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# DESIGN AND DEVELOPMENT OF WEAR TESTING ANALYSIS ON CYLINDER HEAD VALVE, PART 3

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## ABSTRACT

These projects are aimed to design and development of wear testing analysis on cylinder head valve. The cylinder head sits above the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a head gasket. In most engines, the head also provides space for the passages that feed air and fuel to the cylinder, and that allow the exhaust to escape. The head can also be a place to mount the valves, spark plugs, and fuel injectors. The project is based on study the design, mechanical movement and component of head valve and also to analysis the stress and strain of a valve by using finite element method. The exhaust valve system of combustion engines experiences a very complex contact situation of frequent impact involving micro sliding, high and varying temperatures, complex exhaust gas chemistry and possible particulates, etc. In addition, the tribological situation in the exhaust valve system is expected to become even worse due to strict future emission regulations, which will require enhanced combustion and fuels. This will substantially reduce the formation of combustion products that might ease the contact conditions by forming tribofilms on the contacting surfaces. The lack of protective films is expected to result in increased wear of the contact surfaces. The result will present by the successful of the project mechanisms to run and also the simulation of the mechanisms.

***Keyword:*** Wear; Cylinder head valve; Contact surface.

## INTRODUCTION

A valve job is an operation which is performed on any four stroke cycle, internal combustion engine, the purpose of which is to resurface the mating surfaces of the poppet valves and their respective valve seats that control the intake and exhaust of the air/fuel mixture that powers the motion of the pistons after the start cycle. In the earliest automotive engines, the valves needed to be removed and the sealing surfaces sanded ground or lapped multiple times during the life of a typical engine[8-10]. As the decades passed, however, engines ran cleaner and the addition of tetraethyl lead in gasoline meant that such maintenance became less frequent.

Today, valve jobs are rarely done on passenger cars for the purpose of maintenance, although they are still quite common with high-performance cars. Combustion engine used in many applications. The most common used are in transportation and most of 90% transportation are use this application. The basic concept of engine are convert the high pressure and temperature combustion gasses to produce mechanical energy. The piston are connected to crank shaft that convert the displacement to rotational movement.[7-14] The conventional automotive engine is fitted with mechanically operated poppet valves for both inlet and exhaust.

A poppet valve consists of a disc of metal with a coaxial stem on one side which closes a circular opening in a wall separating two chambers, against which wall it is drawn by a spring. To open the valve, a force must be applied to it in, a direction contrary to that of the spring pressure. In the earliest automotive engines, the inlet- valves were opened automatically by the suction in the cylinder during the inlet stroke.[2-14] Automatic valves cannot be used in engines that must operate over a wide speed range, as they close too early at low and too late at high speeds to permit of good volumetric efficiency[20-24].

These valves, moreover, are troublesome in service, because gum in the gasoline may cause them to stick. Poppet valves are lifted from their seats by means of cams, and are closed by springs. The rate at which the valve is opened and closed depends on the cam outline and on the type and size of cam follower employed. From the standpoint of gas flow it is, of course, desirable that the valve should open and close very quickly, and remain fully open for the greatest possible length of time. However, the valve gear must operate quietly, and in order to do this it

must lift and drop the valves more or less gradually. Cams, therefore, usually are so designed that the valve begins to close as soon as it has attained its full lift, and there is no "dwell" in the full-open position.[11-12]

In the combustion engine, the cylinder head valve plays an important role. Engine valve is located in the cylinder head. The main function of the engine valves is to let air in and out of from the cylinder so that the air can help ignite the fuel which can drive the pistons up and down. When more air go into the intake valve and out from the exhaust valve, the more efficient and more power the engine will have. More of the valve has chrome plated steam. This is because the chrome provides a hard, smooth surface, this design feature helps prevent valve scuffing and galling, especially when the engine is first started.

Wear is the loss in material due to interaction with the environment.[1-20] Wear is a cumulative process and valve seat wear or valve recession increases as the number of cycles increases.[2] However, much work has to be done before the wear rate and the coefficient of friction can be determined theoretically based on the basic properties of materials[3-12]. Traditionally wear in this contact has been controlled by use of a valve seat insert and the careful selection of materials for both the valve and the insert.

There is many types of wear includes abrasive wear, adhesive wear, catastrophic wear, corrosive wear, fatigue wear, cutting wear, deformation wear, erosive wear, rolling wear, impact wear and so on. In this study, the main mechanism of wear that happen is abrasive wear. Abrasive wear occurs when a hard rough surface slides across a softer surface. it is the loss of material due to hard particles or hard protuberances that are forced against and move along a solid surface.

Wear is related with the tool life application. Tool life increases with a reduction in cutting speed and feedrate. [28] A material is classified as difficult to cut materials due to their high shear strength, work hardening tendency, highly abrasive carbide particles in the microstructure, strong tendency to weld and low thermal conductivity. [29-30] For the predicted life method, biaxiality correction method gives conservative predicted life as compared to the uniaxial loading. [31]

More recently, due to the increasing demands for both performance and cost, alternative methods of controlling the wear, and the resulting valve recession have been found.[4] Beside that, now the moden technology use the optical microscopy to measure the wear scars and study wear features occurring on the valves and seats. In addition, wear scar widths were measured both during and after the tests. These were converted to recession valves using equation derived from valve and seat geometry.[5-11]

Owing to the expensive character of the material necessary for the exhaust valves, the inlets are now generally made of more common and cheaper material. This practice is encouraged also by the fact that the inlet valves now are generally made of somewhat larger diameter, so they would not be interchangeable with the exhaust valves even if they were made of the same material. Both the mechanical and the thermal stresses on engine valves increase with the speed of operation, and as engine speeds have increased continuously, there has been a constant search for better materials, especially for the exhaust valves. [23-25] Silicon-chromium (Silcrome) steel containing 3-3.5 per cent silicon and 8-9 per cent chromium came into use during the early twenties, and was considered an excellent exhaust-valve material at the time. This steel possessed good workability and good machining qualities, but it left something to be desired with respect to hot strength.

While at normal temperature it showed a tensile strength in excess of 200,000 psi, at 1200 F this dropped to 42,000 psi, and at 1600 F it was only 4600 psi.[21-25] The steel began to scale at 1800 F. Its resistance to war page and corrosion at high temperatures was poor. In the middle thirties specific outputs had increased so much that a better material was needed for heavy-duty bus and truck engines. What was called for particularly was higher hot strength and a higher scaling temperature. These properties could be obtained by a more liberal use of alloying elements, particularly chromium, and a new type of valve steel was then introduced of which Silcrome XB, developed by Thompson Products, Inc., is representative. This has a higher carbon content than the original Silcrome steel, viz., 0.60-0.86 per cent; less silicon, 1.25-2.75; but more than twice as much chromium, 19.00-23.00, and in addition from 1.00 to 2.00 per cent nickel. This steel resists warping much better, and it also has greater resistance to heat corrosion. At 1600 F its tensile strength is 7625 psi, and its scaling temperature is 2150 F.[9-17]

Arduino is an open-source computer hardware and software company, project and user community that designs and manufacturesmicrocontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers.[26] These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for the C, C++ programming languages.

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio. The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written inJava. It originated from the IDE for the Processing programming language project and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such assyntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism for compiling and loading programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".[27]

## MODEL FABRICATION

The wear testing analysis on cylinder head valve test rig have two main parts that are the body of the test rig and the control speed system. The control system used Arduino to build it. After the system is done, it attached to the test rig. Arduino program is based on the controller function which is to control the voltage and speed of the motor for experiment testing on wear analysis. It starts with developing the Arduino coding to ensure that the Arduino can control the voltage of the motor. The developers of the Arduino circuit depend on the desire function to approach.

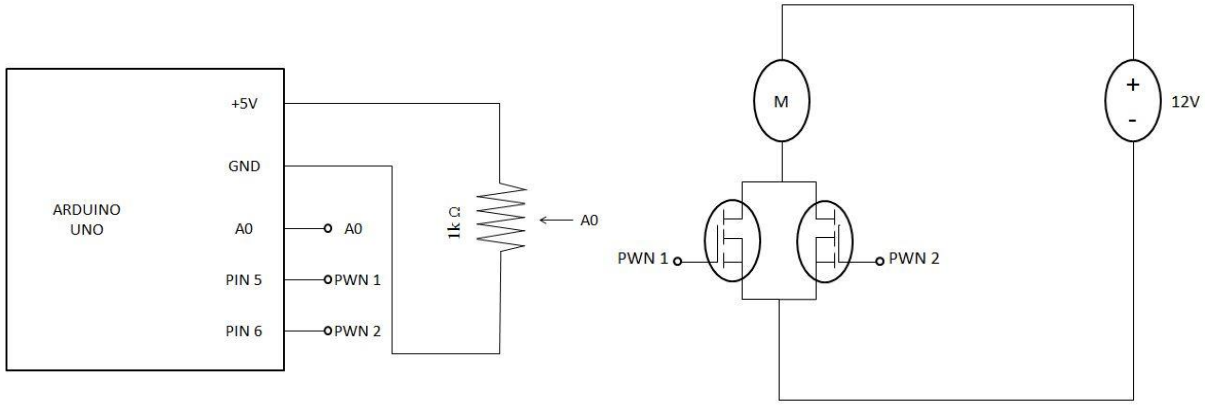



Figure 1: Arduino Connector Diagram and Motor Driver Diagram

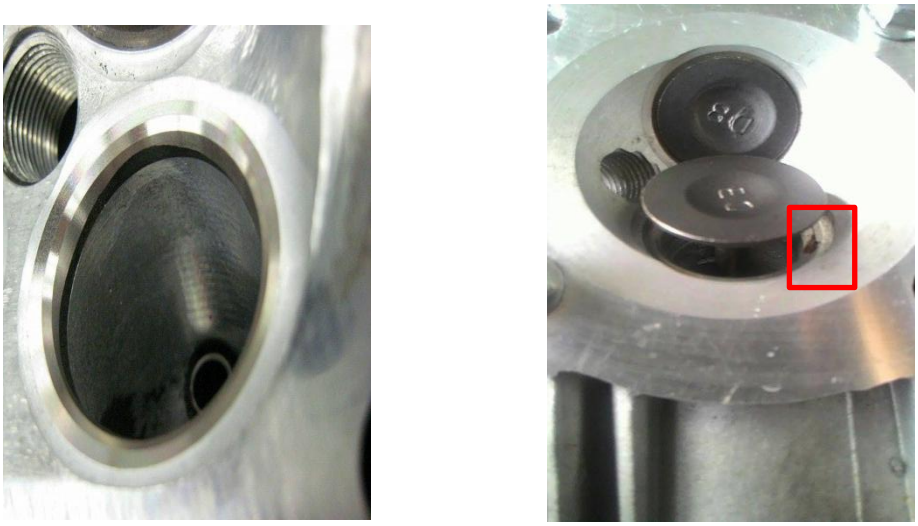
```
long sensorPin = A0;

int motorDriver2 = 5;
int motorDriver1 = 6;

int meterSensor = 0;
int meterValue = 0;

int a = 0;

void setup()
{
  TCCR0B = TCCR0B & B11111000 | B00000001;    //set timer 0 divisor to 1 for PWM frequency of 62500.00 Hz @ pin 5, 6
  pinMode(motorDriver1, OUTPUT);
  pinMode(motorDriver2, OUTPUT);
  Serial.begin(9600);
}

void loop()
{
  meterSensor = analogRead(sensorPin);
  meterValue = map(meterSensor, 0, 1023, 0, 100);

  if(meterValue<50)
  {
   a = 217;
  }

  else if(meterValue>=50)
  {
   a = 255;
  }

 analogWrite(motorDriver1, a);
 analogWrite(motorDriver2, 0);
 delay(500);
 analogWrite(motorDriver2, a);
 analogWrite(motorDriver1, 0);
 delay(500);

}
```

Figure 2: Arduino coding

## RESULT AND DISCUSSION

In figure 3, it shows that the final product of wear testing analysis on cylinder head valve test rig. After fabricating the test rig, it was tested by using maximum speed. In the figure 4, it shows that the result before and after the experiment. In the figure 4b, it shows the wear was produced after the experiment run.


Figure 3: Final product of wear testing analysis on cylinder head valve test rig



(a) (b)

Figure 4: (a)Before experiment and (b)after experiment

In the other hand, the ring valve also analysis using Mechanical Autodesk Simulation to see the displacement, von Mises stress, von Mises strain and von Mises factor of safety when using maximum speed,12V and minimum speed,6V.

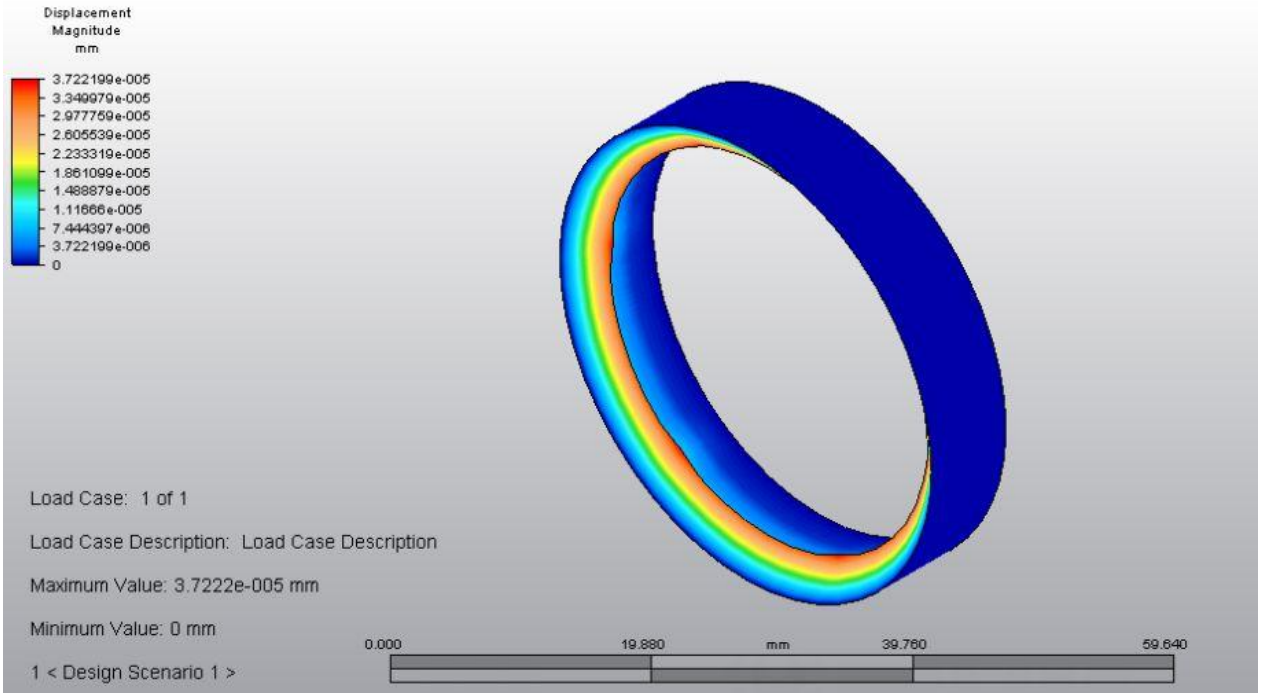



Figure 5: Result of the displacement using minimum speed,6V.

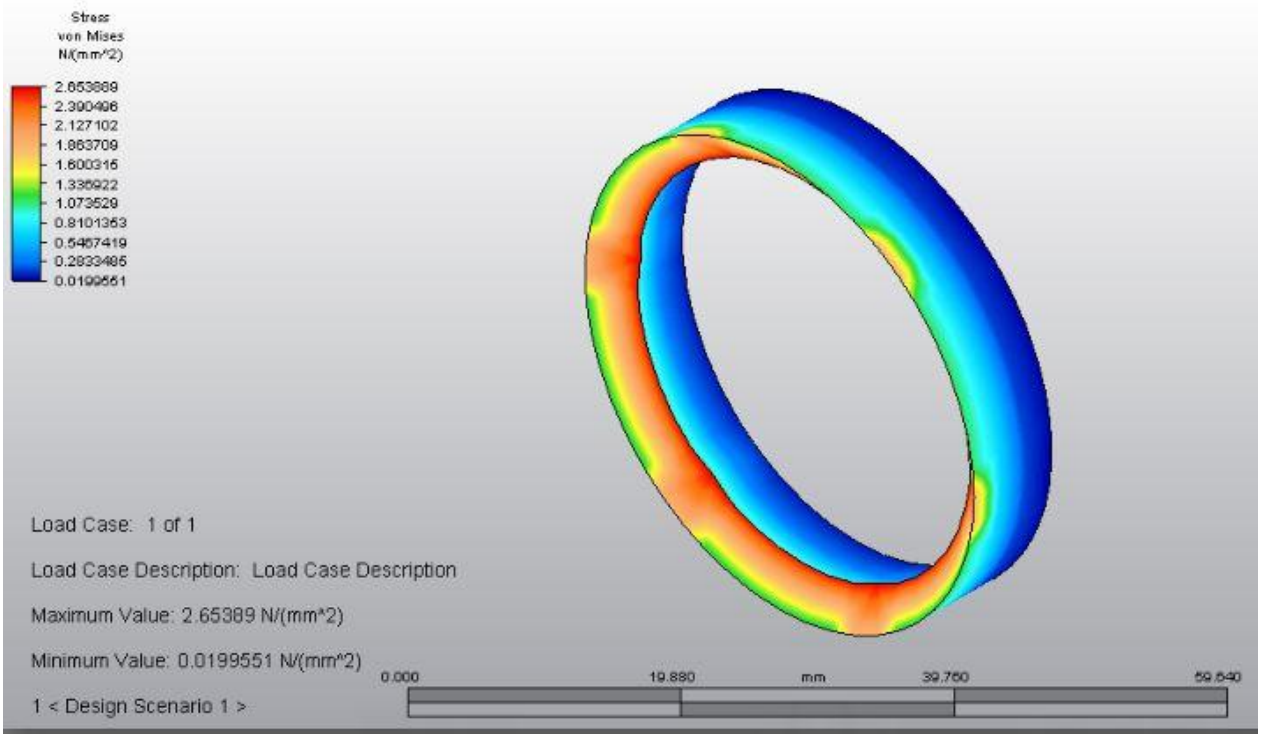



Figure 6: Result of the von Mises stress using minimum speed,6V

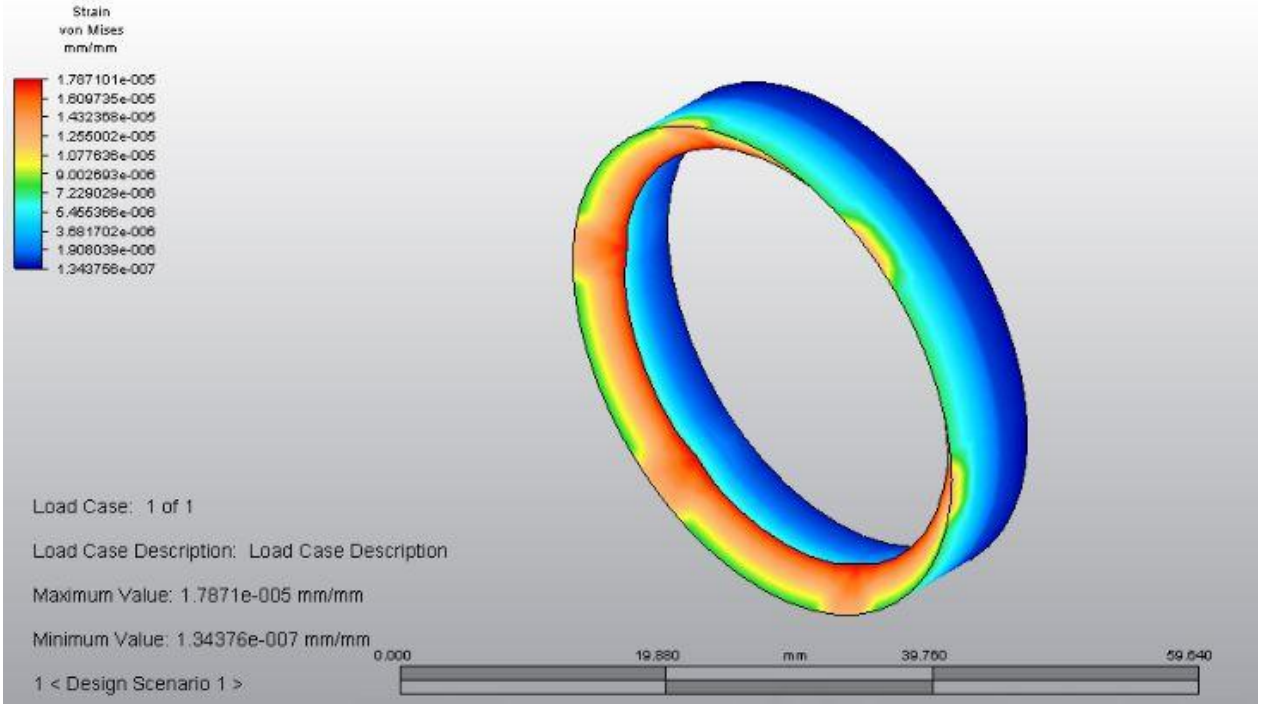



Figure 7: Result of the von Mises strain using minimum speed,6V

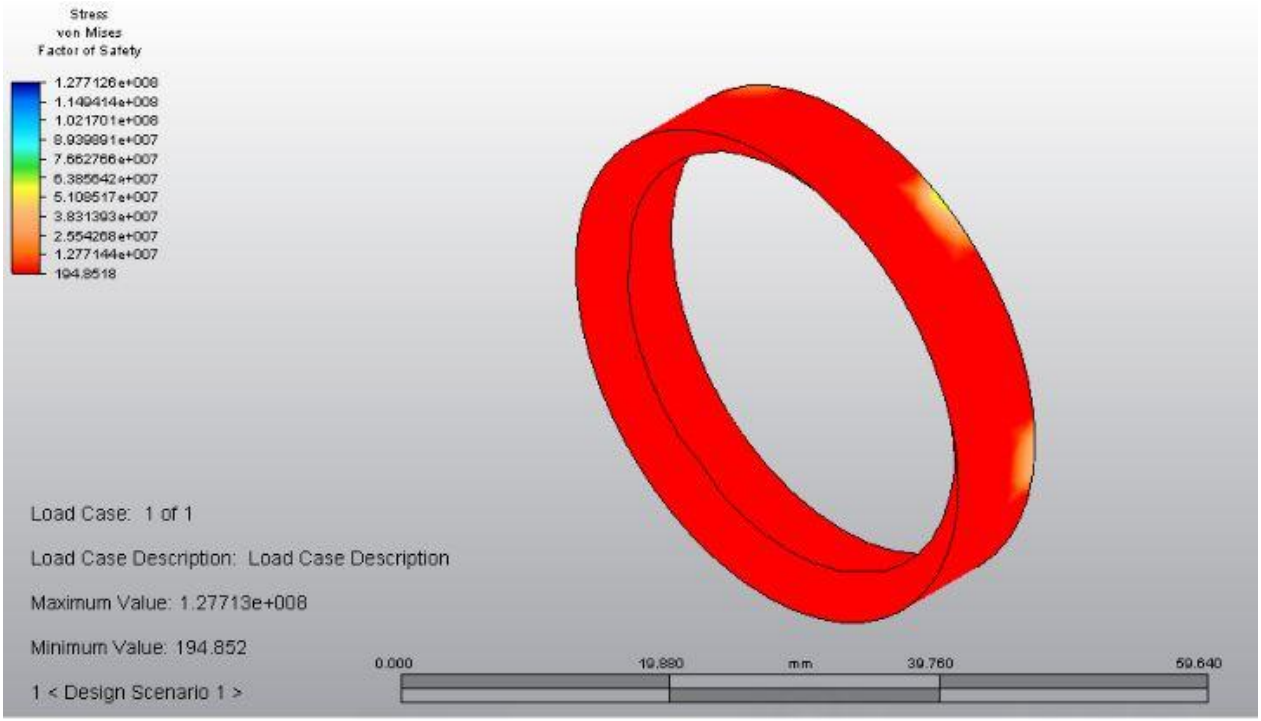



Figure 8: Result of the von Mises factor of safety using minimum speed,6V

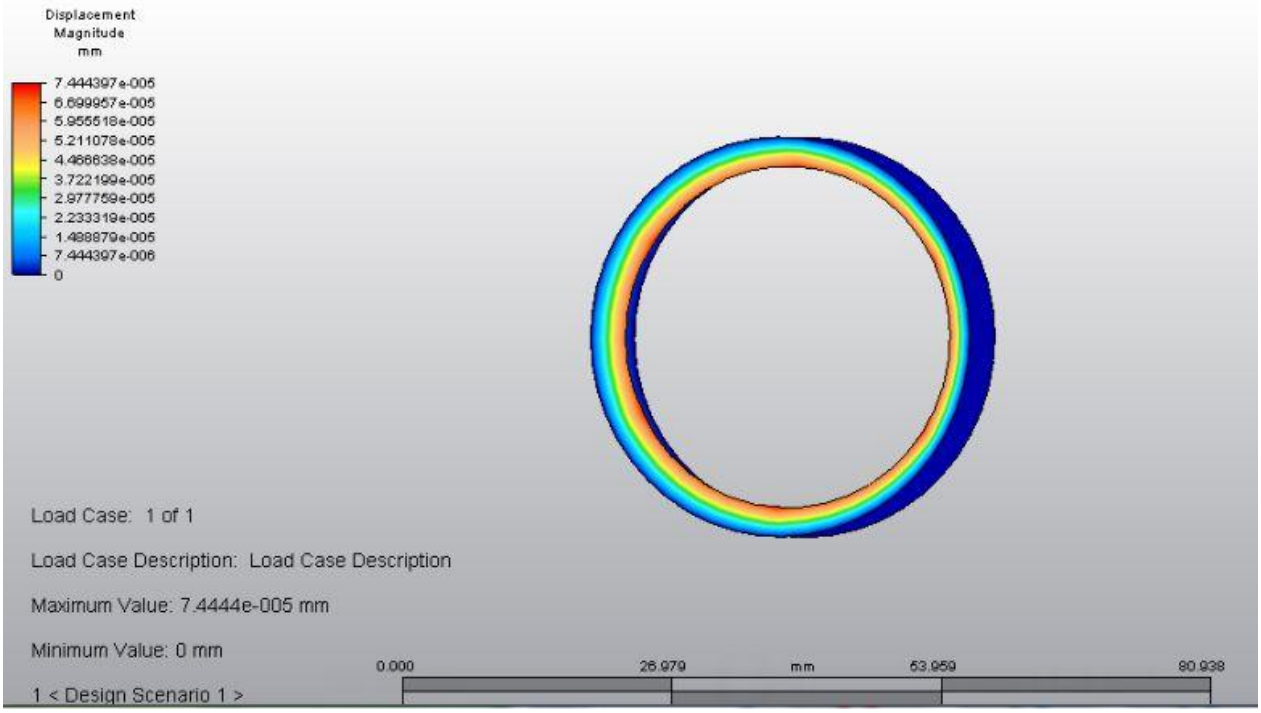



Figure 9: Result of the displacement using maximum speed,12V.

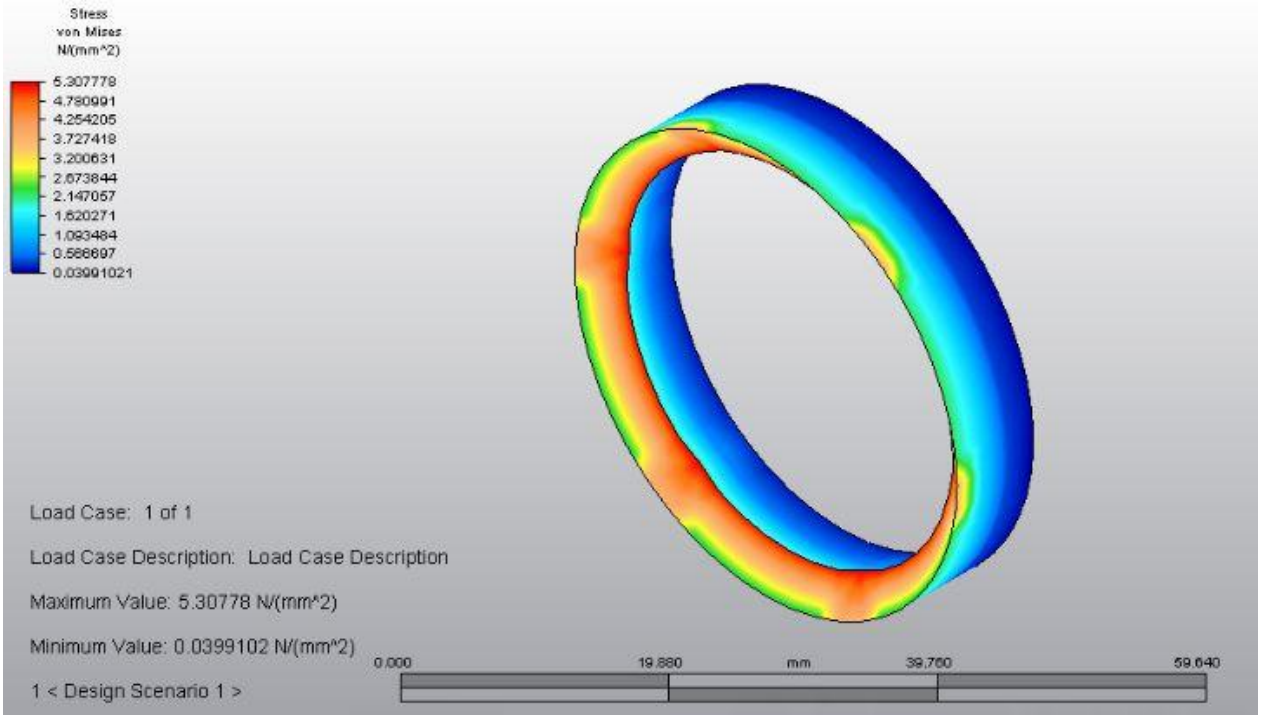



Figure 10: Result of the von Mises stress using maximum speed,12V

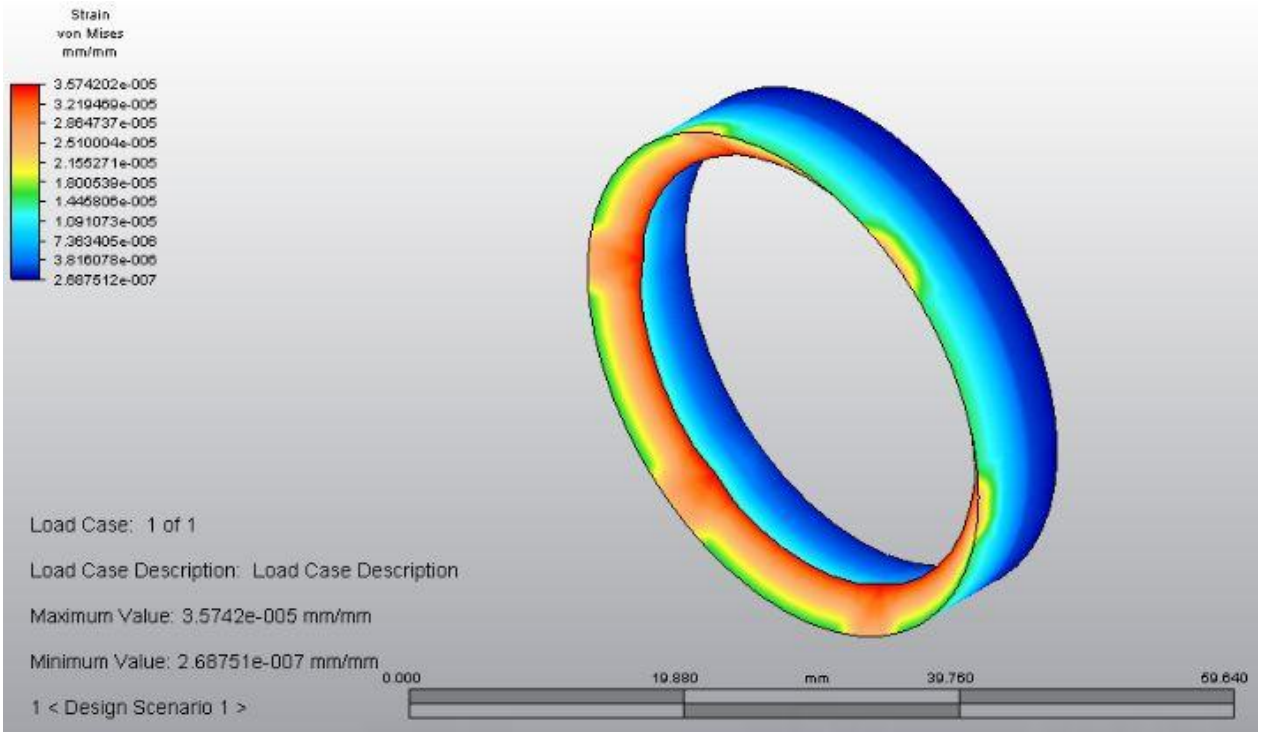



Figure 11: Result of the von Mises strain using maximum speed,12V

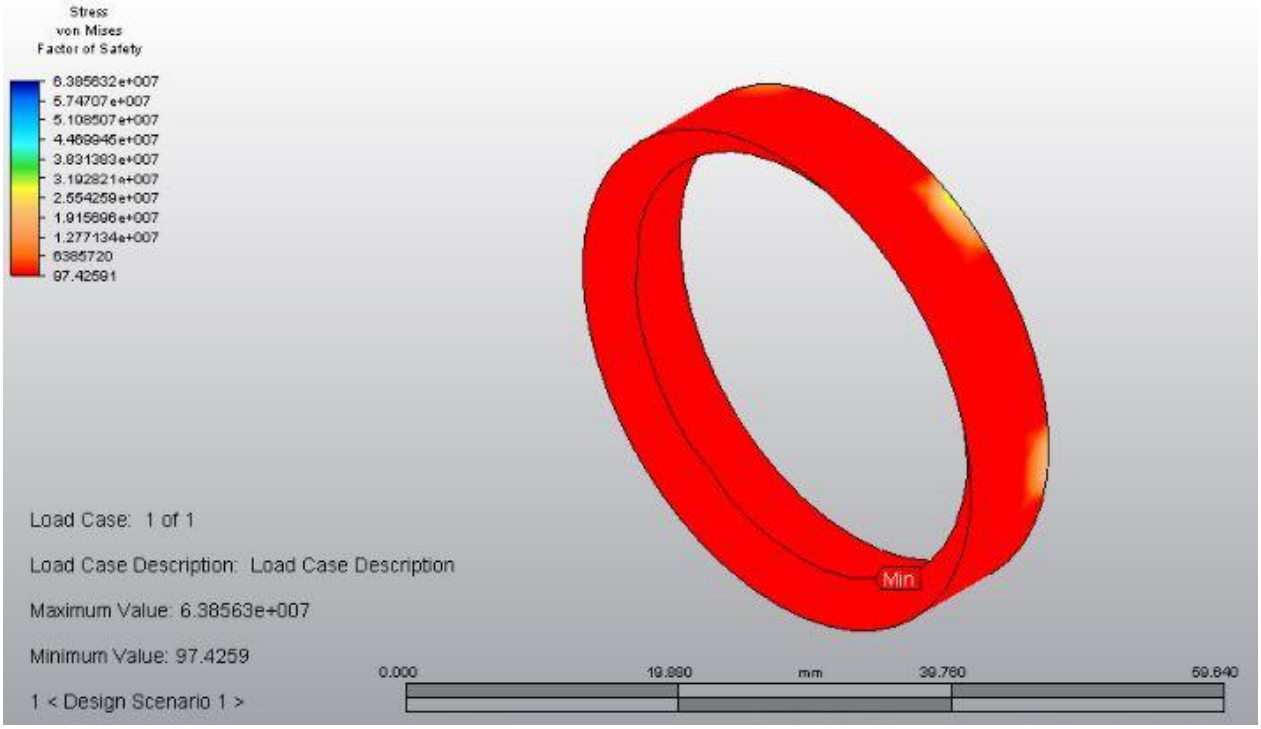



Figure 12: Result of the von Mises factor of safety using maximum speed,12V

From the simulation, we obtain stress von Mises factor of safety. For the minimum speed, the maximum stress von Mises factor of safety is $1.277x10^8$, minimum is 194.85. Beside that, for the maximum speed, the maximum stress von Mises factor of safety is $6.385x10^7$, minimum is 97.43. The yield strength of the stainless steel 302 CD is 275Mpa. The maximum stress von Mises factor of safety of minimum and maximum speed is less than the yield strength therefore the design is safe to use.

## CONCLUSION

As a conclusion, the cylinder head valve test rig had been fabricated according to the design. Beside that, the test rig also light weight due to the material use and easy to assembly and disassembly. The effect of wear of the cylinder head valve is done with the comparison. The mechanisms of abrasive wear are extremely interesting for interpreting the wear because abrasive wear is a very common type of wear. The high friction force is the major contributor to the wear of the valve interface. The result is done using the finite element method (FEM) software and the calculation also done with good factor of safety.

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