PENENTUAN KEPEKATAN GAS DI DALAM RONGGA EKZOS BAGI ENJIN PETROL

(DETERMINATION OF EXHAUST GAS CONCENTRATION AROUND THE EXHAUST MANIFOLD OF A PETROL ENGINE)

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ACKNOWLEDGMENT

I wwould like to specially thank my parents for their support all time, morally and financially. Without them, I could not have been able to complete my studies here.

To my supervisor, En Khairil Faizi Mustafa, I would like to express my gratitude for his guidance, advice and assistance throughout my duration of complete this research.

To all other people in the School of Mechanical Engineering, I realize that is not possible to name each of them, I would like to express my hearty thanks as well.

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ABSTRAK.

Pelepasan bahan pencemar dari kenderaan bermotor adalah punca utama pencemaran udara di Malaysia. Jabatan Alam Sekitar (JAS) sentiasa mencari jalan penyelesaian bagi masalah ini. Pada tahun 1996, Jabatan Alam Sekitar telah memperkenalkan dua peraturan untuk mengawal keluaran dari kenderaan bermotor yang mengandungi piawaian pelepasan ekzos yang dibenarkan bagi kedua-dua kenderaan diesel dan petrol. Peraturan itu telah memberi kuasa kepada Jabatan Alam Sekitar untuk melakukan ujian terhadap kenderaan bermotor.

Jabatan Alam Sekitar telah menghantar permintaan kepada pengarah US-AEP di Malaysia bagi mendapatkan pembentu teknikal Cal/EPA daripada Persekutuan Alam Sekitar California bagi membantu JAS dalam menangani masalah ini. Rentetan daripada itu, dua wakil dari Cal/EPA telah dating ke Kuala Lumpur untuk membincangkan masalah ini dengan lebih terperinci lagi bermula 20-30 Mac 1998. Kumpulan itu datang untuk bermesyuarat dengan JAS dan berkongsi pengalaman mereka dalam menangani masalah pencemaran udara dari kenderaan bermotor. Kumpulan itu telah diminta untuk menyediakan pembantu teknikal kepada JAS dalam membuat:

i) alat pengukur bahan keluaran dari kenderaan di makmal.

ii) Dokumentasi dan prosedur.

iii) Penyeliaan dan masa pemeriksaan termasuk penyelengaraan dan pengawasan system untuk kenderaan bermotor.

Undang-undang di Malaysia yang berkaitan dengan kenderaan bermotor pada hari ini kurang dari segi penguatkuasaan dan tidak ada sijil yang sah yang digunakan untuk kerja-kerja penyeliaan dan penyelengaraan kenderaan. Hanya operasi yang berkaitan dengan penyeliaan keselamatan dan pengeluaran asap dari kenderaan berat dijalankan. Program ini sebenarnya hanya memeberikan kesan sebanyak 10% daripada jumlah pencemaran yang berpunca dari kenderaan bermotor. Setakat ini tiada penyeliaan program untuk kenderaan peribadi dan tiada sijil penguatkuasaan yang piawai bagi semua kenderaan untuk pemeriksaan.

ABSTRACT.

Motor vehicle emissions are the leading cause of air pollution in Malaysia, and the Malaysia Department of Environment (MDOE) is looking for new ways to combat the problem. In 1996, MDOE introduced two regulations to control vehicle emissions, stipulating certain exhaust emission standards for diesel and gasoline vehicles. The regulations will require MDOE to conduct verification tests on the vehicles emissions. The MDOE submitted a request to the US-AEP Director in Malaysia for a Cal/EPA technical assistance team from the California Environmental Partnership to be deployed to Kuala Lumpur to help MDOE address their vehicle emissions problems.

The MDOE submitted a request to the US-AEP Director in Malaysia for a Cal/EPA technical assistance team from the California Environmental Partnership to be deployed to Kuala Lumpur to help MDOE address their vehicle emissions problems. The two representatives from Cal/EPAís Air Resources Board (ARB) selected to serve on the team were in Kuala Lumpur from March 20 through March 30, 1998. The team attended meetings with MDOE to share ARBís experience with motor vehicle pollution control and standards enforcement. The team was asked to provide technical assistance to MDOE personnel in developing

i) An emission measurement capability in a laboratory setting,

ii) Documentation and procedures systems, and

iii) An inspection and periodic checking system, including maintenance and monitoring systems for motor vehicles.

Malaysia is motor vehicle program currently lacks enforcement of certification standards and any in-use inspection/maintenance program. The only currently operating program is a safety inspection and idle emissions test for vehicles used commercially (heavy-duty vehicles, buses, taxis, and other business vehicles). This program affects only about 10 percent of the total vehicle population. There is no inspection program for private vehicles and no enforcement of certification standards through either new or in-use vehicle compliance testing.

CHAPTER 1: INTRODUCTION

1.1). Introduction to the research

Pollution is not a new issues today. This issues had disscussed more than a decade ago. Spark ignition and diesel engine are a major source of urban pollution. The spark-ignition engine exhaust gasses contain oxides of nitrogen (nitric oxide NO, and small amount of nitrogen dioxide , NO_2 – collectively known as NO_x), carbon monoxide CO, and organic compound which are unburned or particially burned hydrocarbon (HC). The relative amounts depends on engine design and operating condition but are of order : NO_x 500 to 1000 ppm or 20g/kg fuel; CO, 1 to 2 percent or 200 g/kg fuel; and HC, 3000 ppm (as C_1) or 25 g/kg fuel. Piston blowby gasses, and fuel evaporation and release to the atmosphere through vents in the fuel tank and carburetor after engine shut-down, are also sources of unburned hydrocarbon. However, in the most modern engine these nonexhaust source are affectively controlled by returning the blowby gases from the crankcase to the engine intake system and by venting the fuel tank and carburetor float bowl through a vapor-absorbing carbon cannister which is purged by some of the engine intake air during normal engine operation. In diesel engine exhaust, concentration of NO_x are compareable to those from SI engines. Diesel hydrocarbon emission are significant through exhaust concentration are lower by about factor of 5 tham typical SI engine level. The hydrocarbon in the exhaust may also condense to form white smoke during engine starting and warm up.

Specific hydrocarbon compounds in the exhaust gasses are the source of diesel odor. Diesel engine are the an important source of particulate emission; between about 0.2 and 0.5 percent of the fuel mass is emitted as small (~0.1 µm diameter) particles which consist primarily of soot with some additional absorbed hydrocarbon material. Diesel engines are not a significant source of carbon monoxide.

In general, the concentration of these pollutants in internal combustion engine exhaust differ from values calculated assuming chemical equilibrium. Thus the detailed chemical mechanisms by which these pollutants form and the kinetics of these process are important in determing emission level. For some pollutants species, e.g, carbon monoxide, organic compounds, and particulates, the formation and destruction reaction are intimately coupled with the primary fuel combustion process. Thus an understanding of the formation of these species requires knowledge of the combustion chemistry. For nitrogen oxides and sulfur oxides, the formation and destruction process are not part of the fuel combustion process.

However, the reaction which produce these species take place in an environment created by the combustion reactions, so the two process are still intimately linked. In sebsequent section, the details of the basic formation mechanisms of each pollutant and the application of these mechanism to the combustion process in the both spark-igniton and compression-igniton engines will be developed.

1.1.1) Exhaust gasses

Generally exhaust gasses is defined as waste gases produced by an internal combustion engine , or the pipework that those waste gases are discharged through. After air/fuel mixture (or nitrous/fuel mixture) burns, some leftovers consisting of a few unburned hydrocarbons (fuel), carbon monoxide, carbon dioxide, nitrogen oxides, sulfur dioxide, phosphorus, and the occasional molecule of a heavy metal, such as lead or molybdenum. These are all in gaseous form, and will be under a lot of pressure as the piston rushes them out of the cylinder and into the exhaust manifold or header.

1.1.2) Exhaust manifold

Made of cast iron or tubular steel, the exhaust manifold mounts to the exhaust side of the cylinder head. An exhaust manifold gasket is used at the connection to ensure a good seal. Engines with their cylinders arranged in-line usually have one exhaust manifold. Engines with V-type cylinder arrangements, like the V6 and V8, have two separate exhaust manifolds, one mounted to each cylinder head.

The exhaust manifold routes the exhaust gases leaving the cylinder head to the exhaust system. As such, the manifold also serves as a connection point for the exhaust pipe. Depending on engine configuration and the number of exhaust manifolds, there may be two exhaust pipe connections. Depending on the year, make and emissions equipment installed on the vehicle, the exhaust manifold may also serve as a mounting location for hardware of the air injection system or for an oxygen sensor. Also, some exhaust manifolds may still include a heat riser valve, controlled by a temperature-sensitive spring. This valve is designed to help divert hot exhaust gas through a separate passage in the intake manifold to aid in better warm-up driveability.

1.2) Research objective

Main objective for this research is to determine exhaust gas concentration around exhaust manifold of a petrol engine. Content of exhaust gases is hydrocarbon (HC), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxide (NO), sulfur dioxide (SO_2), phosphorus (P), lead and other metal. In this paper, all these particle will be analyzed except lead and other material.

CHAPTER 2: LITERATURE REVIEW.

2.1) Introduction to petrol engine.

Petrol engine is a complex piece of machinery made up of about 150 moving parts. It is a reciprocating piston engine, in which a number of pistons move up and down in cylinders. A mixture of petrol and air is introduced to the space above the pistons and ignited. The gases produced force the pistons down, generating power. The engine-operating cycle is repeated every four strokes (upward or downward movement) of the piston, this being known as the four-stroke cycle. The motion of the pistons rotate a crankshaft, at the end of which is a heavy flywheel. From the flywheel the power is transferred to the car's driving wheels via the transmission system of clutch, gearbox, and final drive.

The parts of the petrol engine can be subdivided into a number of systems. The fuel system pumps fuel from the petrol tank into the carburetor. There it mixes with air and is sucked into the engine cylinders. (With electronic fuel injection, it goes directly from the tank into the cylinders by way of an electronic monitor.) The ignition system supplies the sparks to ignite the fuel mixture in the cylinders. By means of an ignition coil and contact breaker, it boosts the 12-volt battery voltage to pulses of 18,000 volts or more. These go via a distributor to the spark plugs in the cylinders, where they create the sparks. (Electronic ignitions replace these parts.) Ignition of the fuel in the cylinders produces temperatures of 700°C/1,300°F or more, and the engine must be cooled to prevent overheating.

2.1.1) Basic cycle in petrol engine.

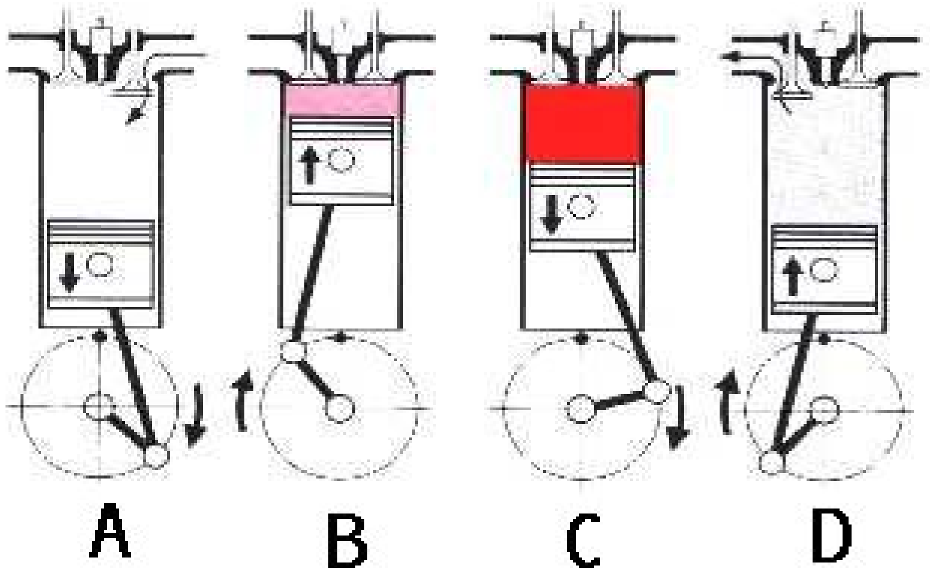

Figure 2.1: Cycle in petrol engine

Intake (A): The descent of the piston produces a depression which sucks the air (fuel injected engine) - or mixture if carbureted - by the open intake valve. The gasoline is injected (common fuel injection engine operating in homogenous mode). The valve is closed again only when the piston is already traveling up because the fresh charge column, carried by its inertia, continues to flow into the cylinder.

Compression (B): The mixture is compressed by the upwards movement of the piston, the two valves being closed (except on fuel injected engines operating in stratified charge mode where the fuel is injected towards the end of the compression stroke). The temperature and the pressure at the end of compression reach respectively more than 400°C and 10 to 15 bar.

Combustion (C): The mixture is ignited by the spark plug. The combustion produces a strong rise in temperature and pressure. The flame front can propagates at more than 100 m/sec with a temperature of 2000°C or even 2500°C. The pressure usually reaches some 60 bars and forcefully pushes the piston back. The exhaust valve starts to open before the end of the expansion stroke to decrease the pressure in the cylinder and to facilitate the return of the piston.

Exhaust (D): The new upwards movement of the piston pushes the combustion gases in the port opened by the exhaust valve and expels them out of the cylinder. The pressure in the latter is just slightly over atmospheric. Towards the end of the exhaust stroke, the inlet valve starts to open, the exhaust one being closed again completely only after the beginning of the intake stroke. This overlap of the valves opening duration is useful because their full lift requires some delay. It also allows a better filling, particularly at highrevs.

2.2) Introduction to exhaust manifold.

An exhaust manifold's purpose is to bring together the expelled exhaust gasses from the numerous engine cylinder and to transfer them to the catalytic converter and silencer box via the exhaust system downpipe. Exhaust gas ejected from the engine cylinder is collected from each exhaust valve-port through branch passages which merge together to form a common passageway, hence the term manifold. The exhaust gas then flow to the downpipe/pipes through one, two and sometimes three flanged outlets.

The basic principle of good design is to keep the exhaust gasses expelled from each cylinder into the branch-passage separate for as long as possible permitting them to merge together. If the manifold branch-passages are very short the exhaust gas from individual cylinder is likely to reverse the direction of flow and move into adjacent branch-passages, thereby causing interfere and impeding the flow of the gas. Equal branch-passage length is desirable but not always practical if identical scavenging from each cylinder is to be achieved. Long branch-passages enable the momentum of the column of exhaust gas moving along the flow-path to leave behind a depression in the exhaust port. If the exhaust valve closure is delayed, an extraction effect pulls the remaining unwanted gas out of the combustion chamber. It thereby permits the fresh charge to enter the cylinders unrestricted.

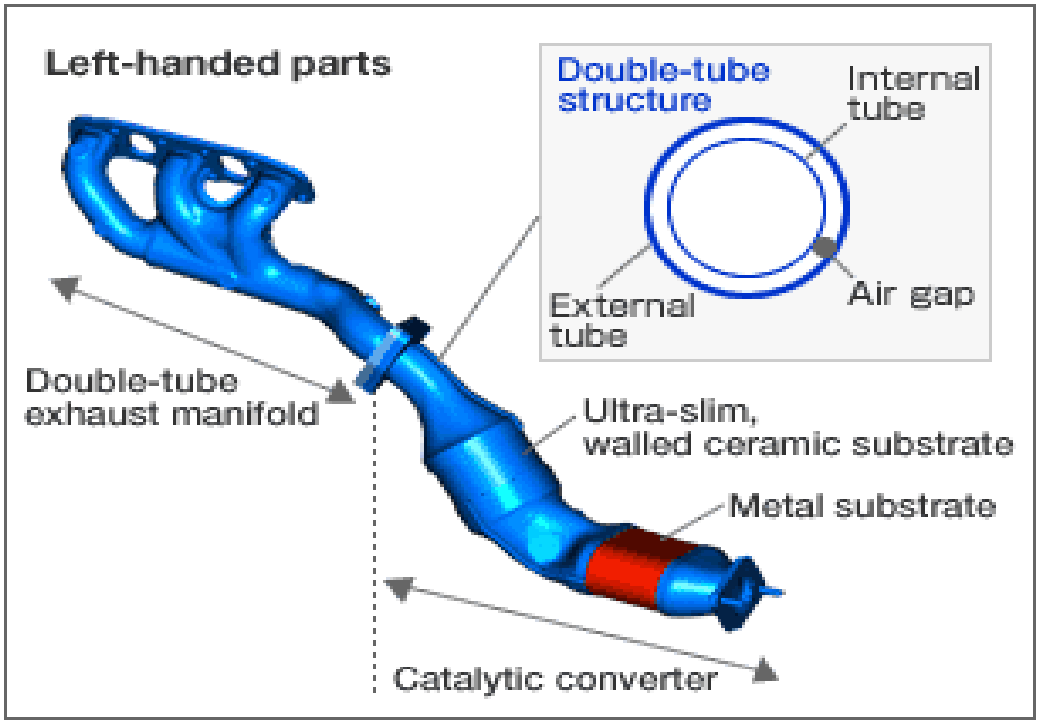

Figure 2.2) Exhaust manifold.

2.2.1) Types of exhaust manifold.

a) In-line four cylinder exhaust manifold.

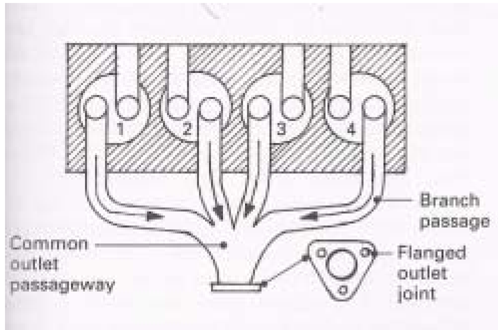

Figure 2.3: Four cylinder engine with four branch central Downpipe exhaust manifold.

Conventional four cylinder manifolds have four branches of unequal length merging into a common central exit passage. This configuration can suffer from exhaust-gas interference between branch- passageway and unequal exhaust port-back pressure and with limited exhaust port depression pull effect to clear the exhaust gasses from the combustion chamber.

b) In-line five cylinder exhaust manifold.

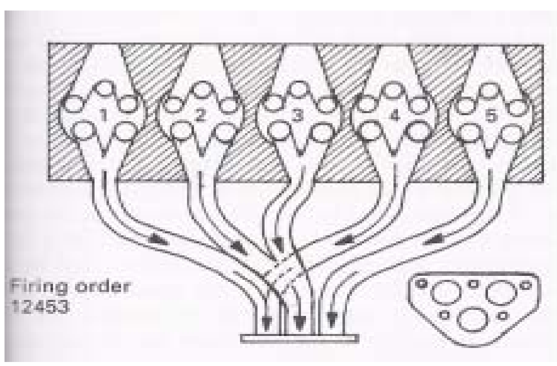

Figure 2.4: Five cylinder engine with five branch triple downpipe exhaust Manifold

The long passageway in which branches 1-4 and 2-3 converge and branch 5 remain on its own forms a very good compromise with this uneven cylinder number arrangement. Piring branches 1-4 and 2-3 and keeping branches 5 separate provides extended irregular discharge interval of 288º. 432º,and 720º respectively, from each of the triple downpipe forks.

c) In-line six cylinder exhaust manifold.

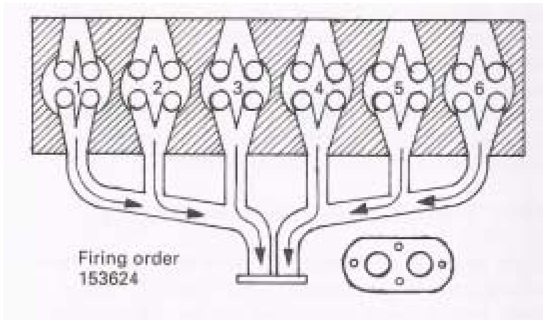

Figure 2.5: In-line six-cylinder engine with six-branch twin downpipe exhaust Manifold.

Dividing the manifold in two so that cylinder 1-2-3 discharge into one downpipe and cylinder 4-5-6 discharge into the other of the twin-fork downpipe layout, provides an equal exhaust expulsion interval between each half manifold exit of 240ºcrankshaft rotation. Adjacent branch-passage exhaust interference is minimal and exhaust-port depression extraction can be useful utilized.

d) Vee-six cylinder exhaust manifold.

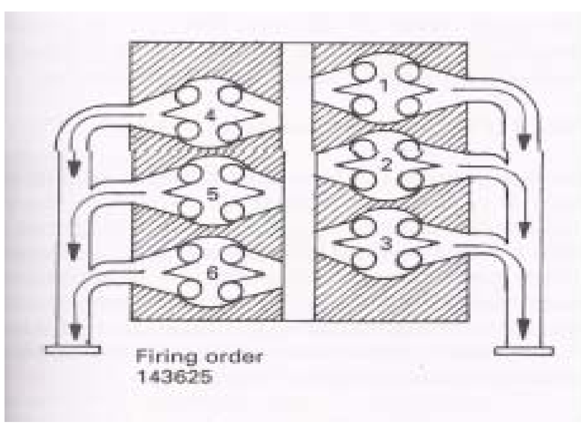

Figure 2.6: Vee-six cylinder engine with tree –branch single downpipe Exhaust manifold.

This arrangement is in effect similar to the split manifold of the in-line six-cylinder engine; however, with a vee-cylinder banked engine each cylinder bank has its own three-branch manifold. Thus, with a typical firing-order 143625, the exhaust discharge alternates from each cylinder bank, thereby providing a 240º crank-angle interval between discharge in each manifold.

e) Vee-eight engines exhaust manifold.

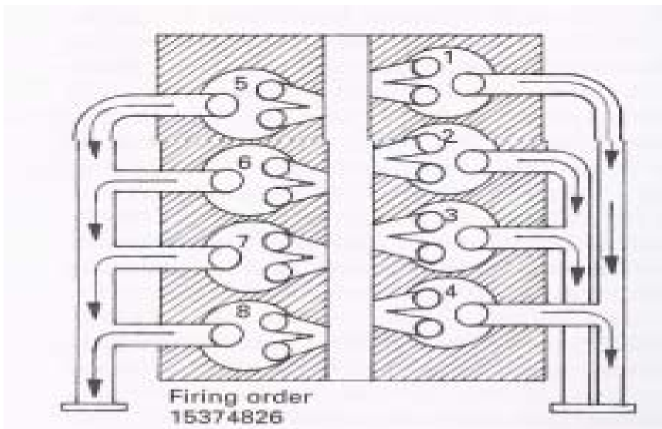

Figure 2.7: Vee-eight with four-branch single.

Each bank of a vee-eight cylinder engine can be considered as a separate four-cylinder engine, both banks being connected to the other by a common crankshaft and crankcase. An eight-cylinder engine has an exhaust discharge every 90º crankshaft rotation, and with an exhaust manifold for each cylinder- bank and a single-plane crankshaft there should be an exhaust discharge interval for each downpipe of 180º .

2.3) Engine emission and hydrocarbon oxidation.

For practical purpose during combustion,nitric oxide (NO) is only nitrogen oxide that is formed. However, as the NO cools it can be oxidised to nitrogen dioxide (NO_2). NO_x refers to mixture of NO and NO_2, and typically over 90 percent of the NO_x from an engine is NO. However the NO will subsequently oxidise to NO_2 in the environment, and it is the NO_2 that can react with unburn non-methane hydrocarbons in the presence of ultra-violet light to form a photochemical smog. On a volumetric basis the proportion of the NO or NO_2 in NO_x makes no difference. This is not true on a gravimetric basis, and since all the NO can oxidise to NO_2 (and it is the nitrogen dioxide that forms smog), then the NO_x is assigned the molar mass of NO_2 (46 kg/kmol).

The terms ‘engine emission’ refers primarily to pollutants in the engine exhaust. Example of pollutants are carbon monoxide (CO), various oxide of nitrogen (NO_x) and unburn hydrocarbon (HC). These emission are worse from the spark ignition engine than from the compression ignition engine. Emission from compression ignition engines are primarily soot, and odour associated with certain hidrocarbons. Recently concern has been expressed about possible carcinogens in the exhaust but it is not clear if these come from the diesel fuel or from the combustion process.

The concentration of CO and NO_x are greater than those predicted by equilibrium thermodynamics. The rate of the forward reaction is different from the backward reaction, and there is insufficient time for equilibrium to be attained. The chemical kinetics involved are complex and work is still proceeding to try and predict exhaust emissions.

Emission of CO, NO_x and HC vary between different engines and are dependent on such variables as ignition timing, load, speed and, in particular fuel/air ratio.Carbon monoxide (CO) is more concentrated with fuel-rich mixtures, as there will be incomplete combustion. With lean mixtures, CO is always present owing to dissociation, but the concentration reduces with reducing combustion temperatures. Hydrocarbon (HC) emissions are reduced by excess air (fuel-lean mixtures) untill the reduced flammability of the mixtures causes a net increase in HC emissions. These emissions originate from the flame quench layer (where the flame is extinguished by cold boundaries), crevices (regions such as piston ring grooves can be particularly important) and from the oil film. The outer edge of the quench layer can also contribute to the CO and aldehyde emissions.

The formation of NO_x is more complex since it is dependent on a series of reaction such as the Zeldovich mechanism:

$$O_2 \leftrightarrow 2\ O$$

$$O + N_2 \leftrightarrow NO + N$$

$$N + O_2 \leftrightarrow NO + O$$

Chemical kinetics shoe that the formation of NO and other oxides of nitrogen increase very strongly with increasing flame temperature. Tis would imply that the highest concentration of NO_x should be for slightly rich mixtures, those that have the highest flame temperature. However, oxygen is also needed for the formation of NO, so the maximum NO emission occur just weak of stoichiometric. NO_x formation will also be influenced by the flame speed. Lower flame speed with lean mixtures provide a longer time for NO_x to form. Similarly NO_x emissions increase with reduced engine speed.

Emission of HC and CO can be reduced by operating with lean mixtures; this has the disadvantages of reducing the engine power output. It is also difficult to ensure uniform mixtures distribution to each cylinder in multi-cylinder engines. Alternatively, exhaust gas catalytic reactor of thermal reactors can complete the oxidation process; if necessary extra air can be admitted.

The way of reducing NO_x emissions are more varied. If either the flame temperature or burn duration is reduced, the NO_x emissions will also be reduced. Retarding the ignition is very effective as this reduces the peak pressure and temperature, but it has an adverse effect on power output and economy. Another approach is to increase the concentration of residual in the cylinder by exhaust gas recirculation (EGR). EGR lowers both flame temperature and speed , but gives significant reduction in NO_x. Between 5 and 10 percent EGR is likely to halve NO_x emissions. However, EGR can lower the efficiency at full load and reduces the lean combustion limit. Catalysts can be used to reduced the NO_x to oxygen and nitrogen but this is difficult to arrange if CO and HC are being oxidised. Such system have complex arrangements and require very close to stoichiometric mixtures of fuels with no lead-based additives.

Compresion ignition engines have fewer gaseous emissions than spark ignition engines, but compression ignition engines have greater particulate emissions. The equivalence ratio in a diesel engine is always less than unity (fuel lean), and this accounts for the low CO emissions, about 0.1 per cent by volume. Hydrocarbons emission (unburn fuel) is also less, but rises towards the emissions level of spark ignition engines as the engine load (bmep) rises.

The emissions of NO_x are about half those for spark ignition engines. This result might, at first, seem to contradict the pattern in spark ignition engines, for which NO_x emissions are worst for an equivalence ratio of about 0.95. In diffusion flames fuel is diffusing towards the oxidant, and oxidant diffuses towards the fuel. The equivalence ratio varies continously, from high values at the fuel droplet to values less than unity in the surrounding gases. The flame position can be defined for mathematical purpose as where the equivalence ratio is unity. However, the reaction zone will extend each side of the stoichiometric region to wherever the mixture is within the flammability limits. This will have an averaging effect on NO_x production. In addition, the radiation from the reaction zone is significant, and NO_x production is strongly temperature-dependent. A common method to reduce NO_x emission is to retard the injection timing, but this has adverse effects on fuel consumption and smoke emissions. Retarding the injection timing may be beneficial because this reduces the delay period and consequently the uncontrolled combustion period.

The most serious emission from compression ignition engines is smoke, with the characteristic grey or black of soot (carbon) particles. Smoke does not include the bluish smoke that signifies lubricating oil is being burnt, or the white smoke that is characteristic of unburn fuel. These type of smoke occur only with malfunctioning engines, both compression and spark ignition.

Smoke from compression ignition engines originates from carbon particles formed by cracking of large hydrocarbon molecules on the fuel-rich side of the reaction zone. The carbon particles can grow by agglomeration untill they reach the fuel-lean zone, where they can be oxidised. The final rate of soot release depends on the difference betweemn the rate of formation and the rate of formation and the rate of oxidation. The maximum fuel injected (and consequently power output) is limited so that the exhaust smoke is just visible. Smoke output can be reduced by advancing the injection timing or by injecting a finer fuel spray, the latter being obtained by higher injection pressure and finer nozzles. Smoke from a compression ignition engine implies a poorly calibrate injector pump or faulty injectors.

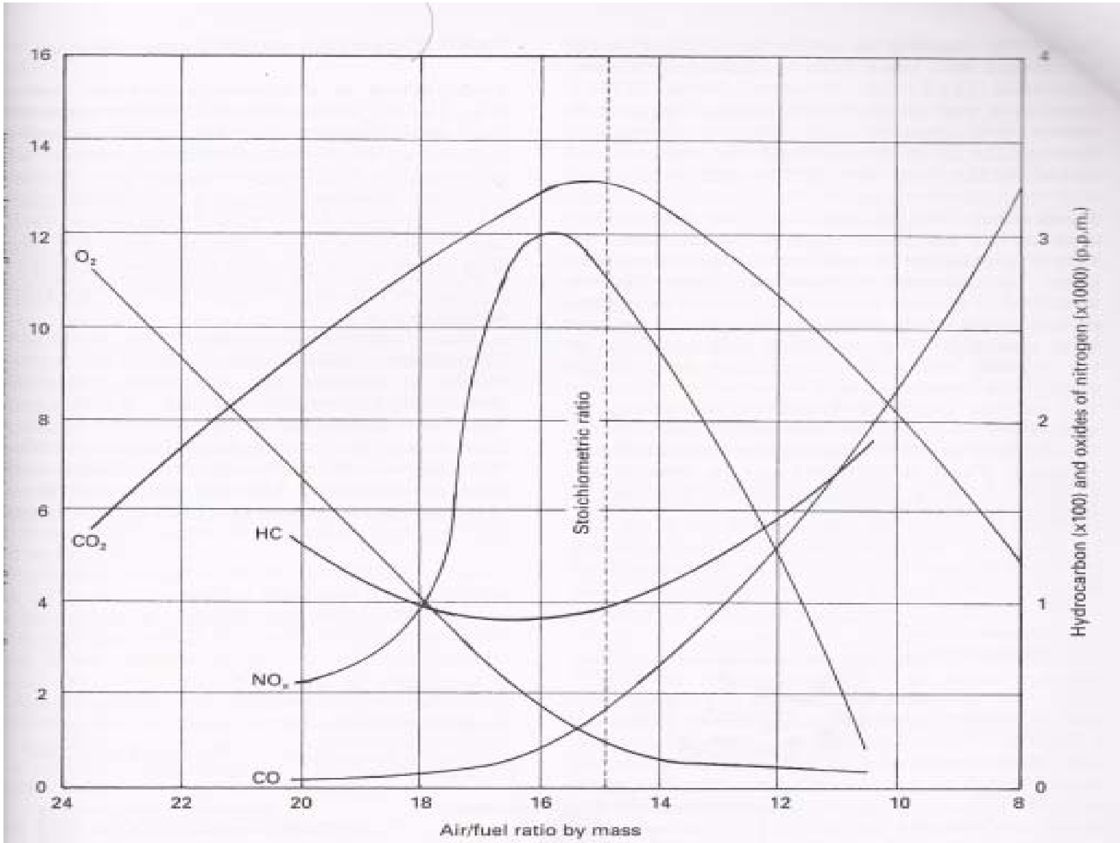

Figure 2.8: Exhaust gas composition for typical petrol engines.

2.3.1) Nitric oxide formation.

The mixture of nitric oxide (NO) and nitrogen dioxide (NO_2) is referred to as NO_x. Nitric oxide is usually by far the most dominant nitrogen oxide formed during combustion. However, subsequent further oxidation leads to nitrogen dioxide in the environment, and it is the nitrogen dioxide that reacts with the non-methane hydrocarbons in the presence of ultra-violet lights, to form a photochemical smog. Thus although the major part of NO_x will be NO, when emission are calculated on a specific basis then it is assumed that all the nitric oxide is oxidised to nitrogen dioxide.

Nitric oxide is formed in flames by three mechanisms; thermal, prompt and nitrous oxide. The thermal mechanism is based on the extended Zeldovich mechanism:

$O + N_2 \leftrightarrow NO + N$

$N + O_2 \leftrightarrow NO + O$

$N + OH \leftrightarrow NO + H$

The rate constant for the thermal mechanism are very slow compared to those for combustion, and NO formation is only significant when there is a high enough temperature (say above 1800 K) and sufficient time. Thus the thermal NO mechanism is assumed to occur in the hot combustion gases, in which it can be taken that all the others species are in equilibrium apart from the NO. Measurement of the NO concentration in the burnt gases do not extrapolate to zero at the flame. This implies that NO is formed in the flame, by the so-called prompt mechanism. The prompt mechanism is significant when there is fuel-bound nitrogen, or when the combustion temperatures are so low as to make the thermal mechanism negligible.

2.3.2 Carbon monoxide emission.

The carbon monoxide emissions lie between those predicted for equilibrium at peak pressure and the equilibrium values at exhaust valve opening; they tend to be closer to the maximum pressure values for rich mixtures, and closer to the exhaust valve opening values for weak mixtures. As with the nitric oxide emissions, this is a consequence of the reaction rates falling during expansion, so that a temperature is reached at which the carbon monoxide concentration appears to ‘freeze’. The CO emissions can be modelled by specifying a ‘freezing’ temperature at which the equilibrium concentration is evaluated. More accurate models need to include the kinetics. However, the main determinant of carbon monoxide emissions is the air/fuel ratio. In multicylinder engines operating at stoichiometric, the inter-cylinder variation in air/fuel ratio will have the biggest effect on the carbon monoxide emissions.

2.4) Effect of exhaust emission on human being and other living organisms.

Atmospheric pollutants combine with moisture and other harmful substances to form a kind of fog known as smog. The formation of smog is particularly seen in areas where the level of pollution is high. Smog is produced is when nitrogen oxide reacts with hydrocarbon in the presence of sunlight. Smoke mixes with the moisture in air producing dense layer of smog in the sky which considerably hinder visibility and also cause eye irritation in human being.

Smoke produced by automobiles also decrease visibility on roads. Besides, engine smoke also possesses a foul odour due to; presence of aldehydes and oxygenated compounds.

Eczema, asthma, emphysema, cardio-vascular difficulties, lung cancer and stomach cancer have been directly linked to air pollution.

Mutagens produced due to sulphates and hydrocarbon in the emissions are said to cause hereditary changes in the structural arrangement of genes in human beings.

The soots particles produced in exhaust gases settle on the surface of buildings. After considerable exposure to soot, the appearance of building and paintings may be spoiled. Paints applies to house may also start to peel. Food crops and tree are affected by the engine smoke due to the presence of nitrogen oxide and sulphur dioxide in the exhaust gases. Smog damages food crops. Cattle, poultry animals, birds as well as wildlife are as much affected by air pollution as human being.

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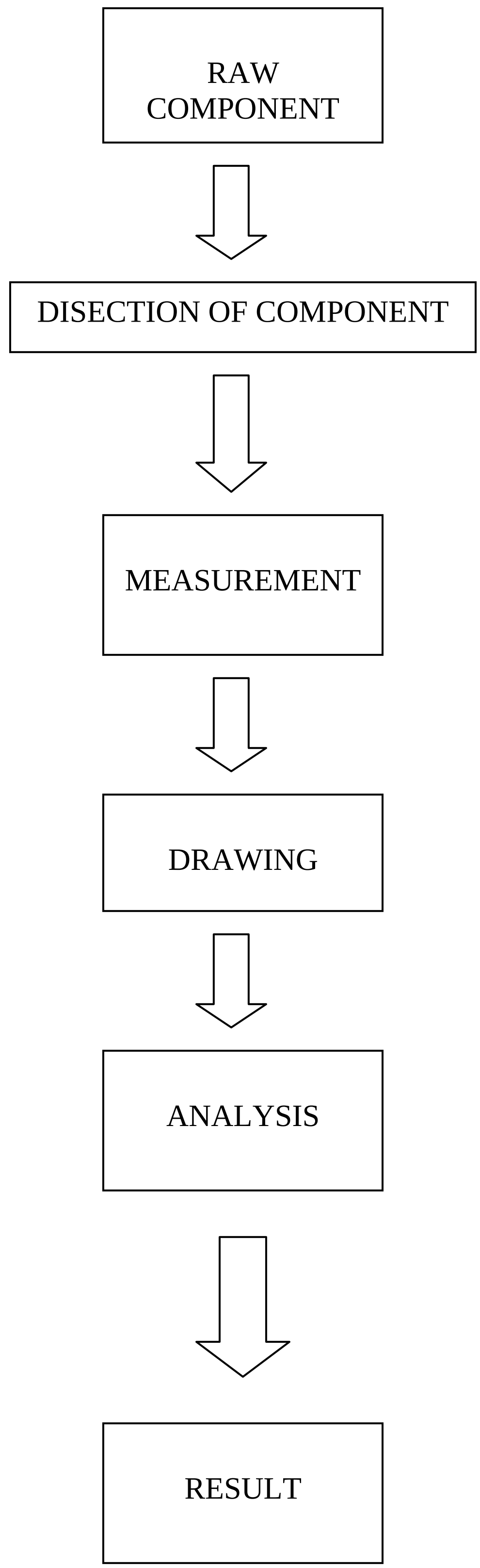
CHAPTER 3:METHODOLOGY.

Flow process for this project is shown below:



3.1). Raw component.

In this project, a Perodua Kancil 660cc four-stroke engine exhaust manifold was selected.

Figure 3.1: Perodua Kancil exhaust manifold.

Figure 3.2 : Perodua Kancil exhaust manifold

3.2) Disection of component.

In this research, an analysis was made for an internal part of the exhaust manifold This part was selected and the internal shape was measured.

Figure 3.2: Peordua Kancil exhaust manifold after dissection.

3.3). Measurement

Ruler and vernier caliper were used to make measurement. Dimension for these are essential for IDEAS modeling.

3.4) Drawing.

After all relevant dimension was got, the next step is make drawing for the part. IDEAS is software was utilized to make a complete drawing for exhaust manifold. A few tools was used in IDEAS are listed below:

i) Parts-cylinder.

ii) Sketch in plane.

iii) Polyline.

iv) Extrude.

v) Resolve.

vi) Loft.

vii) Move.

Second part in IDEAS is Simulation-Meshing. 3mm meshing was selected, so, results are shown below :

i). Total element generates: 79203

ii). Total nodes generates: 121954

3.5) Analysis.

This is the most important step. FLUENT software was utilized to make the analysis. FLUENT is a state-of-the-art computer program for modeling fluid flow and heat transfer in complex geometries. FLUENT provides complete mesh flexibility, solving flow problems with unstructured meshes that can be generated about complex geometries with relative ease. Supported mesh types include 2D triangular/quadrilateral, 3D tetrahedral/hexahedral/pyramid/wedge, and mixed (hybrid) meshes. FLUENT also allows us to refine or coarsen your grid based on the flow solution

FLUENT is written in the C computer language and makes full use of the flexibility and power offered by the language. Consequently, true dynamic memory allocation, efficient data structures, and flexible solver control are all made possible. In addition, FLUENT uses a client/server architecture, which allows it to run as separate simultaneous processes on client desktop workstations and powerful compute servers, for efficient execution, interactive control, and complete flexibility of machine or operating system type.

Step followed in FLUENT to make analysis:

1. Create the model geometry and grid.
2. Start the appropriate solver for 2D or 3D modeling.
3. Import the grid.
4. Check the grid.
5. Select the solver formulation.
6. Choose the basic equations to be solved: laminar or turbulent .
7. Specify material properties.
8. Specify the boundary conditions.
9. Adjust the solution control parameters.
10. Initialize the flow field.
11. Calculate a solution.
12. Examine the results.
13. Save the results.

CHAPTER 4: RESULTS AND DISCUSSION

In this chapter, analysis of components exhaust gases will discuss. The primary components in exhaust gas are nitrogen (N_2), carbon dioxide (CO_2),and water vapour (H_2O). These are not toxic substances.

Nitrogen is the most abundant element in the atmosphere. Although not directly involved in combustion process, at roughly 71% it is the main component in exhaust gas. Small amounts of nitrogen do, through, react with oxygen to form nitrous oxides.

Complete combustion converts the hydrocarbons contained in the fuel's chemical bonds into carbon dioxide, which makes up about 14% of the exhaust gas. Reduction of CO_2 is becoming increasingly significant, as it is a suspected contributor to the "greenhouse effects". Because CO_2 is one of the products of complete combustion (which may proceed within the exhaust gas), the only way to reduce CO_2 emissions is via reductions in fuel consumption.

The hydrogen chemically bonded within the fuel burns to produce water vapour, most of which condenses as it cools. This is the vapor cloud that can be seen emerging from exhaust pipes in cool weather.

4.1) CARBON MONOXIDE CO

Carbon monoxide (CO) is a colourless and odorless gas produced by incomplete combustion. It can cause asphyxiation by impairing the blood's ability to absorb oxygen. This is why an engine should never be allowed to run in an enclosed area unless an exhaust-gas extraction system is in operation.

Table 4.1: Carbon monoxide properties.

PROPERTIES	VALUE
Density	1.1233 kg/m^3
Heat capacity cp	1044 j/kg-K
Thermal conductivity	0.025 w/m-K
viscosity	1.75e-05 kg/m-s

4.1.1)Pressure:

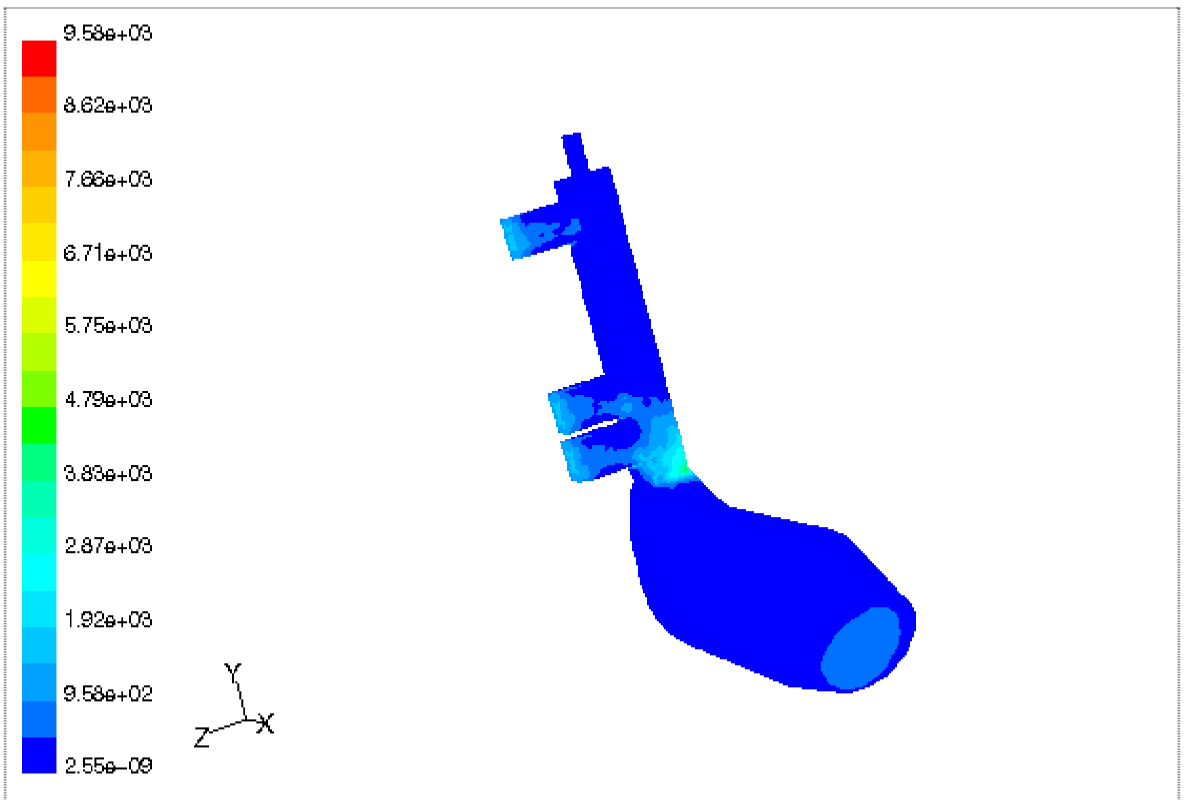


Figure 4.1.1: Pressure of CO in exhaust manifold.

4.1.2)Density:

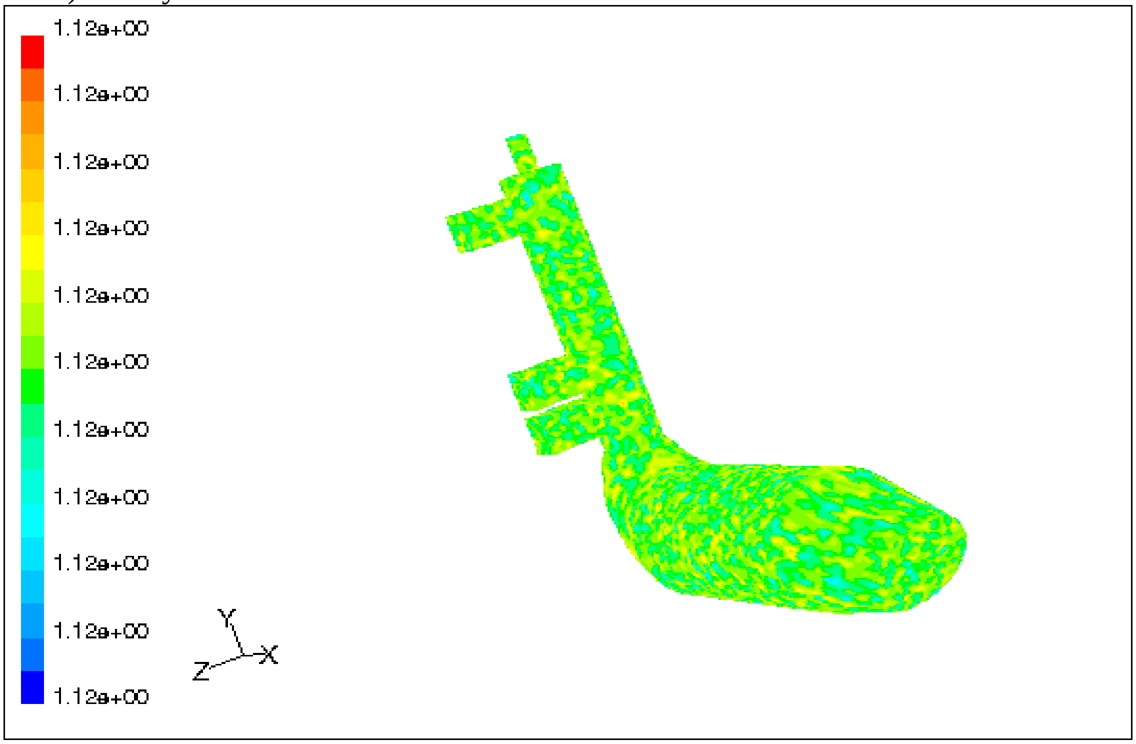


Figure 4.1.2: Density of CO in exhaust manifold.

4.1.3) Temperature:

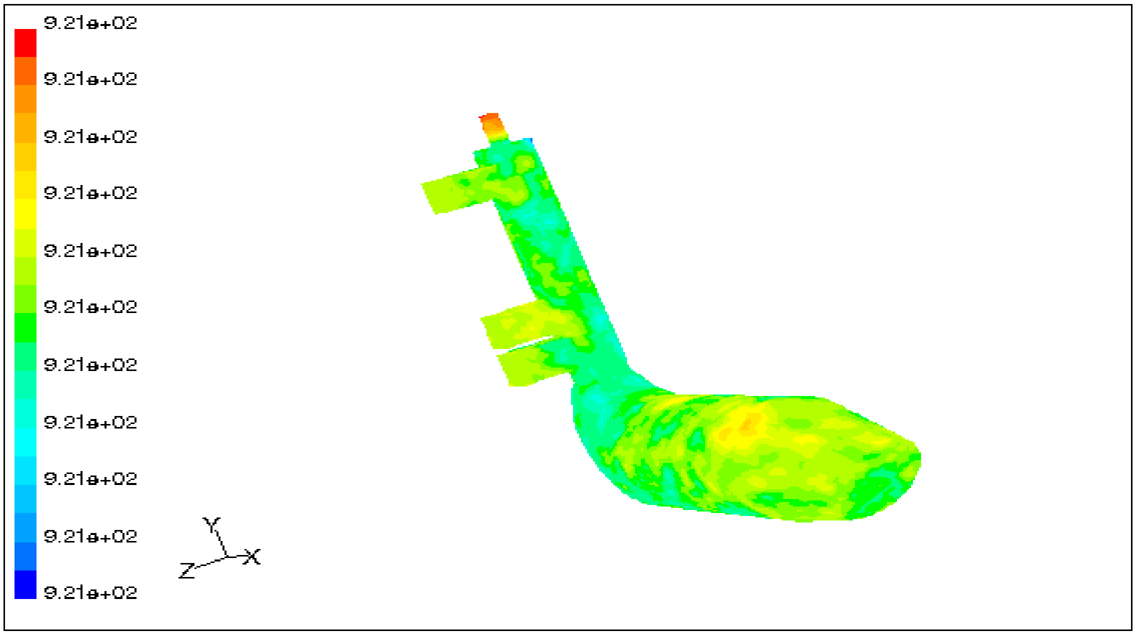


Figure 4.1.3: Temperature of CO in exhaust manifold.