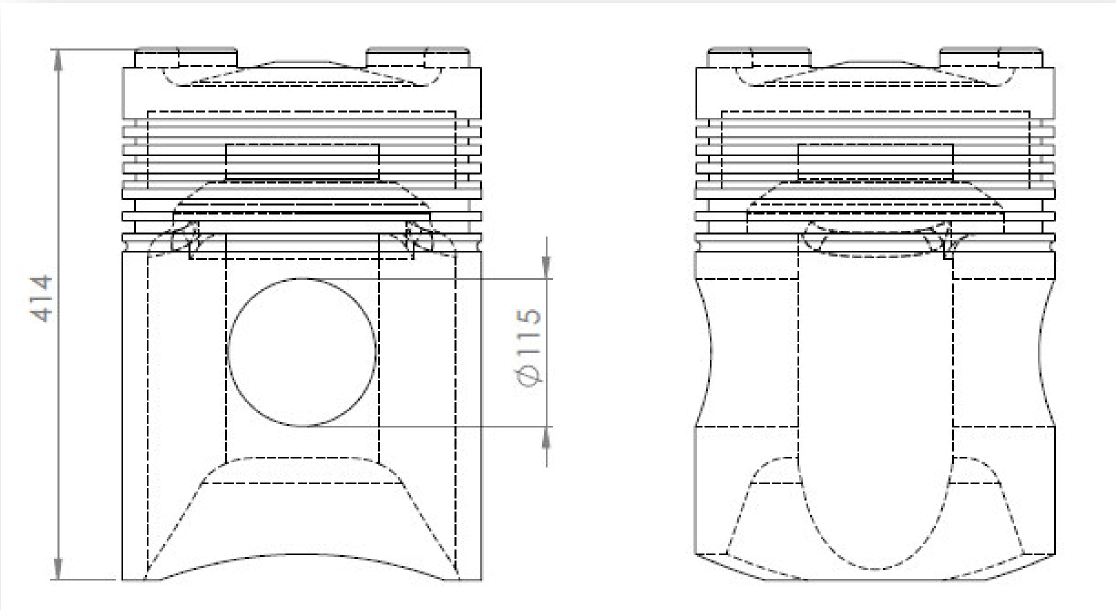


Figure.3.2.c dimensions of piston (assembly)

(D). Type of modeling

The modeling of the phenomenon in 3D will be adopted because it proves that it is the closest to the reality.

3.2.2 Assumptions of physical behaviors

A) Descriptions of the materials

It has five (05) types of materials of which the mechanical and thermal properties we are provided by the Table 3.1. These properties are the parameters of our simulation.

We keep the material of the skirt which is the gray cast iron and has each simulation we change the material of the head piston with the four types of steel that was.

Table 3.1 Characteristics of the materials used in the manufacture of the Piston [2]

Characteristics	Austenitic steel	Steel (Cr-Mo)	AS12 UNG	AS12UNG strengthened by fiber	Gray cast iron
Young's Modulus (GPa)	190	190	55	55	160
Poisson's ratio	0.33	0.33	0.33	0.33	0.33
Density (Kg/m^3)	7800	7800	2700	2700	7200
Thermal Conductivity (W/m.K)	20	40	150	100	35
Coefficient of Thermal expansion (10^{-6} K^{-1})	12	13	24	20	35

B) Model of physical behavior

The mechanical behavior of materials is considered linear, elastic and isotropic.

C) Sections

In the case of a 3D modeling, we have "sections" 3D with homogeneous materials.

D) Assignment of behaviors

The piston is made up of two (02) materials, head steel piston and the skirt in made of cast iron.

3.3 Construction of the geometric model

The construction is made with solid-Works software.

This step is difficult because the form of piston is very complex; it requires several steps to build a model more close as possible to the actual form.

Our first step is to build the head of the piston figure (3.3)

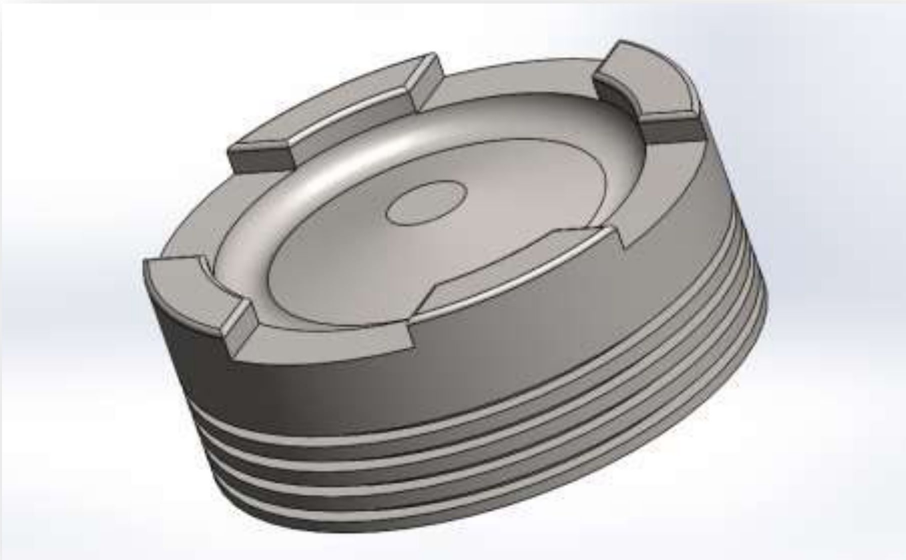


Figure.3.3: The head of the piston

The second step is to build the piston skirt figure (3.4).

Figure 3.4: The piston skirt

After the stages of construction, was assembled the two parties to obtain the final form of the piston, Figure 3.5 represents a 3D view of piston on its final form.

Figure.3.5: 3D view of the piston

3.4 Meshing

A) Choice of the type of finite elements

The purpose of this study is to obtain a good approximation of displacement and constraints in linear elasticity. We choose in a first time elements tetrahedral.

B) Method of meshing

The mesh is automatically performed to the use of the elements, the structure is discretized in 67956 nodes and 37751 tetrahedral elements figure (3.6)

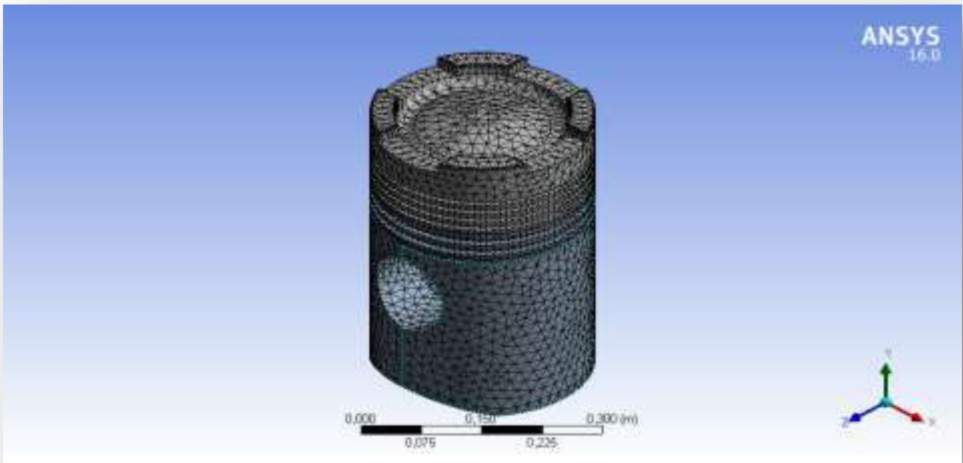


Figure.3.6: mesh of the piston of study

3.5 Boundary Conditions

All nodes that are located at the level of the internal surface of the axis of the piston are fixed in translation and rotation (Fig.3.7).

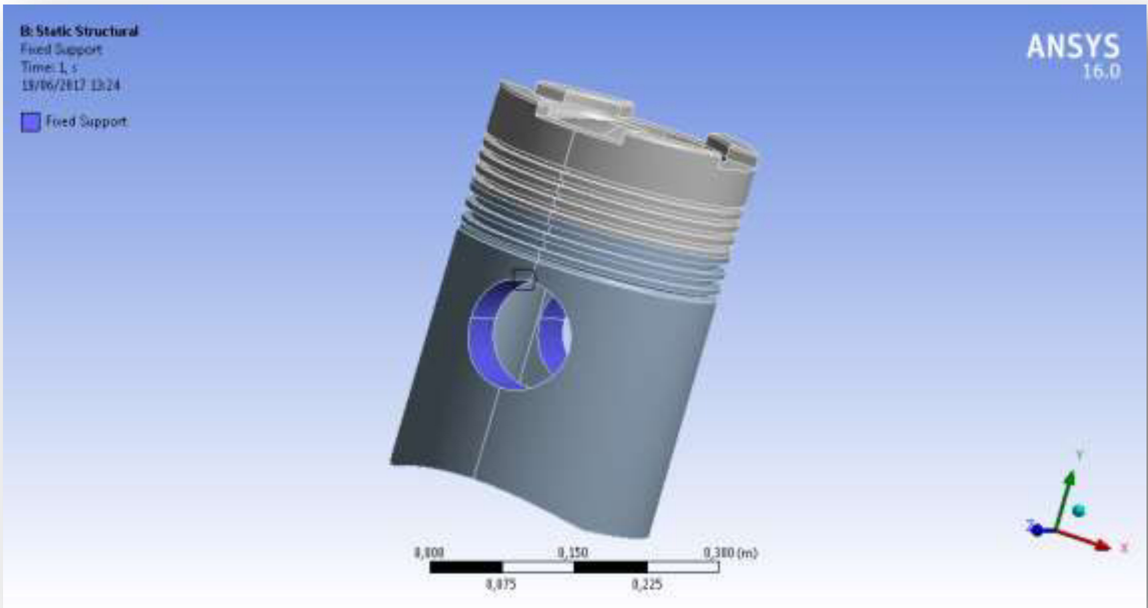


Figure.3.7: Boundary conditions of the piston

3.6 Conditions of thermal loading of the piston

The combustion produces a significant quantity of calorific energy. The piston receives a part of the heat that is transferred by convection to the head and then passes through the inside of the piston by conduction. This quantity of heat is a function of the temperature of the combustion gases and the heat transfer coefficient.

In regime established the engine, the temperature field is considered stationary with a value of 3581,049 K (constant temperature, constant loads).

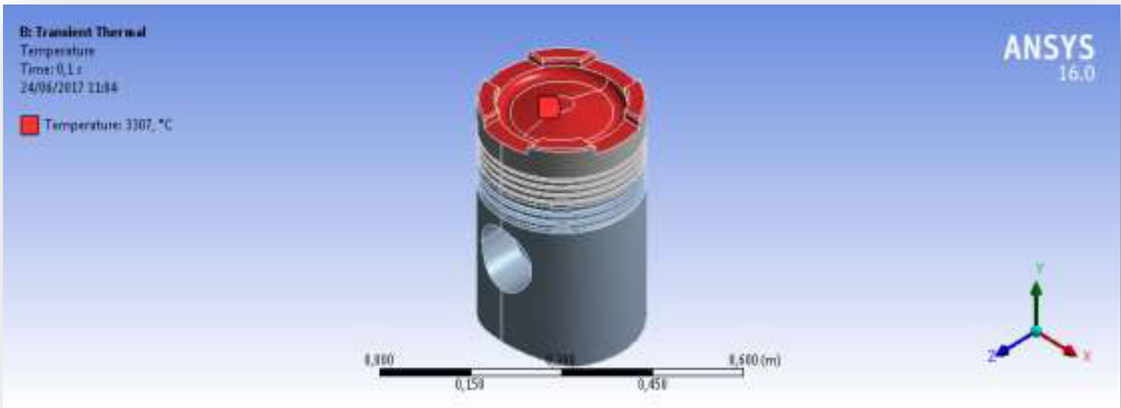


Figure3.8: Application of the temperature of the combustion gas

3.7 Conditions of mechanical loading of the piston

The pressure acting on the bottom of the piston, due to the action of the combustion gases, is assumed to be evenly spread with a value of 71,964 bars.

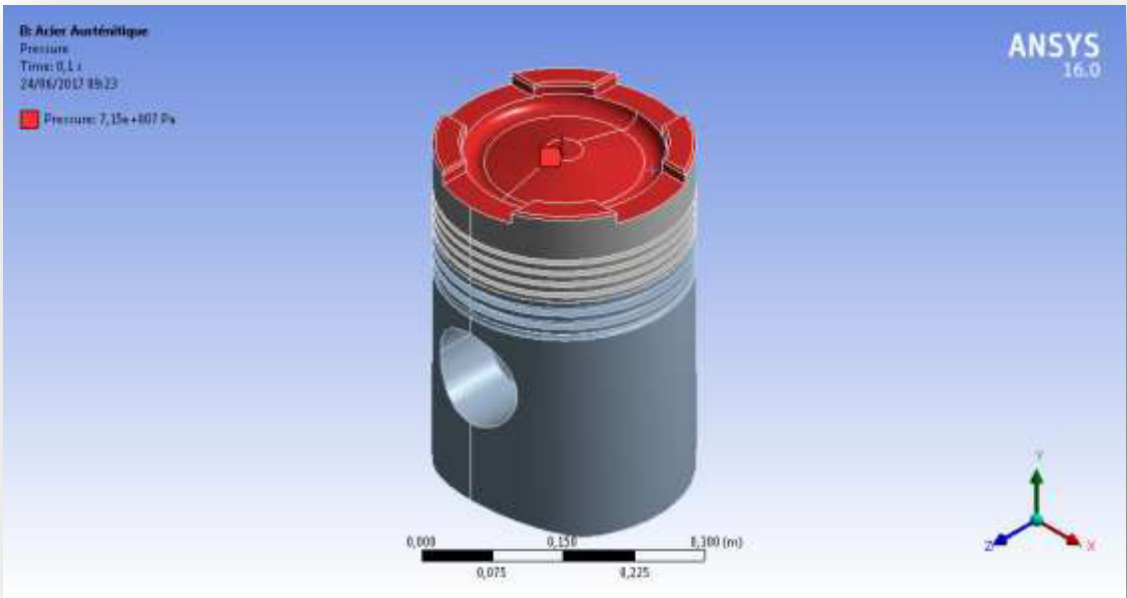


Figure.3.9: Application of the pressure of combustion gases

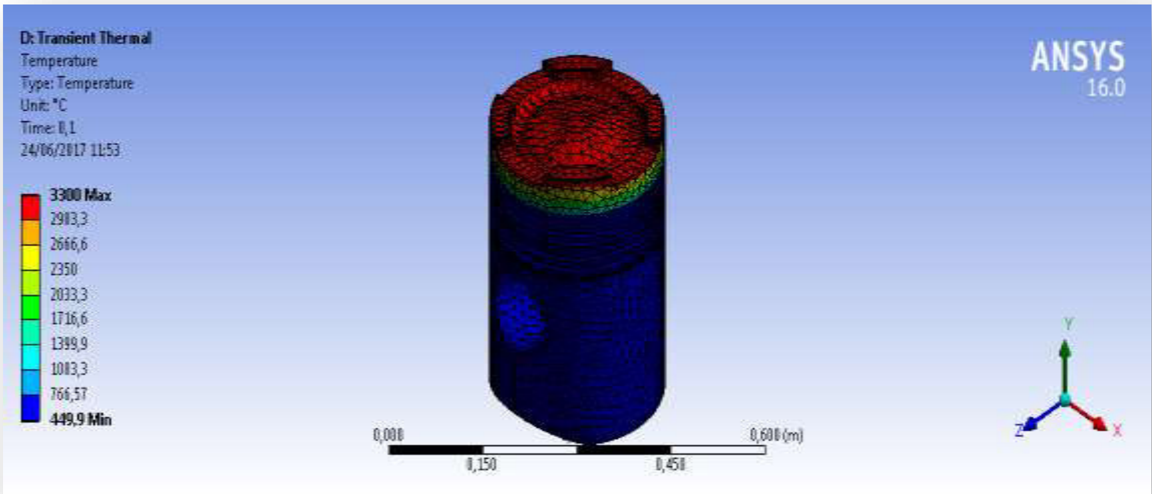
4 Results and Discussion

4.1 Introduction

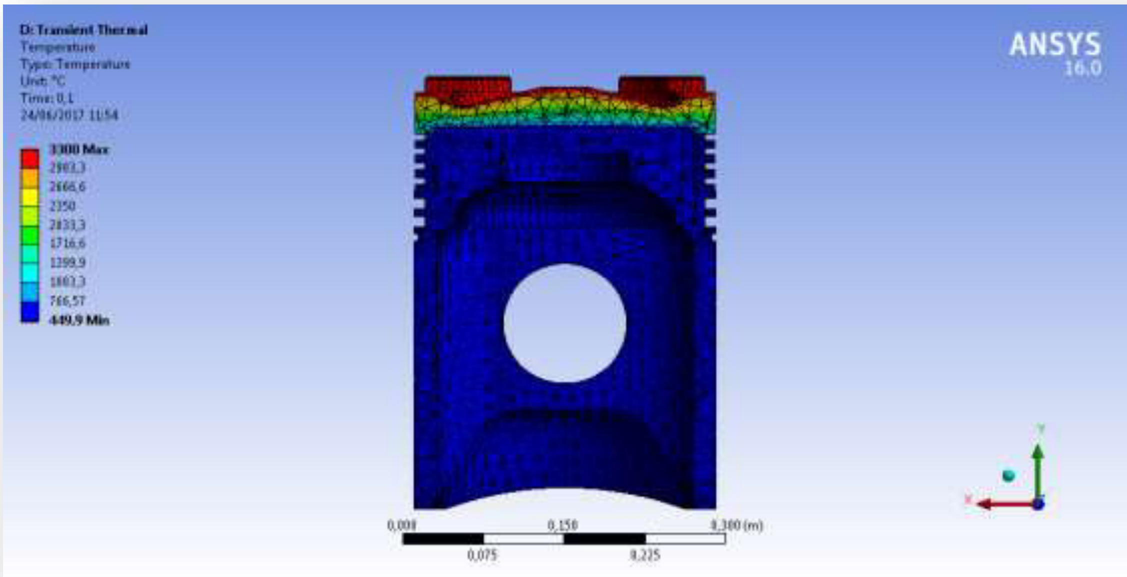
We will present in this chapter the distribution of temperature due to the heat flow and the distribution of the field of thermal stress due to the variation of the temperature between the piston and its environment and the distribution of the field of mechanical stress due load pressure of combustion gases. Then we present the results of the thermal loads and mechanical.

4.2 Distribution of fields of thermal in the piston

It takes into account only the thermal interactions for the determination of thermal distribution, because they are due to variations in temperatures to the various points of the piston. The results for each material are presented in the following figures.



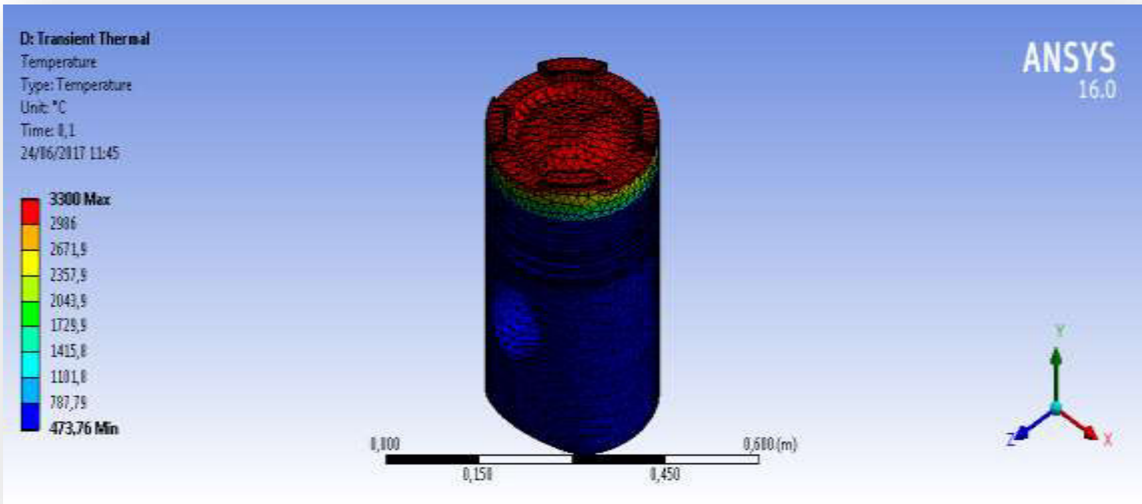
(A). Thermal distribution in the piston



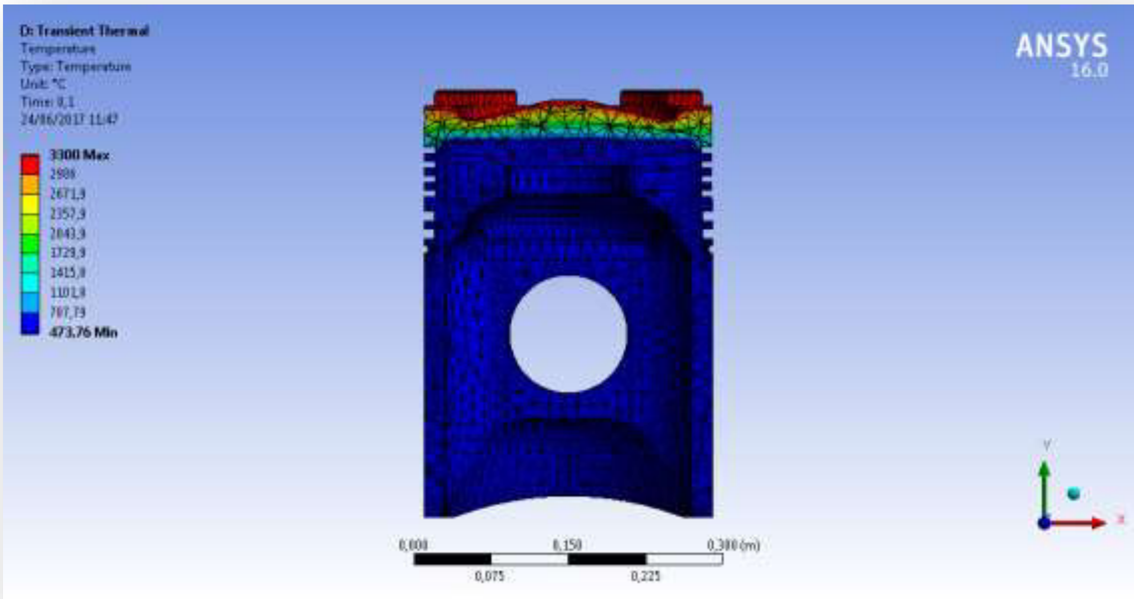
(B). Thermal distribution in section cut A-A

Figure.3.10. (a).(b). Distribution of temperature field.

The piston head to steel (Cr-Mo)



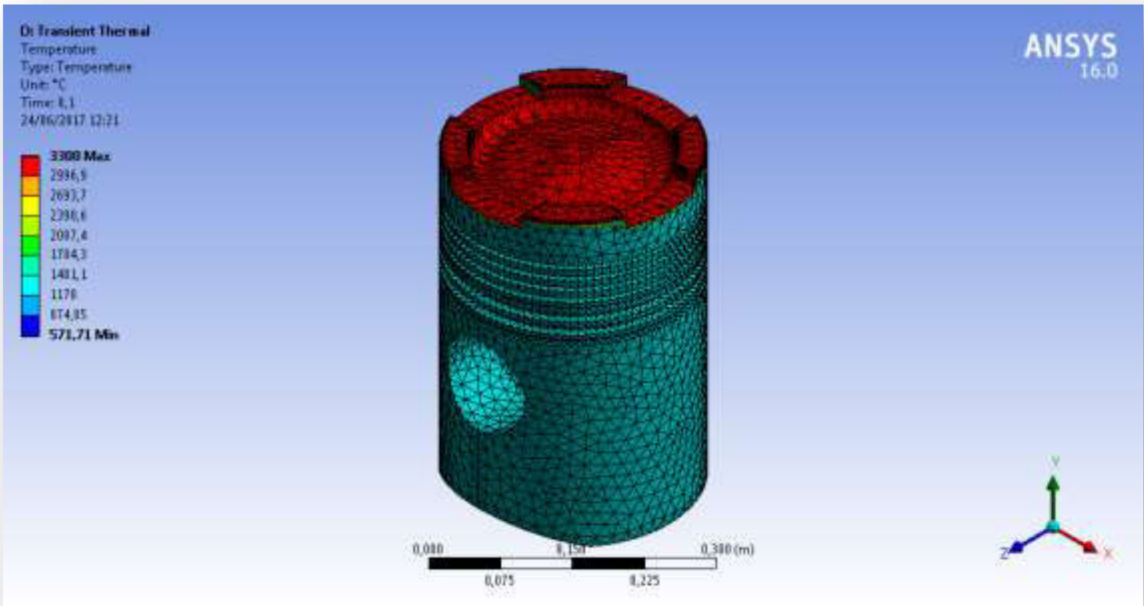
(A). Thermal distribution in the piston



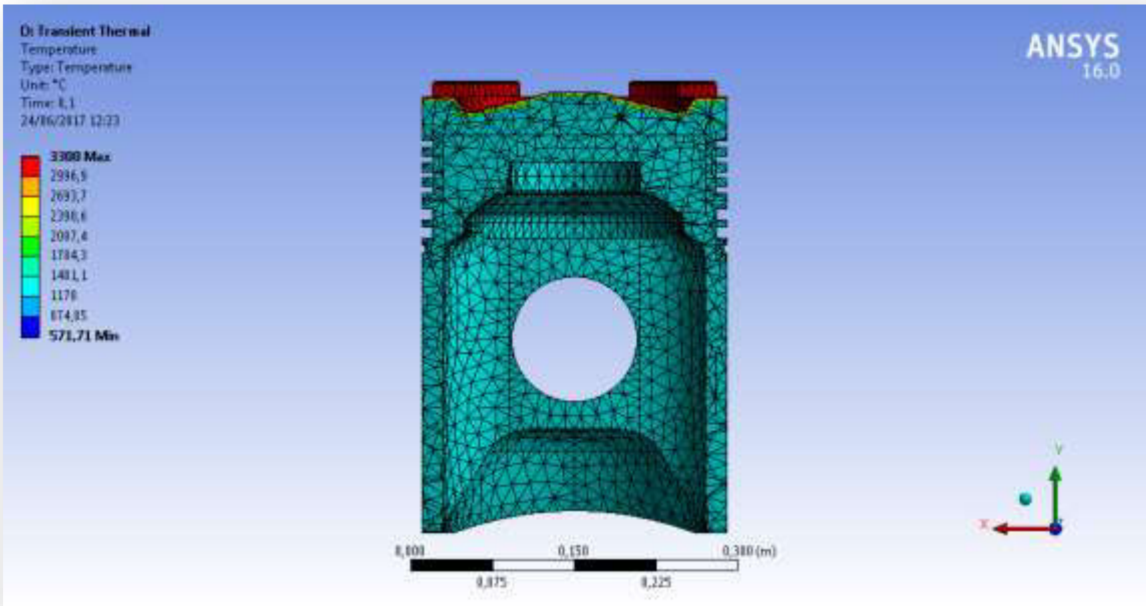
(B). Thermal distribution in the piston cut A-A

Figure.3.11.(a).(b). Distribution of temperature fields.

The piston head made of austenitic steel



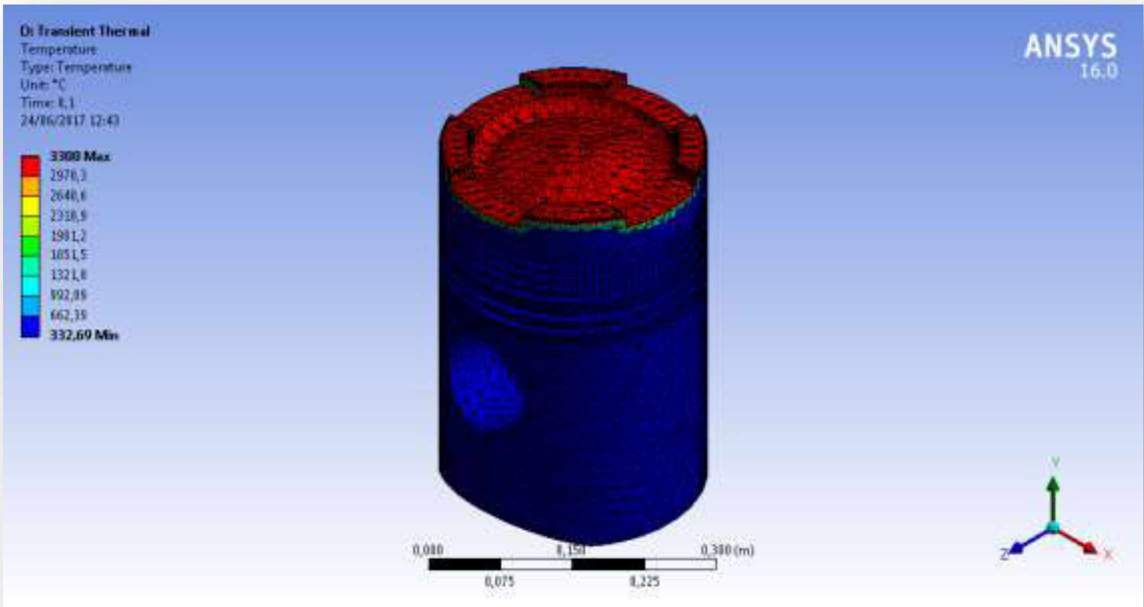
(A). Thermal distribution in the piston



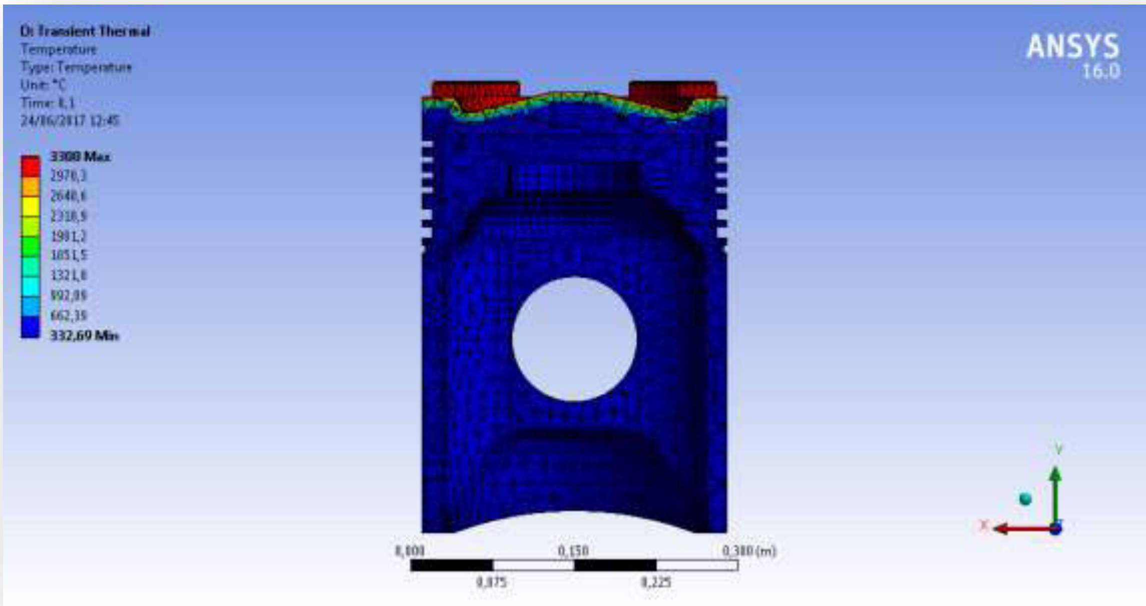
(B). Thermal distribution in the piston cut A-A

Figure.3.12. (A).(b). Distribution of temperature fields.

The piston head in as 12 UNG reinforced by fiber



(A). Thermal distribution in the piston



(B). Thermal distribution in the piston cut A-A

Figure 3.13. (A).(b). Distribution of temperature fields.

The piston head in AS 12 UNG

4.3 Distribution of fields of mechanical stress in the piston

If one removes the effect of temperature, only the burden of pressure due to combustion gas that will act on the bottom of the piston (Figure 4.14). This allows you to calculate the mechanical stress.

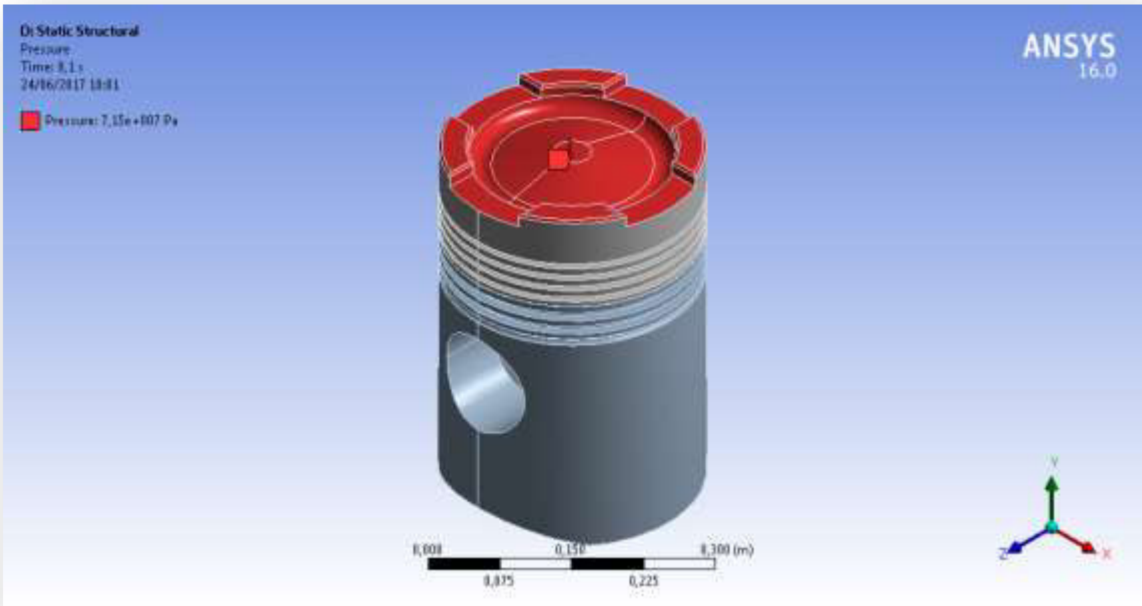
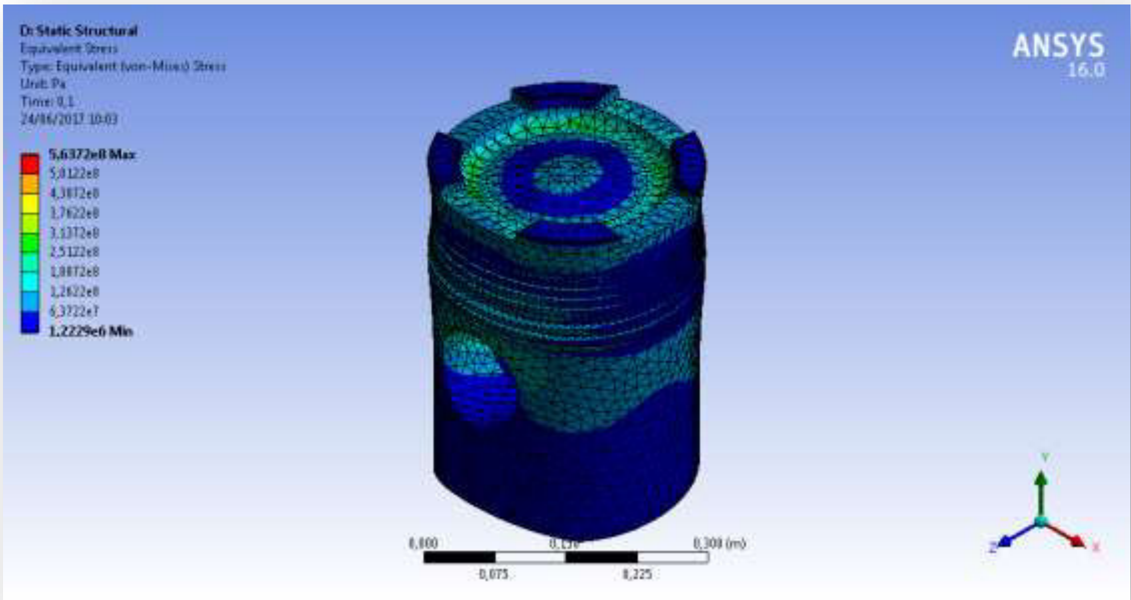
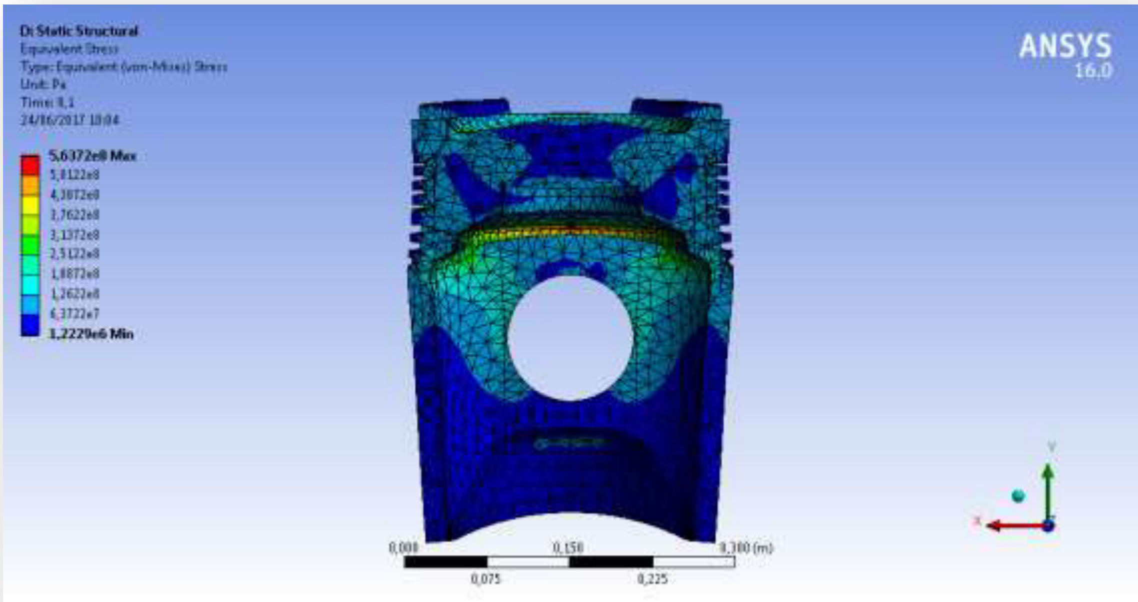


Figure.3.14. Distribution of the pressure of combustion gases on the piston head

The figures (3.11),(3.12),(3.13) and(3.14) show the distribution of the field of mechanical constraints on the 3D model of the piston for the different materials.



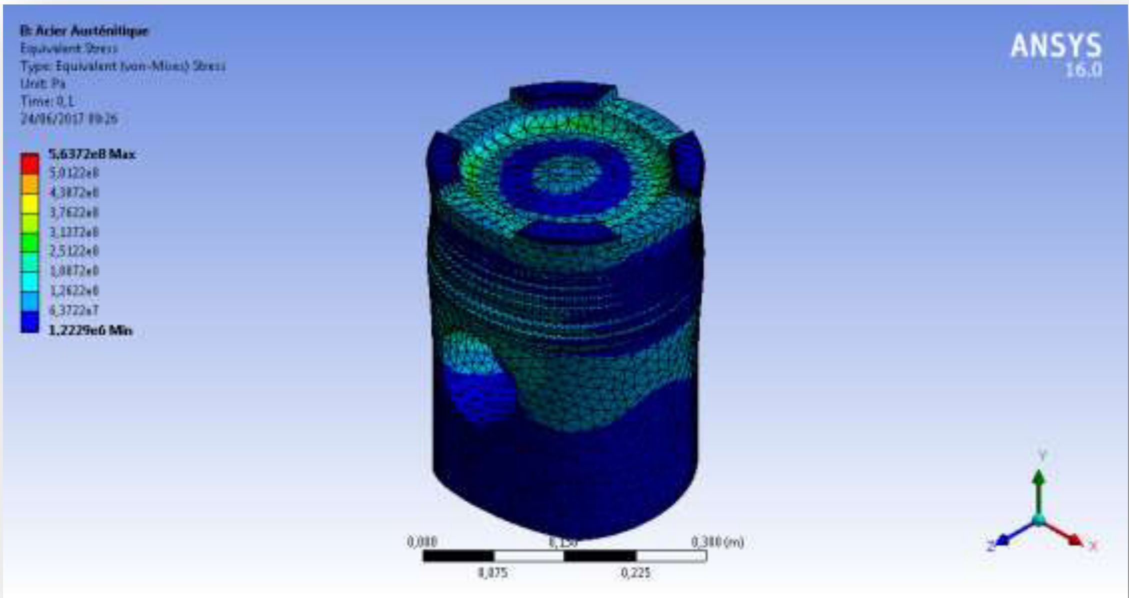
(A). Equivalent stress distribution in the piston



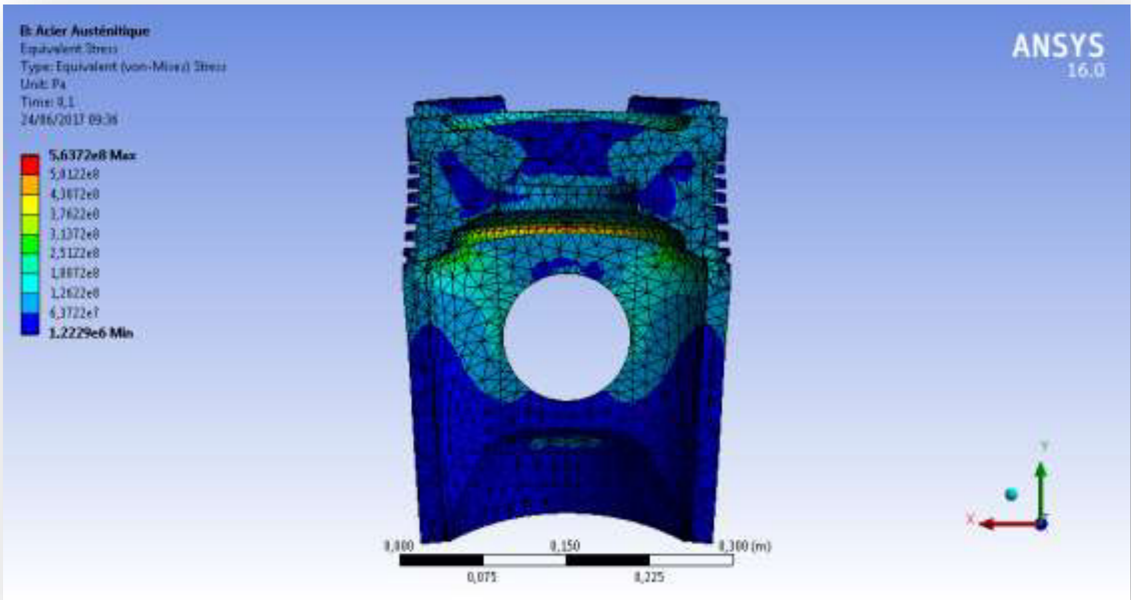
(B). Equivalent stress distribution in the piston cut A-A

Figure.3.15.(a).(b).Distribution of fields of mechanical stress.

The piston head to steel (Cr-Mo)

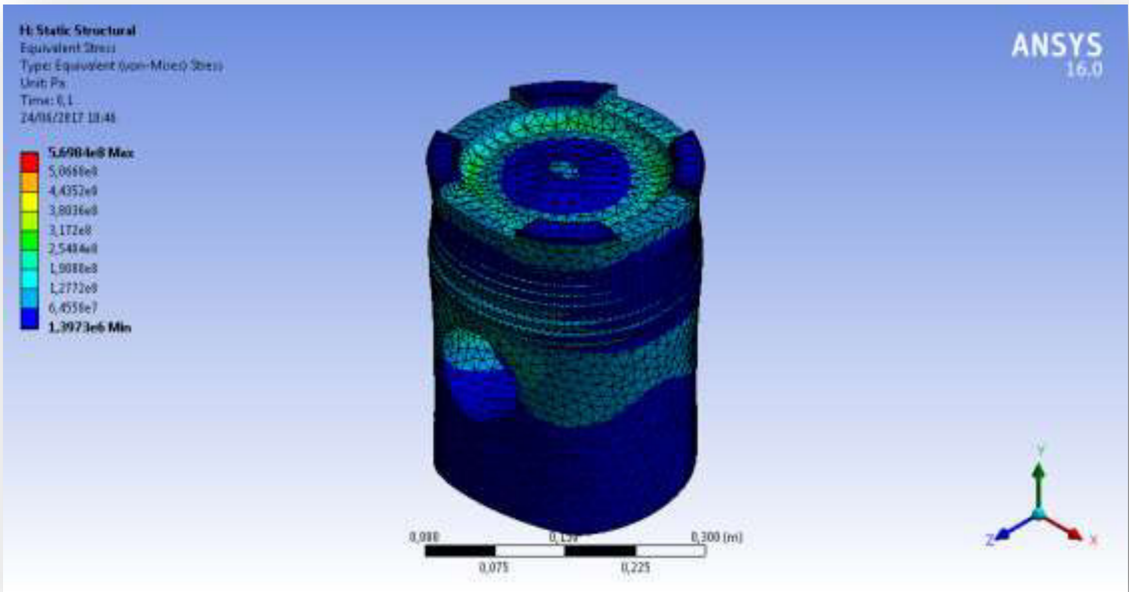


(A). Equivalent stress distribution in the piston

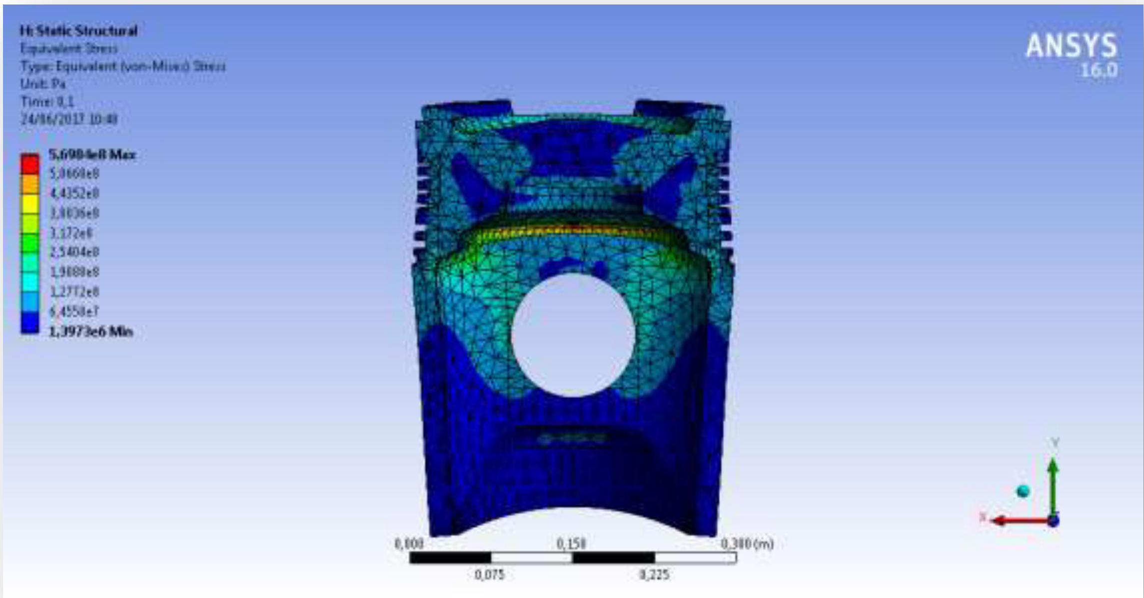


(B). Equivalent stress distribution in the piston cut A-A

Figure.3.16.(a).(b). Distribution of the fields of mechanical stress. The piston head made of austenitic steel



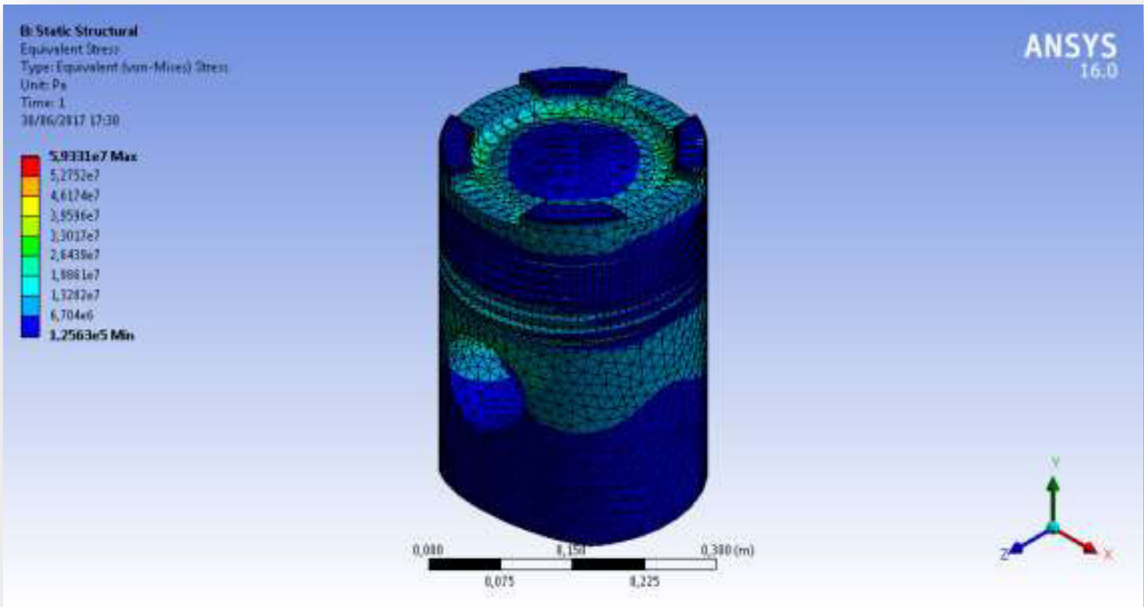
(A). Equivalent stress distribution in the piston



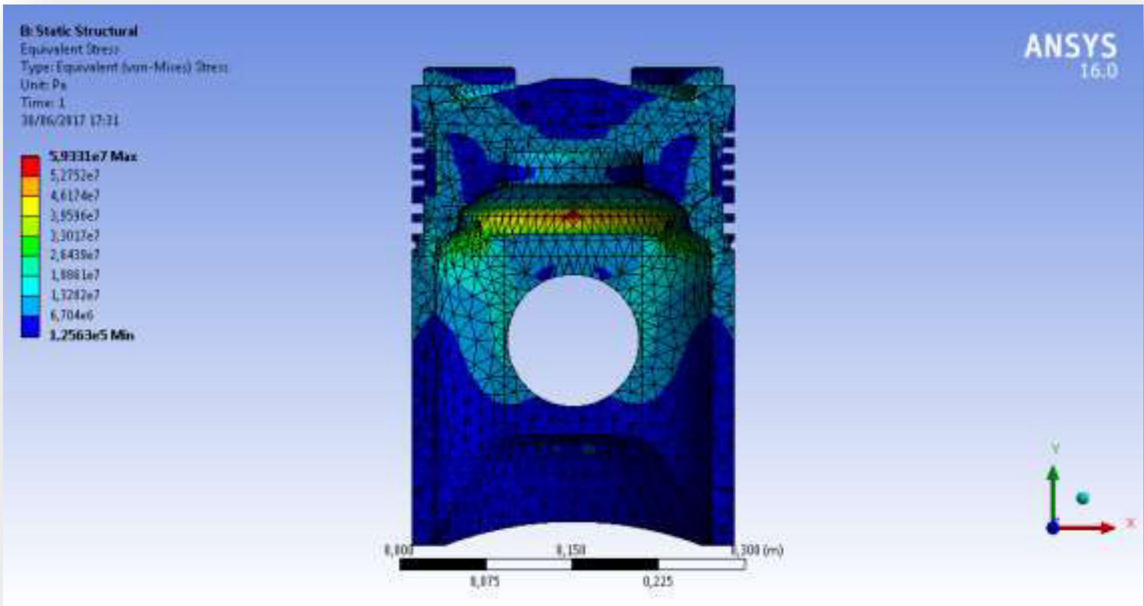
(B). Equivalent stress distribution in the piston cut A-A

Figure.3.17.(a).(b) . distribution of fields of mechanical stress.

The piston head in AS 12 UNG reinforced by fiber



(A). Equivalent stress distribution in the piston



(B). Equivalent stress distribution in the piston cut A-A

Figure.3.18.(a).(b) . distribution of fields of mechanical stress.

The piston head in AS 12 UNG

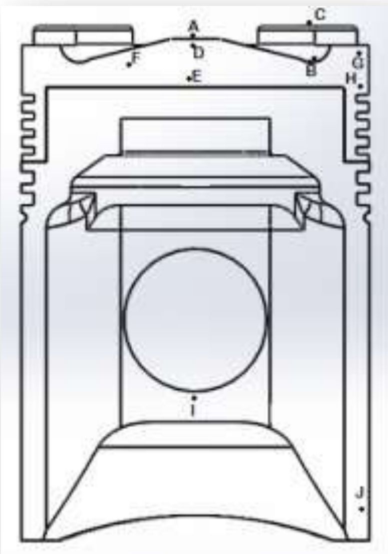
The figures (3.15),(3.16),(3.17) and(3.18) show that there is a small difference of mechanical constraints between the four (04) materials.

We note a concentration of mechanical stress near of the chamfers of the cavity and on the points of assembling the ribs with the inner part of the head of the piston.

Also of note is that the piston the less requested is the one having the type of material in aluminum (AS12UNG reinforced by fiber). It is to say that this material offers a better resistance compared to other materials.

4.4 Choice of specific points to consider

On the basis of the previous results it chooses a few points on the parties most requested of the piston (Fig.4.19) to make the comparison. Table 4.1 gives the values of temperatures and constraints corresponding to the points of the Specifies piston.



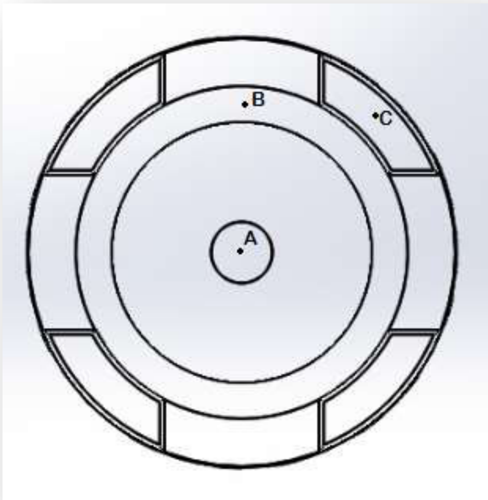


Figure .3.19. Selected Points

Table 3.2 Values of the temperatures and stress for the selected points

Nods	Cast iron							
	Steel (Cr-Mo)		Austenitic steel		AS 12 UNG		AS 12 UNG reinforced by fiber	
	T (C°)	σ (Pa)	T (C°)	σ (Pa)	T (C°)	σ (Pa)	T (C°)	σ (Pa)
A	3300	7,9128e+06	3300	7,9128e+06	3300	2,5515e+06	3300	2,5515e+06
B	3300	1,8964e+07	3300	1,8964e+07	3300	1,6925e+07	3300	1,6925e+07
C	3300	4,1949e+06	3300	4,1949e+06	3300	5,7392e+06	3300	5,7392e+06
D	2716,1	1,4916e+07	2696,4	1,4916e+07	2275,3	1,3269e+07	2384,7	1,3269e+07
E	1505,9	3,7550e+06	1534,9	3,7550e+06	729,59	1,6202e+06	736,37	1,6202e+06
F	2146,3	7,2538e+06	2218.9	7,2538e+06	1731,2	9,6278e+06	1196,2	9,6278e+06
G	2072,2	7,9435e+06	1928	7,9435e+06	1984,5	8,9352e+06	1518,7	8,9352e+06
H	1504,7	1,0870e+07	1504,3	1,0870e+07	727,65	9,9614e+06	735,96	9,9614e+06
I	1500,2	7,6856e+06	1500	7,6856e+06	729,59	2,1226e+06	729,53	2,1226e+06
j	1500	3,4906e+07	1500	3,4906e+07	729,59	9,5975e+05	729,59	9,5975e+05

The comparison between the values of thermal stress in the various specified points is given in Figures 2.2

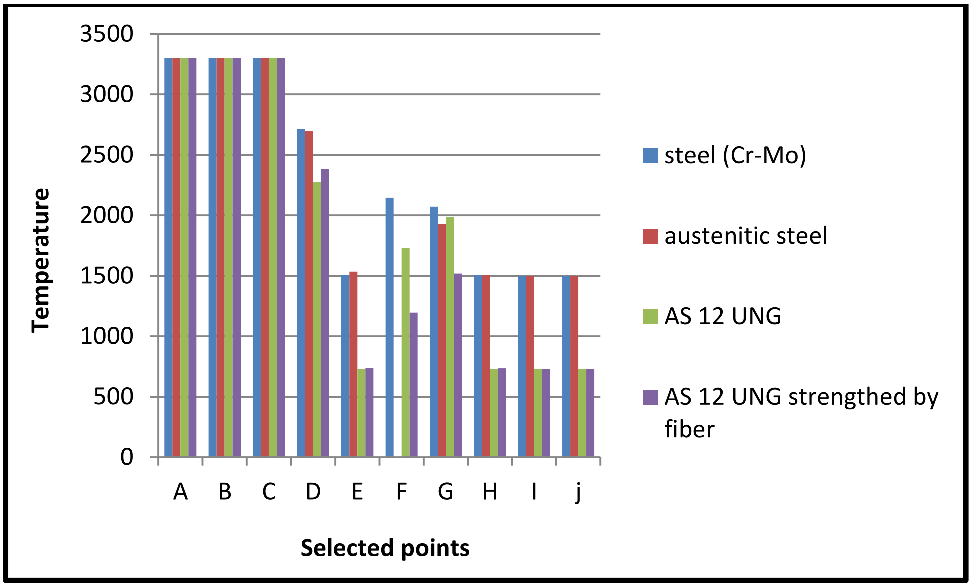


Figure 3.20 Values of temperature on the selected points in the piston

The comparison between the values of mechanical stress in the various specified points is given in Figure

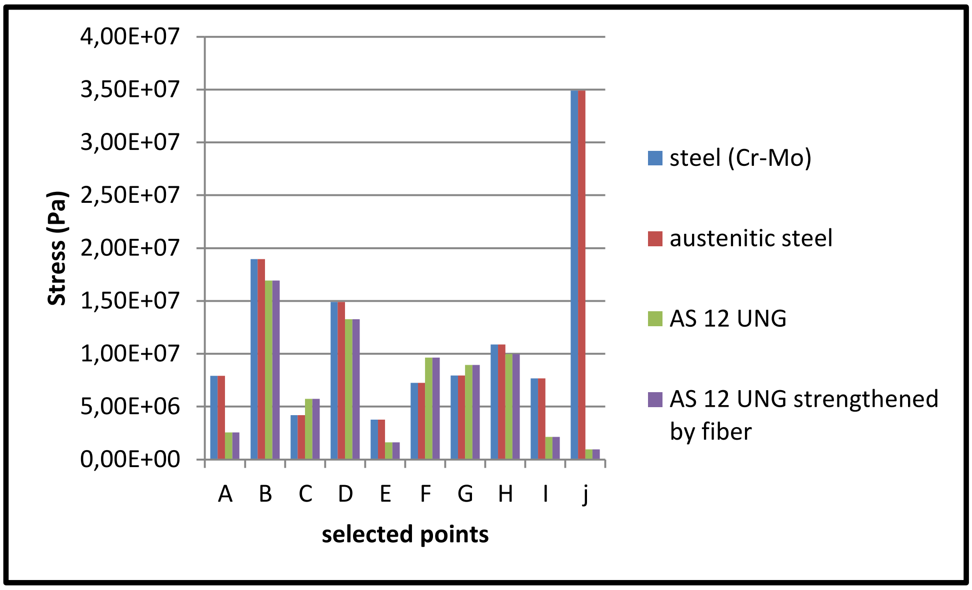


Figure 3.21 Values of mechanical stress on the selected points in the piston

5 interpretation of the result

We note that among the selected points on the bottom of the piston, the maximum value of the mechanical stress is the one at the point "B", and the maximal value for all the piston is the one at point " j " which is located at the level of the piston skirt.

We note that the maximal thermal distribution for all the piston are "A, B, C" and the minimal value is the one at point "I".

The minimal value of mechanical and thermal stresses on those points corresponds to the material AS12UNG reinforced by fiber.

6 Conclusion

In this chapter we introduced the thermal and mechanical simulation of the piston of the Marine Engine Niigata 6MG28BX.

The simulation is made with software ANSYS which has enabled us to achieve the phenomenon of the self-ignition with application temperature and pressure maximum.

General conclusion

This study constitutes an important enough contribution to the modeling of the piston to the analysis by finite elements of the influence of the thermal and mechanical effect.

It allows determining the characteristic temperatures in the piston as well as the maximum temperature that considerably affects the properties of the material.

This temperature increases the vulnerability to the cracking of the piston heads, taking into account the high level of stress.

It was determined the maximum values of the stress of Von Mises in the aim to assess the behavior of the material. This allows us to select the material more adequate.

The comparison of the stress of Von Mises of different materials, has allowed us to see also the piston the least sought and therefore the more efficient.

It could find the results on the temperature and on the dilations, to find the material compatible with the parameters pressure and temperature of our marine diesel engine Niigata" 6MG28BX" . This gives a more realistic way to this study.

[1] : Pratique d'entretien et de réparation des moteurs diesel.2008

[2] : document de l'entreprise ERENAV manuel d'instructions du moteur diesel NIIGATA model 6MG28BX.

[3] : Piston (mécanique).

[4] : Moteur diesel marin.

[5] : Moteurs thermiques rédigé par prof. PAN Sovanna.

[6] : Olivier GRONDIN.,"MODÉLISATION DU MOTEUR À ALLUMAGE PAR COMPRESSION DANS LA PERSPECTIVE DU CONTRÔLE ET DU DIAGNOSTIC". Thèse pour obtenir le titre de Docteur de l'Université de Rouen, (2004).

[7] : Journal of KONES Powertrain and Transport, Vol. 18, No. 1 2011 THERMOMECHANICAL FE ANALYSIS OF THE ENGINE PISTON MADE OF COMPOSITE MATERIAL WITH LOW HISTERESIS.

[8]: Simulation thermomécanique d'un piston d'un moteur diesel