بسم الله الرحمن الرحيم

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
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"DESIGN SIMULATION AND FABRICATION OF VEHICLE EXHAUST GASES EMISSION CONTROL SYSTEM"

(SMART EXHAUST TECHNOLOGY)

A thesis submitted to the department of Mechanical and chemical Engineering (MCE), Islamic University of Technology (IUT), in the partial fulfillment of the requirement for degree of Bachelors of Science in Mechanical Engineering.

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It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma

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We seek excuse for any errors that might be in this report despite of our best efforts.

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CHAPTER 01

INTRODUCTION

1.1 Problem statement:

Throughout the 1950s and 1960s, various federal, state and local governments in the United States conducted studies into the numerous sources of air pollution. These studies ultimately attributed a significant portion of air pollution to the automobile, and concluded air pollution is not bounded by local political boundaries. At that time, such minimal emission control regulations as existed in the U.S. were promulgated at the municipal or, occasionally, the state level. The ineffective local regulations were gradually supplanted by more comprehensive state and federal regulations. By 1967 the State of California created the California Air Resources Board, and in 1970, the federal United States Environmental Protection Agency (EPA) was established. Both agencies, as well as other state agencies, now create and enforce emission regulations for automobiles in the United States. Similar agencies and regulations were contemporaneously developed and implemented in Canada, Western Europe, Australia, and Japan.

The first effort at controlling pollution from automobiles was the PCV (positive crankcase ventilation) system. This draws crankcase fumes heavy in unburned hydrocarbons a precursor to photochemical smog into the engine's intake tract so they are burned rather than released unburned from the crankcase into the atmosphere. Positive crankcase ventilation was first installed on a widespread basis by law on all new 1961-model cars first sold in California. The following year, New York required it. By 1964, most new cars sold in the U.S. were so equipped, and PCV quickly became standard equipment on all vehicles worldwide

The first legislated exhaust (tailpipe) emission standards were promulgated by the State of California for 1966 model year for cars sold in that state, followed by the United States as a whole in model year 1968. Also in 1966, the first emission test cycle was enacted in the State of California measuring tailpipe emissions in PPM (parts per million). The standards were progressively tightened year by year, as mandated by the EPA.

By the 1974 model year, the emission standards had tightened such that the de-tuning techniques used to meet them were seriously reducing engine efficiency and thus increasing fuel usage. The new emission standards for 1975 model year, as well as the increase in fuel usage, forced the invention of the catalytic converter for after-treatment of the exhaust gas. This was not possible with existing leaded gasoline, because the lead residue contaminated the platinum catalyst. In 1972, General Motors proposed to the American Petroleum Institute the elimination of leaded fuels for 1975 and later model year cars. The production and distribution of unleaded fuel was a major challenge, but it was completed successfully in time for the 1975 model year cars. All modern cars are now equipped with catalytic converters and leaded fuel is nearly impossible to buy in most First World countries.

Now considering the above discussed scenario, in this project we are going to design a Smart Exhaust system which will be very effective in emission control. It will be economically feasible and readily available. The existing technology is Catalytic converter which in fact is an expensive item and can’t be accessible to all.

Air pollution is by far the most harmful form of pollution in our environment. Air pollution is cause by the injurious smoke emitted by cars, buses, trucks, trains, and factories, namely sulphur dioxide, carbon monoxide and nitrogen oxides. Even smoke from burning leaves and cigarettes are harmful to the environment causing a lot of damage to man and the atmosphere. Evidence of increasing air pollution is seen in lung cancer, asthma, allergies, and various breathing problems along with severe and irreparable damage to flora and fauna. Even the most natural phenomenon of migratory birds has been hampered, with severe air pollution preventing them from reaching their seasonal metropolitan destinations of centuries.

Chlorofluorocarbons (CFC), released from refrigerators, air-conditioners, deodorants and insect repellents cause severe damage to the Earth's environment. This gas has slowly damaged the atmosphere and depleted the ozone layer leading to global warming.

Water pollution caused industrial waste products released into lakes, rivers, and other water bodies, has made marine life no longer hospitable. Humans pollute water with large scale disposal of garbage, flowers, ashes and other household waste. In many rural areas one can still find people bathing and cooking in the same water, making it incredibly filthy. Acid rain further adds to water pollution in the water. In addition to these, thermal pollution and the depletion of dissolved oxygen aggravate the already worsened condition of the water bodies. Water pollution can also indirectly occur as an offshoot of soil pollution – through surface runoff and leaching to groundwater.

Noise pollution, soil pollution and light pollution too are the damaging the environment at an alarming rate. Noise pollution include aircraft noise, noise of cars, buses, and trucks, vehicle horns, loudspeakers, and industry noise, as well as high-intensity sonar effects which are extremely harmful for the environment. Maximum noise pollution occurs due to one of modern science's best discoveries – the motor vehicle, which is responsible for about ninety percent of all unwanted noise worldwide. [21]

Soil pollution, which can also be called soil contamination, is a result of acid rain, polluted water, fertilizers etc., which leads to bad crops. Soil contamination occurs when chemicals are released by spill or underground storage tank leakage which releases heavy contaminants into the soil. These may include hydrocarbons, heavy metals, MTBE, herbicides, pesticides and chlorinated hydrocarbons.

Light Pollution includes light trespass, over-illumination and astronomical interference. Cars and trucks produce air pollution throughout their life, including pollution emitted during vehicle operation, refueling, manufacturing, and disposal. Additional emissions are associated with the refining and distribution of vehicle fuel.

Air pollution from cars and trucks is split into primary and secondary pollution. Primary pollution is emitted directly into the atmosphere; secondary pollution results from chemical reactions between pollutants in the atmosphere.

1.1.1 CAR EMISSIONS AND GLOBAL WARMING.

Global warming endangers our health, jeopardizes our national security, and threatens other basic human needs. Some impacts such as record high temperatures, rising seas, and severe flooding and droughts are already increasingly common.

Our personal vehicles are a major cause of global warming. Collectively, cars and trucks account for nearly one-fifth of all US emissions, emitting around 24 pounds of carbon dioxide and other global-warming gases for every gallon of gas. About five pounds comes from the extraction, production, and delivery of the fuel, while the great bulk of heat-trapping emissions more than 19 pounds per gallon comes right out of a car’s tailpipe.

In total, the US transportation sector which includes cars, trucks, planes, trains, ships, and freight produces nearly thirty percent of all US global warming emissions, more than almost any other sector. [22]

Unfortunately, oil-related emissions may rise in the coming years as the oil industry extracts and refines “unconventional” oils, such as tar sands and tight oil. Using less oil and avoiding unnecessary emission from the oil we do use is the real solution.

Fuel-efficient vehicles use less gas to travel the same distance as their less efficient counterparts. When we burn less fuel, we generate fewer emissions. When emissions go down, the pace of global warming slows.

Cleaner fuels produce fewer emissions when they’re burned. Some fuels such as those made from cellulosic biofuels can reduce emissions by 80 percent compared to gasoline. And better regulations would help prevent the gasoline we do use from getting any dirtier.

Electric cars and trucks use electricity as fuel, producing fewer emissions than their conventional counterparts. When the electricity comes from renewable sources, all-electric vehicles produce zero emissions to drive.

These and other solutions are here today but more can be done. Learn more about our plan to Half the Oil, or find out what you can do for clean vehicles. [23]

Clean vehicle and fuel technologies provide us with an affordable, available means of reducing transportation-related air pollution and climate change emissions. These include fuel-efficient vehicles that use less oil; cleaner fuels that produce fewer emissions; and electric cars and trucks that can entirely remove tailpipe emissions.

Strong federal and state policies also help. Vehicle emission standards have helped cut pollution from cars and trucks by about 90 percent since 1998, with further improvements coming from the Tier 3 standards. Future emissions reductions from trucks and other freight sources are essential for meeting air quality standards and protecting the health of those who live and work close to ports, rail yards, and freight corridors.

1.1.2 GREENHOUSE GASES.

Cars produce greenhouse gases that contribute to global warming and climate change. The main greenhouse gas is carbon dioxide. Others include nitrous oxide and methane. Greenhouse gases occur naturally in the atmosphere, trapping some of the heat radiated from the Earth's surface. Increases in the amount of these gases, mainly through the burning of carbon-based fuels such as coal and oil, are increasing the average temperature of the Earth, affecting local climates including temperature and rainfall.

Passenger vehicles contribute about 10% of total greenhouse gas emissions in Australia (Australian Climate Change Authority, 2014). Reducing fuel consumption will reduce these emissions.

For every liter of petrol used, 2.3 kg of carbon dioxide (the main greenhouse gas) is emitted into the atmosphere. The average passenger vehicle emits about four tons of carbon dioxide each year. Read our 10 tips for reducing fuel costs for tips on reducing your fuel consumption and greenhouse emissions.

- 1 liter petrol = 2.3 kilograms of carbon dioxide
- 1 liter LPG = 1.5 kilograms of carbon dioxide
- 1 liter diesel = 2.7 kilograms of carbon dioxide

Another way of helping to reduce the greenhouse impact of your driving is to offset your emissions. The Alternative Technology Association (ATA) also offers advice how to reduce your emissions as well as provide special offers to RACV members. The gases used in car air conditioning systems, although small in volume, make a comparatively large greenhouse impact. It is therefore important to avoid leaks of these gases. To reduce leakage of these gases, follow the manufacturer's instructions as to air conditioner use. Generally they suggest using your air conditioner for a short period on a regular basis to prevent the seals from developing leaks.

1.1.3 AIR QUALITY.

Even with increasing numbers of cars travelling longer distances, air pollution has been decreasing over time. This is due to a tightening of regulations affecting industry and vehicle emission standards. Emissions from motor vehicles are decreasing as newer cars with better emission controls replace older cars. Although a smoky exhaust indicates a polluting car, the reverse is not true. Many pollutants are not visible. Your car could be a big polluter and you would not see a thing. So it is important to keep your vehicle properly maintained. Air pollution has negative health effects, especially for vulnerable people, including those with allergic and respiratory conditions, such as asthma, hay fever and sinusitis, and respiratory and lung conditions commonly associated with the elderly. Research suggests that certain air pollutants (e.g. benzene) are carcinogenic. Air pollution is not uniform across a city, but varies with concentrations of industry, traffic conditions, land form and weather patterns. Emissions from vehicles include carbon monoxide, oxides of nitrogen, hydrocarbons, and particles. Passenger vehicles contribute 47% of carbon monoxide emissions, 40% of nitrogen oxides, 27% of hydrocarbons and 4% of particles (1998 inventory of Melbourne's air pollution by EPA Victoria). Evaporated fuel is also a pollutant. About a third of vehicle hydrocarbon emissions are from evaporation, which occurs when driving, during refueling, and even when stationary. Evaporation is increased by poorly sealed fuel tanks (including poorly fitting fuel caps or caps with worn seals), spillage, and overfilling of the fuel tank.

When a car’s engine is running, several different types of gasses and particles are emitted that can have detrimental effects on the environment. Of particular concern to the environment are carbon dioxide, a greenhouse gas; hydrocarbons -- any of more than a dozen volatile organic compounds, some of which are known carcinogens; nitrogen oxides; sulfur oxides; and particulate matter, tiny particles of solids, such as metal and soot. Other emissions that affect human health and create smog include ozone and carbon monoxide. The good news is that despite the increase of vehicles on the road, air quality today is actually better than it was in the 1970s, thanks to the 1970 Clean Air Act. In fact, lead emissions from cars have been almost completely eradicated because of the phasing out of leaded gasoline.

Vehicle emissions can affect the environment in several ways. Cars emit greenhouse gasses, such as carbon dioxide, which contribute to global warming. Some air pollutants and particulate matter from cars can be deposited on soil and surface waters where they enter the food chain; these substances can affect the reproductive, respiratory, immune and neurological systems of animals. Nitrogen oxides and sulfur oxides are major contributors to acid rain, which changes the pH of waterways and soils and can harm the organisms that rely on these resources.

The ozone layer helps to protect life on earth from the sun's ultraviolet rays, but human activities have contributed to the accelerated depletion of this protective shield. Substances that contribute to ozone depletion usually have high concentrations of chlorine or bromine atoms and include chlorofluorocarbons, or CFCs, halons, methyl bromide, carbon tetrachloride and methyl chloroform. Vehicle emissions contain few chlorine- or bromine-heavy substances, and therefore have little effect on ozone depletion. Even though they are not good for human health, hydrocarbons are recognized by the EPA as having no ozone depletion potential.

1.2 THESIS OBJECTIVES:

In this project we are designing an emission control device, in which we are using activated carbon which is normally used to reduce harmful gases. Our main target is to design in such a way that,

- It should be economically feasible.
- No back pressure on the engine because it reduces engine efficiency.
- It should reduce the concentration of harmful gases.
- To study the exhaust gas properties.
- To fabricate the Emission control device.
- To check the effectiveness of adapter capsule (Emission control device)

1.3 **Thesis Possible Outcomes:**

The replacement of carburetors with computer-controlled, port fuel injection and precise air/fuel ratio control based on exhaust oxygen sensing has allowed catalytic converters to operate with close to 100 percent efficiency and better longevity, often exceeding 100,000 miles. But catalytic converter is expensive and in this case, Smart exhaust Technology is helpful to overcome this problem. Possible outcomes of this Project are,

- How the gas mixture expelled from the engine, and the conversion performance of the Adapter Capsule, depend on the air/fuel (A/F) ratio.
- List the chemical reactions whereby the Adapter capsule removes carbon monoxide (CO), hydrocarbons and oxides of nitrogen (NOx) from petrol vehicle exhausts.
- Interpret the results of experimental studies (involving activity tests, kinetic measurements, adsorption studies and/or various surface science techniques) of the adapter capsule and appropriate model systems
- Discuss possible mechanisms for the catalytic reactions removing CO, hydrocarbons and NOx from vehicle exhausts
- Effectiveness of adapter capsule.

1.4 **SOURCES OF VEHICLE EMISSIONS:**

Following are the sources of vehicle emissions,

- Engine Crankcase Blow-by Fumes (20%) heating oil and burning of fuel that blows past piston rings and into the crankcase.
- Fuel Vapor (20%) chemicals that enter the air as fuel evaporate
- Engine Exhaust (60%) blown out the tailpipe.
- When engine burns a hydrocarbon based fuel.

Types of emissions:

Emissions of many air pollutants have been shown to have variety of negative effects on public health and the natural environment. Emissions that are principal pollutants of concern include:

- **Hydrocarbons:** A class of burned or partially burned fuel, hydrocarbons are toxins. Hydrocarbons are a major contributor to smog, which can be a major problem in urban areas. Prolonged exposure to hydrocarbons contributes to asthma, liver disease, lung disease, and cancer. Regulations governing hydrocarbons vary according to type of engine and jurisdiction; in some cases, "non-methane hydrocarbons" are regulated, while in other cases, "total hydrocarbons" are regulated. Technology for one application (to meet a non-methane hydrocarbon standard) may not be suitable for use in an application that has to meet a total hydrocarbon standard. Methane is not directly toxic, but is more difficult to break down in a catalytic converter, so in effect a "non-methane hydrocarbon" regulation can be considered easier to meet. Since methane is a greenhouse gas, interest is rising in how to eliminate emissions of it.

- **Carbon monoxide (CO):** A product of incomplete combustion, carbon monoxide reduces the blood's ability to carry oxygen; overexposure (carbon monoxide poisoning) may be fatal. Carbon Monoxide poisoning is a killer in high concentrations.

- **NOx:** Generated when nitrogen in the air reacts with oxygen at the high temperature and pressure inside the engine. NOx is a precursor to smog and acid rain. NOx is the sum of NO and NO2. NO2 is extremely reactive. NOx production is increased when an engine runs at its most efficient (i.e. hottest) part of the cycle.

- **Particulate matter:** Soot or smoke made up of particles in the micrometer size range: Particulate matter causes negative health effects, including but not limited to respiratory disease and cancer.

- **Sulfur oxide (SOx):** A general term for oxides of sulfur, which are emitted from motor vehicles burning fuel containing sulfur. Reducing the level of fuel sulfur reduces the level of Sulfur oxide emitted from the tailpipe.

- **Volatile organic compounds (VOCs):** Organic compounds which typically have a boiling point less than or equal to 250 °C; for example chlorofluorocarbons (CFCs) and formaldehyde. Volatile organic compounds are a subsection of Hydrocarbons that are mentioned separately because of their dangers to public health.

1.5 EMISSION CONTROL TECHNIQUES:

Engine efficiency has been steadily improved with improved engine design, more precise ignition timing and electronic ignition, more precise fuel metering, and computerized engine management.

Advances in engine and vehicle technology continually reduce the toxicity of exhaust leaving the engine, but these alone have generally been proved insufficient to meet emissions goals. Therefore, technologies to detoxify the exhaust are an essential part of emissions control.

1.5.1 Air injection:

One of the first-developed exhaust emission control systems is secondary air injection. Originally, this system was used to inject air into the engine's exhaust ports to provide oxygen so unburned and partially burned hydrocarbons in the exhaust would finish burning. Air injection is now used to support the catalytic converter's oxidation reaction, and to reduce emissions when an engine is started from cold. After a cold start, an engine needs an air-fuel mixture richer than what it needs at operating temperature, and the catalytic converter does not function efficiently until it has reached its own operating temperature. The air injected upstream of the converter supports combustion in the exhaust head pipe, which speeds catalyst warm-up and reduces the amount of unburned hydrocarbon emitted from the tailpipe. Vehicle emissions control is the study of reducing the motor vehicle emissions produced by motor vehicles, especially internal combustion engines.

1.5.2 EXHAUST EMISSIONS:

Exhaust Emissions are produced by cars, buses, and motorcycle

Four basic types of exhaust emission.

1. Hydrocarbons (HC)
2. Carbon monoxides (CO)
3. Oxides of nitrogen (NOx)
4. Particulates.

1.5.3 Engine Modification Related to Emission Control:

Lower Compression Ratios

- Use of unleaded gasoline that permits use of catalytic converters and burns Completely to lower HC emissions.
- Lower combustion temperature = Lower NOx emissions

Smaller Combustion Chamber Surface Volume.

- Reduce HC emissions.
- Lowers the amount of heat dissipation out of the fuel mixture.
- Reduce the chance of fuel condensation.

Reduce Quench Areas in the Combustion Chambers.

- Lower HC and CO emissions.
- Quench areas- movement of piston too close to the cylinder head.
- If too close, it tends to quench (put out) combustion and increase emissions, Due to unburned fuel.

1.5.4 Evaporative Emission Control Systems (EVAP)

Approximately 20% of all hydrocarbon (HC) emissions from the automobile originate from evaporative sources. The Evaporative Emission Control (EVAP) System is designed to store and dispose of fuel vapors normally created in the fuel system; thereby, preventing its escape to the atmosphere. The EVAP system delivers these vapors to the intake manifold to be burned with the normal air/fuel mixture. This fuel charge is added during periods of closed loop operation when the additional enrichment can be managed by the closed loop fuel control system. Improper operation of the EVAP system may cause rich drivability problems, as well as failure of the Two Speed Idle test or Enhanced I/M evaporative pressure or purge test.

The EVAP system is a fully closed system designed to maintain stable fuel tank pressures without allowing fuel vapors to escape to the atmosphere. Fuel vapor is normally created in the fuel tank as a result of evaporation. It is then transferred to the EVAP system charcoal canister when tank vapor pressures become excessive. When operating conditions can tolerate additional enrichment, these stored fuel vapors are purged into the intake manifold and added to the incoming air/fuel mixture.

The old EVAP control system is a system which utilizes the intake manifold vacuum to draw the evaporative emissions into the intake manifold and mix then in with the intake air. The ECM controls a duty–cycle type VSV (vacuum switching valve) to purge the evaporative emissions from the charcoal canister.

The ECM controls the opening and closing of the EVAP VSV (vacuum switching valve). When the EVAP VSV is opened, the engine speed and the air/fuel ratio should change. The ECM monitors both of the engine RPM and the air/fuel ratio for this EVAP system diagnostic test. If the ECM does not detect any change in the engine RPM or the air/fuel ratio when opening the EVAP VSV, the ECM will determine that there is a malfunction of the EVAP VSV and set a DTC.

The EVAP control system is a system which utilizes the intake manifold vacuum to draw the evaporative emissions into the intake manifold and mix them with intake air. The ECM controls a duty–cycle type VSV (vacuum switching valve) to purge evaporative emissions from the charcoal canister. The ECM uses the vapor pressure sensor to detect malfunctions in the evaporative emissions (EVAP) system. This diagnostic checks the function of the EVAP VSV and VSV for vapor pressure sensor, the integrity of these components and the fuel tank from the standpoint of fuel vapor emissions. When the VSV for vapor pressure sensor is closed, the ECM monitors the vapor pressure in the fuel tank. When it is open, the ECM monitors the vapor pressure in the charcoal canister. The ECM senses pressure in the fuel tank using the vapor pressure sensor. The ECM supplies the sensor with a regulated 5 V reference–voltage and the sensor returns a signal voltage between 0.5 V and 4.5 V according to the pressure level in the fuel tank. When the pressure in the fuel tank is low, the output voltage of the vapor pressure sensor is low. When it is high, the output voltage is high.

1.5.5 Exhaust Gas Recirculation (EGR):

Exhaust gas recirculation (EGR) is an effective strategy to control NOx emissions from diesel engines. The EGR reduces NOx through lowering the oxygen concentration in the combustion chamber, as well as through heat absorption. Several configurations have been proposed, including high- and low-pressure loop EGR, as well as hybrid systems. EGR is also used in gasoline engines, primarily in order to reduce pumping work and increase engine efficiency. The introduction of EGR technology to diesel passenger cars in the 1990s went almost unnoticed and was not considered a major breakthrough for several reasons. Because the required NOx reduction was quite modest, the system allowed little EGR back into the cylinder and there was no need for EGR cooling. Typical passenger car engines operate mostly at part load conditions where temperatures are relatively low. It was only the Euro 3/4 legislation that created higher demands on EGR systems and triggered the introduction of increasingly more sophisticated, electronically controlled cooled EGR systems on light-duty engines. [24]

A widely adopted route to reduce NOx emissions is Exhaust Gas Recirculation (EGR). This involves recirculating a controllable proportion of the engine's exhaust back into the intake air. A valve is usually used to control the flow of gas, and the valve may be closed completely if required.

The substitution of burnt gas (which takes no further part in combustion) for oxygen rich air reduces the proportion of the cylinder contents available for combustion. This causes a correspondingly lower heat release and peak cylinder temperature, and reduces the formation of NOx. The presence of an inert gas in the cylinder further limits the peak temperature (more than throttling alone in a spark ignition engine).

The gas to be recirculated may also be passed through an EGR cooler, which is usually of the air/water type. This reduces the temperature of the gas, which reduces the cylinder charge temperature when EGR is employed. This has two benefits- the reduction of charge temperature results in lower peak temperature, and the greater density of cooled EGR gas allows a higher proportion of EGR to be used. On a diesel engine the recirculated fraction may be as high as 50% under some operating conditions.

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CHAPTER 02

LITERATURE REVIEW

2.1 CATALYTIC CONVERTER:

There are millions of cars on the road in the United States, and each one is a source of air pollution. Especially in large cities, the amount of pollution that all the cars produce together can create big problems. To solve those problems, cities, states and the federal government create clean-air laws that restrict the amount of pollution that cars can produce. Over the years, automakers have made many refinements to car engines and fuel systems to keep up with these laws. One of these changes came about in 1975 with an interesting device called a catalytic converter. The job of the catalytic converter is to convert harmful pollutants into less harmful emissions before they ever leave the car's- exhaust system. Catalytic converters are amazingly simple devices, so it is incredible to see how big an impact they have, which pollutants are produced by an engine and how a catalytic converter deals with each of these pollutants to help reduce vehicle emissions. In order to reduce emissions, modern car engines carefully control the amount of fuel they burn. They try to keep the air-to-fuel ratio very close to the stoichiometric point, which is the ideal ratio of air to fuel. Theoretically, at this ratio, all of the fuel will be burned using all of the oxygen in the air. For gasoline, the stoichiometric ratio is about 14.7:1, meaning that for each pound of gasoline, 14.7 pounds of air will be burned. The fuel mixture actually varies from the ideal ratio quite a bit during driving. Sometimes the mixture can be lean (an air-to-fuel ratio higher than 14.7), and other times the mixture can be rich (an air-to-fuel ratio lower than 14.7).

The main emissions of a car engine are:

Nitrogen gas (N_2) - Air is 78-percent nitrogen gas, and most of this passes right through the car engine.

Carbon dioxide (CO_2) - This is one product of combustion. The carbon in the fuel bonds with the oxygen in the air.

Water vapor (H_2O) - This is another product of combustion. The hydrogen in the fuel bonds with the oxygen in the air.

These emissions are mostly benign, although carbon dioxide emissions are believed to contribute to global warming. Because the combustion process is never perfect, some smaller amounts of more harmful emissions are also produced in car engines. Catalytic converters are designed to reduce all three:

Carbon monoxide (CO) is a poisonous gas that is colorless and odorless.

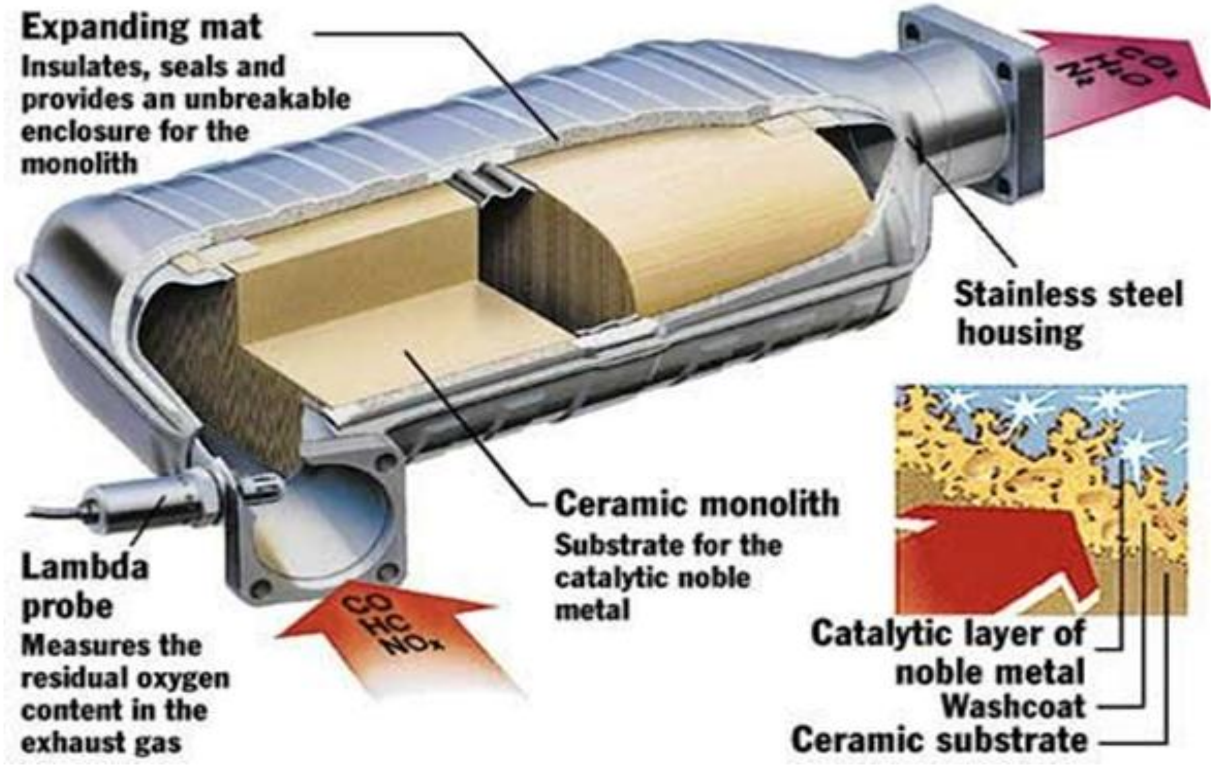
Hydrocarbons or volatile organic compounds (VOCs) are a major component of smog produced mostly from evaporated, unburned .fuel.

Nitrogen oxides (NO and NO_2, together called NOx) are a contributor to smog and acid rain, which also causes irritation to human mucus membranes.

In the catalytic converter, there are two different types of catalyst at work, a reduction catalyst and an oxidation catalyst. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and/or palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream, while also minimizing the amount of catalyst required, as the materials are extremely expensive. Some of the newest converters have even started to use gold mixed with the more traditional catalysts. Gold is cheaper than the other materials and could increase oxidation-, the chemical reaction that reduces pollutants, by up to 40%.

Some early converter designs greatly restricted the flow of exhaust, which negatively affected vehicle performance, drivability, and fuel economy. Because they were used with carburetors incapable of precise fuel-air mixture control, they could overheat and set fire to flammable materials under the car.

- Although catalytic converters are effective at removing hydrocarbons and other harmful emissions, they do not reduce the emission of carbon dioxide (CO2) produced when fossil fuels are burnt.
- Carbon dioxide produced from fossil fuels is one of the greenhouse gases indicated by the Intergovernmental Panel on Climate Change (IPCC) to be a “most likely” cause of global warming.



2.2 SMART EXHAUST TECHNOLOGY:

Development of internal combustion engine control system is currently oriented on exhaust emissions, performance and fuel efficiency. This is caused by fuel prices rising which led to a crisis on the transport sector; therefore it is crucial to develop a fuel-efficient vehicles technology. Gasoline engine fuel efficiency can be improved by several methods such as by controlling the air-to-fuel ratio (AFR). AFR technology currently still has many problems due to its difficulty setting characteristic since AFR control is usually as internally engine control. Fuel efficiency can be improved by influence of external engine system. Brake control system is an external engine system that used in this research. The purpose of this research is to design and implement the AFR and brake control system in a vehicle to improve fuel efficiency of gasoline engines along braking period. The basic idea is the controller has to reduce the consumption of fuel injection along braking period. The applied control system on vehicle works using smart controller, such as Fuzzy Logic Controller (FLC). When the vehicle brakes, fuel injection is controlled by the ECU brake control system. This control system works in parallel with the vehicle control system default. The results show, when the engine speed exceeds 2500 rpm, AFR value increased infinitely, so that maximum efficiency is achieved. At engine speed less than 2500 rpm, AFR value reaches a value of 22. The fuel measurement has been able to show a decrease in fuel consumption of 6 liters to 4 liters within the distance of 50.7 km. Improvement of fuel efficiency can be achieved by approximately of 33.3%.

Automotive industry is currently experiencing rapid growth. This positive impact is also negative. Negative impact is because the high levels of pollutants from vehicle emissions, especially in urban areas. The transportation sector is the largest contribution in air pollution. This is because increase number of vehicles per year which is comparable with the increase in motor vehicle exhaust emissions. Departing from the above problems, we offer the appropriate technology solutions in the form of SMART exhaust. It is expected to reduce levels of gaseous pollutants of motor vehicles and give the solution for environmental problems. SMART Exhaust is a technology package in the form of a tube in which there are activated carbon and catalyst. Activated carbon is used as a media adsorb because it is detoxification capability, readily available, economical, and effective. As for the TiO2 catalyst used. The working principle of this tool is the use of properties of activated carbon that can be Cox and Nox adsorption media, so that motor vehicle emissions of gases trapped in the tube, so Cox and Nox concentrations generated would be reduced.

In this process exhaust gas is allowed to pass through solid adsorbents where the gas molecules in the exhaust are captured by pores present in the adsorbents. The mechanism involved in this process is known as Adsorption. Post-combustion-capture methods have an advantage that they may be more easily retrofitted to existing combustion systems. If a carbon-capture process is implemented in automobiles, it would be the first employ post-combustion capture, since this could be appended to the downstream management of exhaust gases without directly affecting the inputs to the internal combustion engine. In smart technology various adsorbents such as activated carbons are used to control the CO2 emission. Activated carbon are the most effective and recent technology used to control CO2, carbon particle is the world's only mineral with a naturally -occurring negative charge. it simply lock and hold many positive ions, absorbing a multitude of environmental contaminants such as sodium, potassium; barium and calcium, and positively charged groups such as water and ammonia. Nearly every application of carbon particle has been driven by environmental concerns, or plays a significant role in reducing toxic waste and energy consumption. It is the highly porous and consistent matrix of zeolite that provides the adsorption qualities.

The high thermal and chemical stability of these inorganic crystals make them ideal materials for use in high temperature applications such as catalytic membrane reactors. Carbon particle also have the potential to achieve precise and specific separation of gases including the removal of H2O, CO2and SO2 from low-grade natural gas streams, as separation experiments through zeolite-containing membranes indicate that competitive adsorption can selectively separate light gas mixtures. In addition to the benefits function as targeting young people as our target market, Smart Exhaust product also has an attractive design and easy installation. In Exhaust Smart Packaging Every buyer will be given a paper user manual so no need to shop for installation. The design and colors we have made as attractive as possible so that young people are interested in using it. With the easy installation, eye-catching packaging, and attractive design, we hope this product can be a Smart Exhaust Green Technology Accessory trendsetter in Indonesia.

SMART EXHAUST SYSTEM.

2.3 Substrate and Coating Technologies:

The technology of the substrates, on which the active catalyst is supported, has seen great progress. In 1974, ceramic substrates had a cell density of 200 cells per square inch (cpsi) of cross section (31 cells/cm²) and a wall thickness of 0.012 inch or 12 mil (0.305 mm). By the end of the 70's the cell density had increased through 300 to 400 cpsi and wall thickness had been reduced by 50% to 6 mil. Now 400, 600 and 900 and even 1200 cpsi substrates are available and wall thickness can be reduced to 2 mil - almost 0.05 mm.

In parallel, in the late 1970's, substrates derived from ultra-thin foils of corrosion-resistant steels came on to the market. From the beginning, the foils could be made from material only 0.05 mm thick allowing high cell densities to be achieved. Complex internal structures can now be developed; 800 and 1000 cpsi metallic substrates are available and their wall thickness is down to

0.025 mm. This progress in ceramic and metal substrate technology has major benefits. A larger catalyst surface area can be incorporated into a given converter volume and this allows better conversion efficiency and durability. The thin walls reduce thermal capacity and limit pressure losses. Alternatively, the same performance can be incorporated into a smaller converter volume, making the catalyst easier to fit close to the engine as cars are made more compact. Optimized systems incorporating these new technologies are in production. The use of additional catalytic converters close to the exhaust manifold reduces the time to light-off in the cold start and, therefore, the total emissions. Light-off times have been reduced from as long as one to two minutes to a few seconds. Improved substrate technology, combined with highly thermally stable catalysts and oxygen storage components, allows the close-coupled catalyst approach to meet the Euro 4, 5 and 6 standards. A further option that can be used for some types of catalyst is to incorporate the active materials directly into the ceramic substrate, so that the extruded ceramic matrix provides catalytic activity without further coating. Such ‘homogeneous’ catalysts are primarily used in the Selective Catalytic Reduction of NOx emissions.

2.4 Diesel Particulate Filter (DPF):

Diesel Particulate Filters (DPFs) have been applied to production vehicles since 2000 and have become standard equipment on all new diesel cars in Europe since the introduction of the Euro 5 norm. Some buses and trucks meeting the Euro IV, V and EEV (Enhanced Environmentally-friendly Vehicle) emissions standards were equipped with DPFs and now all Euro VI heavy-duty vehicles are equipped with them so as to meet the PM mass and particle number emissions requirements.

There is, as a result, quite an active field of development in regeneration optimization, substrates materials and catalyst improvements plus developments in related On-Board Diagnostics. In wall-flow filters, particulate matter is removed from the exhaust by physical filtration using a honeycomb structure similar to a catalyst substrate but with the channels blocked at alternate ends. The exhaust gas is thus forced to flow through the walls between the channels and the particulate matter is deposited as a soot cake on the walls. Such filters are made of ceramic silicon carbide honeycomb materials.

Ceramic wall-flow filters remove almost completely the carbonaceous and metallic particulates, including fine particulates of less than 100 nanometers (nm) diameter with an efficiency of >95% in mass and >99% in number of particles over a wide range of engine operating conditions. The latest European emissions limit values (i.e. Euro 5, 6, VI and Stage V) are set on the basis of both mass and number counts to ensure control of the ultrafine particles, which are thought to be more critical indicators of health impact. Since the continuous flow of soot into the filter would eventually block it, it is necessary to 'regenerate' the filtration properties of the filter by burning-off the collected particulate on a regular basis.

2.5 Gasoline Particulate Filter (GPF):

The European CO2 legislation promotes the uptake of fuel-efficient Gasoline Direct Injection (GDI) cars in the EU. However for these GDI vehicles particle number emissions can be substantially higher on the road than on the regulatory test cycle. Stemming from the success of the DPF for diesel vehicles, a new technology the Gasoline Particulate Filter (GPF) offers a durable solution to control ultrafine particles emissions from GDI cars in all driving conditions, even in highly dynamic driving.

As stated by the Joint Research Centre (JRC) of the European Commission, the preferred solution is relatively small GPF close-coupled to the engine. This configuration will enable passive regeneration under most operating conditions due to the relatively high exhaust temperatures of GDI engines. The main challenge in this case is to minimize any delay in the catalyst light-off imposed by the thermal mass of the GPF. Alternatively, the GPF can also be installed in an underfloor position in which case there might be some need for active regeneration under urban and repeated start-stop operating conditions. In both cases, active regeneration will most probably be achieved through retarded spark timing and split fuel injection for engines running stoichiometric and by post fuel injection for engines running lean, approaches already employed to heat up the catalyst under cold start. The ultimate target is to replace conventional Three Way Catalysts (TWC) with coated GPF systems, using the same precious metal content.

2.6 Selective Catalytic Reduction (SCR):

SCR was originally developed and used to reduce Ox emissions from coal, oil and gas fired power stations, marine vessels and stationary diesel engines. SCR technology permits the NOx reduction reaction to take place in an oxidizing atmosphere. It is called “selective” because the catalytic reduction of NOx with ammonia (NH3) as a reluctant occurs preferentially to the oxidation of NH3 with oxygen. In Europe SCR technology is now fitted to most new heavy-duty diesel vehicles (i.e. truck and bus) and non-road mobile machinery such as construction equipment. A growing number of diesel light-duty vehicles and passenger cars are also equipped with SCR systems. The efficiency of SCR for NOx reduction also offers a benefit for fuel consumption. It allows diesel engine developers to take advantage of the trade-off between NOx, PM and fuel consumption and calibrate the engine in a lower area of fuel consumption than if they had to reduce NOx by engine measures alone. Particulate emissions are also lowered and SCR catalytic converters can be used alone or in combination with a particulate filter. Once the exhaust system is warm enough, SCR provides high levels of NOx reduction, when appropriate amounts of ammonia reluctant are injected into the exhaust stream. For mobile source applications ammonia is used as a selective reluctant, in the presence of excess oxygen, to convert over 70% (up to 95%) of NO and NO2 to nitrogen over a special catalyst system. Different precursors of ammonia can be used; but for vehicles the most common option is a solution of urea in water carefully metered from a separate tank and sprayed into the exhaust system where it hydrolyses into ammonia ahead of the SCR catalyst is a stable, nonflammable, colorless, and odorless solution containing 32.5% urea which is not classified as hazardous to health and does not require any special handling precautions. It is made to internationally-recognized standards.

Urea is used as an artificial fertilizer and is found in products such as cosmetics. The consumption for a Euro 6b vehicle strongly depends on the car manufacturer product strategy, Vehicle application, driving style, load, and road conditions and the urea tank needs to be topped up periodically.

For heavy-duty vehicles, the consumption is typically 5-7% of fuel consumption for a Euro V engine, and 2.5-6% for a Euro VI engine, depending on driving, load and road conditions. A truck can have a tank which will hold enough urea solution to last for up to 10 000 km. On-board systems alert the driver when it isNH_3 NOx

$4 NO + 4 NH_3 + O_2 4 N_2 + 6 H_2O$
$6 NO_2 + 8 NH_3 7 N_2 + 12 H_2O$ NH_3
$4 NO + 4 NH_3 + O_2 4 N_2 + 6 H_2O$
$6 NO_2 + 8 NH_3 7 N_2 + 12 H_2O$

Development of SCR technology is very dynamic and improvements are being made in low temperature performance, urea delivery systems, system design, and exhaust flow mixing devices, urea dosing strategy, and providing alternatives to liquid urea. Indeed, SCR has been introduced in the light-duty and passenger car sector with the Euro 6 standard and Real-Driving Emissions (RDE) requirements and further NOx reductions are also desired in the heavy-duty sector in urban driving or other low load conditions. Urea injection quality and mixing are complex and critically important. A study shows that the urea droplet quality from various nozzle designs can impact the deNOx system efficiency by up to 10% while the urea distribution across the catalyst can result in efficiency variations from 60 to 95%.Modelling studies to improve urea injection and mixing using a variety of devices are numerous, and about 10-20% de NOx efficiency improvements can come from good injection practice with nominally 5-10% coming from using a variety of mixers. Ammonia storage models also help with cold start deNOx.

2.7 Lean deNOx Catalysts:

Lean De-NOx catalysts, also known as hydrocarbon SCR systems use advanced structural properties in the catalytic coating to create a rich 'microclimate' where hydrocarbons from the exhaust can reduce the nitrogen oxides to nitrogen, while the overall exhaust remains lean. The hydrocarbon may be that occurring in the exhaust gas (‘native’) or may be added to the exhaust gas through injection of a small amount of additional fuel. This has the advantage that no additional reductant source (i.e. urea) needs to be carried but these systems do not, at present, offer the same performance as ammonia-SCR systems and are therefore not considered as mainstream deNOx technology.

A study evaluated the influence of diesel fuel sulfur content on the performance of a passive deNOx catalyst. The program used two specially prepared fuels with different sulfur contents, but with other fuel parameters unchanged. The NOx conversion efficiency of the deNOx catalyst increased from 14 to 26% over the European test cycle when the sulfur content was reduced from 49 to 6 ppm. Developments on HC-SCR using hydrocarbons from the fuel are reported in the literature and a patent specifies very low precious metal loadings (0.7 g/l) but the system needs temperature greater than 300°C to perform well.

A concept is reported to combine an HC-trap and LNT, wherein the zeolite HC-adsorber is applied first on to the honeycomb substrate and the LNT material is placed on top. The HC-adsorber helps reducing cold start HC emissions and adsorbs HC during the lean periods. Upon release during the hotter rich periods, hydrogen and
CO are formed to help LNT regeneration.

2.8 ACTIVATED CARBON:

Activated carbon, also called activated charcoal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions. Activated is sometimes substituted with active. Due to its high degree of micro porosity, just one gram of activated carbon has a surface area in excess of 3,000 m2 (32,000 sq ft), as determined by gas adsorption. An activation level sufficient for useful application may be attained solely from high surface area; however, further chemical treatment often enhances adsorption properties.

Activated carbon is usually derived from charcoal and is sometimes utilized as bio char. Those derived from coal and coke are referred as activated coal and activated coke respectively. [9]

Activated carbon has an incredibly large surface area per unit volume, and a network of submicroscopic pores where adsorption takes place. Activated carbon is a material that is produced from carbonaceous source materials, such as coal, coconuts, nutshells, peat, wood, and lignite. The primary raw material used for activated carbon is any organic material with a high carbon content. The carbon-based material is converted to activated carbon through physical modification and thermal decomposition in a furnace, under a controlled atmosphere and temperature. The finished product has a large surface area per unit volume and a network of submicroscopic pores where adsorption takes place. [10]

An activated carbon product can be characterized by its activity and physical properties. Activity properties include pore size distribution that defines the available pore volume of a carbon over three pore size regions: the micropore, mesopore, and macropore regions:

Micropore region - less than 100 Angstroms
Mesopore region - between 100 and 1,000 Angstroms
Macropore region - greater than 1,000 Angstroms

Pore size distribution properties are key indicators of a carbon's potential performance for removing contaminants (adsorbates) from water. The molecules encountered in the gas phase are generally smaller than those in the liquid phase applications; therefore, a gas phase carbon has the majority of its pores concentrated in the micropore region.

A broad range of pore sizes must be available, both for ease of movement of adsorbates through the carbon pores and for the adsorption of particular molecular sizes. Liquid phase carbons often contain a broader pore size distribution to remove color bodies and larger organic materials, while maintaining some micro porosity for the removal of taste and odor compounds. [11]

2.8.1 Classification of Activated carbon.

Activated carbons are complex products which are difficult to classify on the basis of their behavior, surface characteristics and other fundamental criteria. However, some broad classification is made for general purpose based on their size, preparation methods, and industrial applications.

- **Powdered activated carbon (R 1, PAC).**
  A micrograph of activated charcoal (R 1) under bright field illumination on a light microscope. Notice the fractal-like shape of the particles hinting at their enormous

surface area. Each particle in this image, despite being only around 0.1 mm across, has a surface area of several square meters. [15] The entire image covers a region of approximately 1.1 by 0.7 mm, and the full resolution version is at a scale of 6.236 pixels/μm.

Normally, activated carbons (R 1) are made in particulate form as powders or fine granules less than 1.0 mm in size with an average diameter between 0.15 and 0.25 mm. Thus they present a large surface to volume ratio with a small diffusion distance. Activated carbon (R 1) is defined as the activated carbon particles retained on a 50-mesh sieve (0.297 mm).

PAC material is finer material. PAC is made up of crushed or ground carbon particles, 95–100% of which will pass through a designated mesh sieve. The ASTM classifies particles passing through an 80-mesh sieve (0.177 mm) and smaller as PAC. It is not common to use PAC in a dedicated vessel, due to the high head loss that would occur. Instead, PAC is generally added directly to other process units, such as raw water intakes, rapid mix basins, clarifiers, and gravity filters.

- **Granular activated carbon (GAC).**
  A micrograph of activated charcoal (GAC) under scanning electron microscope Granular activated carbon has a relatively larger particle size compared to powdered activated carbon and consequently, presents a smaller external surface. Diffusion of the adsorbate is thus an important factor. These carbons are suitable for adsorption of gases and vapors, because they diffuse rapidly. Granulated carbons are used for water treatment, deodorization and separation of components of flow system and is also used in rapid mix basins. GAC can be either in granular or extruded form. GAC is designated by sizes such as 8×20, 20×40, or 8×30 for liquid phase applications and 4×6, 4×8 or 4×10 for vapor phase applications. A 20×40 carbon is made of particles that will pass through a U.S. Standard Mesh Size No. 20 sieve (0.84 mm) (generally specified as 85% passing) but be retained on a U.S. Standard Mesh Size No. 40 sieve (0.42 mm) (generally specified as 95% retained). AWWA (1992) B604 uses the 50-mesh sieve (0.297 mm) as the minimum GAC size. The most popular aqueous phase carbons are the 12×40 and 8×30 sizes because they have a good balance of size, surface area, and head loss characteristics.
- **Extruded activated carbon (EAC):**
  Extruded activated carbon combines powdered activated carbon with a binder, which are fused together and extruded into a cylindrical shaped activated carbon block with diameters from 0.8 to 130 mm. These are mainly used for gas phase applications because of their low pressure drop, high mechanical strength and low dust content. Also sold as CTO filter (Chlorine, Taste and Odor).
- **Bead activated carbon (BAC)**
  Bead activated carbon is made from petroleum pitch and supplied in diameters from approximately 0.35 to 0.80 mm. Similar to EAC, it is also noted for its low pressure drop, high mechanical strength and low dust content, but with a smaller grain size. Its spherical shape makes it preferred for fluidized bed applications such as water filtration.

- **Impregnated carbon.**
  Porous carbons containing several types of inorganic impregnate such as iodine, silver, cations such as Al, Mn, Zn, Fe, Li, Ca have also been prepared for specific application in air pollution control especially in museums and galleries. Due to its antimicrobial and antiseptic properties, silver loaded activated carbon is used as an adsorbent for purification of domestic water. Drinking water can be obtained from natural water by treating the natural water with a mixture of activated carbon and Al $(OH)_3$, a flocculating agent. Impregnated carbons are also used for the adsorption of Hydrogen Sulfide(H_2S) and thiols. Absorption rates for H_2S as high as 50% by weight have been reported.
- **Polymer coated carbon.**
  This is a process by which a porous carbon can be coated with a biocompatible polymer to give a smooth and permeable coat without blocking the pores. The resulting carbon is useful for hemoperfusion. Hemoperfusion is a treatment technique in which large volumes of the patient's blood are passed over an adsorbent substance in order to remove toxic substances from the blood.

2.8.2 Properties of activated carbon:

A gram of activated carbon can have a surface area in excess of 500 m^2, with 1500 m^2 being readily achievable. Carbon aerogels, while more expensive, have even higher surface areas, and are used in special applications.

Under an electron microscope, the high surface-area structures of activated carbon are revealed. Individual particles are intensely convoluted and display various kinds of porosity; there may be many areas where flat surfaces of graphite-like material run parallel to each other, separated by only a few nanometers or so. These micropores provide superb conditions for adsorption to occur, since adsorbing material can interact with many surfaces simultaneously. Tests of adsorption behavior are usually done with nitrogen gas at 77 K under high vacuum, but in everyday terms activated carbon is perfectly capable of producing the equivalent, by adsorption from its environment, liquid water from steam at 100 °C (212 °F) and a pressure of 1/10,000 of an atmosphere.

James Dewar, the scientist after whom the Dewar (vacuum flask) is named, spent much time studying activated carbon and published a paper regarding its adsorption capacity with regard to gases. In this paper, he discovered that cooling the carbon to liquid nitrogen temperatures allowed it to adsorb significant quantities of numerous air gases, among others, that could then be recollected by simply allowing the carbon to warm again and that coconut based carbon was superior for the effect. He uses oxygen as an example, wherein the activated carbon would typically adsorb the atmospheric concentration (21%) under standard conditions, but release over 80% oxygen if the carbon was first cooled to low temperatures. Physically, activated carbon binds materials by van der Waals force or London dispersion force. Activated carbon does not bind well to certain chemicals, including alcohols, diols, strong acids and bases, metals and most inorganics, such as lithium, sodium, iron, lead, arsenic, fluorine, and boric acid.

Activated carbon adsorbs iodine very well. The iodine capacity, mg/g, (ASTM D28 Standard Method test) may be used as an indication of total surface area. Carbon monoxide is not well adsorbed by activated carbon. This should be of particular concern to those using the material in filters for respirators, fume hoods or other gas control systems as the gas is undetectable to the human senses, toxic to metabolism and neurotoxic. Substantial lists of the common industrial and agricultural gases adsorbed by activated carbon can be found online.

Activated carbon can be used as a substrate for the application of various chemicals to improve the adsorptive capacity for some inorganic (and problematic organic) compounds such as hydrogen sulfide (H2S), ammonia (NH3), formaldehyde (HCOH), mercury (Hg) and radioactive iodine-131(131I).

2.8.3 How Does Activated Carbon Work?

Physical adsorption is the primary means by which activated carbon works to remove contaminants from liquid or vapor streams. Carbon's large surface area per unit weight allows for contaminants to adhere to the activated carbon media.

The large internal surface area of carbon has several attractive forces that work to attract other molecules. These forces manifest in a similar manner as gravitational force; therefore, contaminants in water are adsorbed (or adhered) to the surface of carbon from a solution as a result of differences in adsorbate concentration in the solution and in the carbon pores.

Physical adsorption occurs because all molecules exert attractive forces, especially molecules at the surface of a solid (pore walls of carbon), and these surface molecules seek to adhere to other molecules.

The dissolved adsorbate migrates from the solution through the pore channels to reach the area where the strongest attractive forces are located. Contaminants adsorb because the attraction of the carbon surface for them is stronger than the attractive forces that keep them dissolved in solution. Those compounds that exhibit this preference to adsorb are able to do so when there is enough energy on the surface of the carbon to overcome the energy needed to adsorb the contaminant.

Contaminants that are organic, have high molecular weights, and are neutral, or non-polar, in their chemical nature are readily adsorbed on activated carbon. For water adsorbates to become physically adsorbed onto activated carbon, they must both be dissolved in water so that they are smaller than the size of the carbon pore openings and can pass through the carbon pores and accumulate.

Besides physical adsorption, chemical reactions can occur on a carbon surface. One such reaction is chlorine removal from water involving the chemical reaction of chlorine with carbon to form chloride ions.

2.8.4 Why are Activated Carbons Different?

Activated carbons are different because of the starting material and manufacturing methods. These raw materials establish the general characterizes, and differences will exist in the finished product.

Domestically, most carbons are manufactured from coals. The base raw material and pretreatment steps prior to activation can affect many of the physical and activity characteristics of activated carbon. These different properties make some carbons more suited than others for specific applications.

Bituminous coal activated carbons have a broad range of pore diameters. Since these carbons have both a fine and wide pore diameter, they are well-suited for general dechlorination and the removal of a wider variety of organic chemical contaminants from water, including the larger color bodies. Coconut-based carbon tends to exhibit greater microporosity, which is more suited for removal of low concentrations of organics such as in drinking water applications. This property can be deduced when comparing iodine numbers on the activated carbons. Carbons with higher iodine numbers will tend to have larger surface area; therefore, they will have higher capacity for comparatively weakly adsorbed organics. On the other hand, carbons with lower iodine numbers may still have wider pores, which could be favored for removal of large organic molecules. There are some applications where color removal will be better facilitated by a reactivated carbon as opposed to a high iodine carbon.

Another comparative factor is the hardness of the carbon. For instance, the abrasion resistance of activated carbons can be important if the carbon is to be used in an application where frequent back-washing will be required. As mentioned above, coconut carbons have a higher abrasion number than bituminous coal-based carbons and would be expected to experience less attrition over time in this type of an application.

Density can also be a major consideration for specific applications. As the table below shows, the densities of activated carbons vary with the raw material. Fewer pounds of carbon with a low density will fit into a given container as compared to a carbon with a high density. This is significant because, while a container may require less carbon weight of a low-density carbon to make a volume fill, its contaminant removal performance may be severely reduced as compared to a higher density carbon. [11]

2.8.5 Applications of Activated Carbon.

Ash content can play an important role in applications for water treatment. The water soluble ash fraction may be liberated on contact with the activated carbon; this may lead to undesirable effects, such as imparting cloudiness to the water. Some applications with water having low pH can also liberate acid soluble ash and can actually impart color, such as when coal-based carbons are exposed to low pH water and iron is eluted from the carbon, imparting a yellowish-orange color to the effluent water. The table above summarizes these comparative properties.

While activated carbon is very useful for applications such as municipal water treatment, it is important for the user to solicit the product information and pricing from the activated carbon provider, ensuring that the best possible choice is made for the application. In this way, although a number of carbons may be good candidates for the application, the one that may offer the best cost-effective solution is the one that is used.

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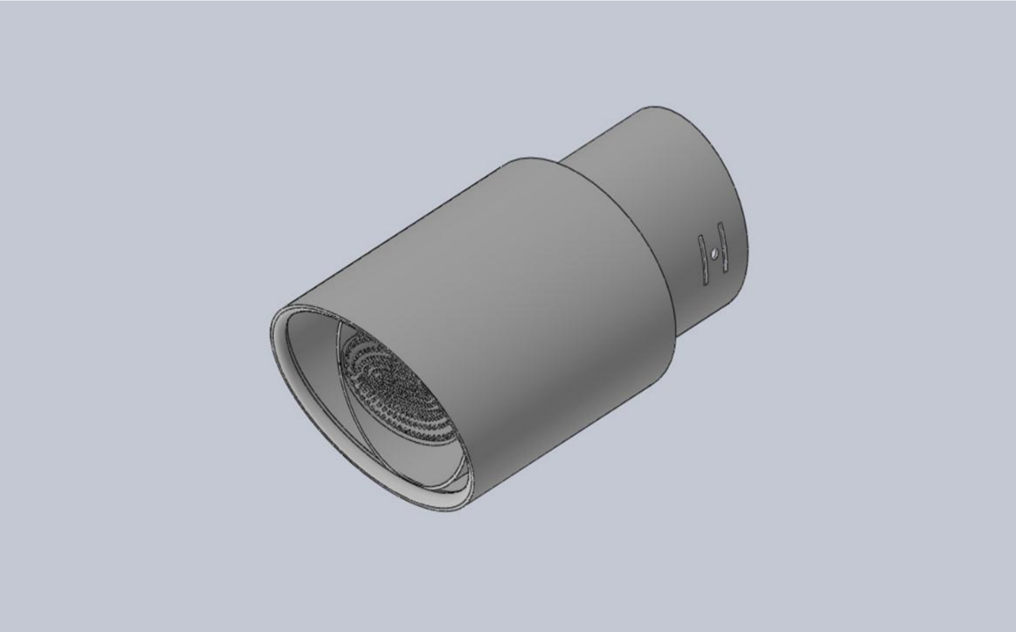
CHAPTER 03

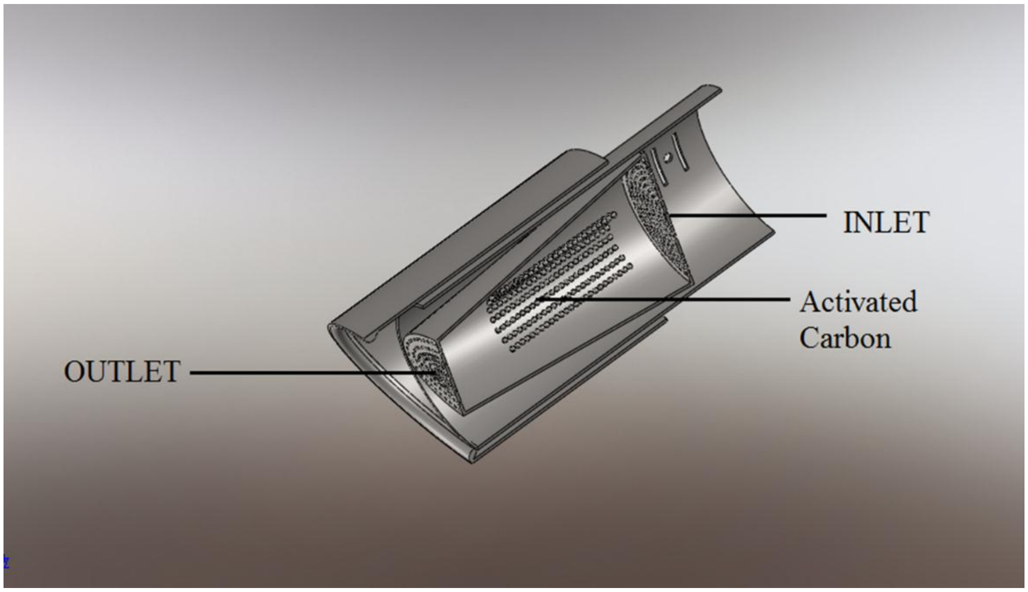
METHODOLOGY

3.1 DESIGN CONSIDERATIONS.

We designed an emission control device using Solid works and we used Ansys software for analysis. Our main target is to design in such a way that pressure drop in the device should be minimum otherwise it will create back pressure on the engine. We have done the analysis at first by changing the no. of holes in the exhaust plates and also by increasing or decreasing the distance between the exhaust plates which we will show in the following slides.



Solid works Design.



Cut View

Installation of Smart Exhaust Capsule.

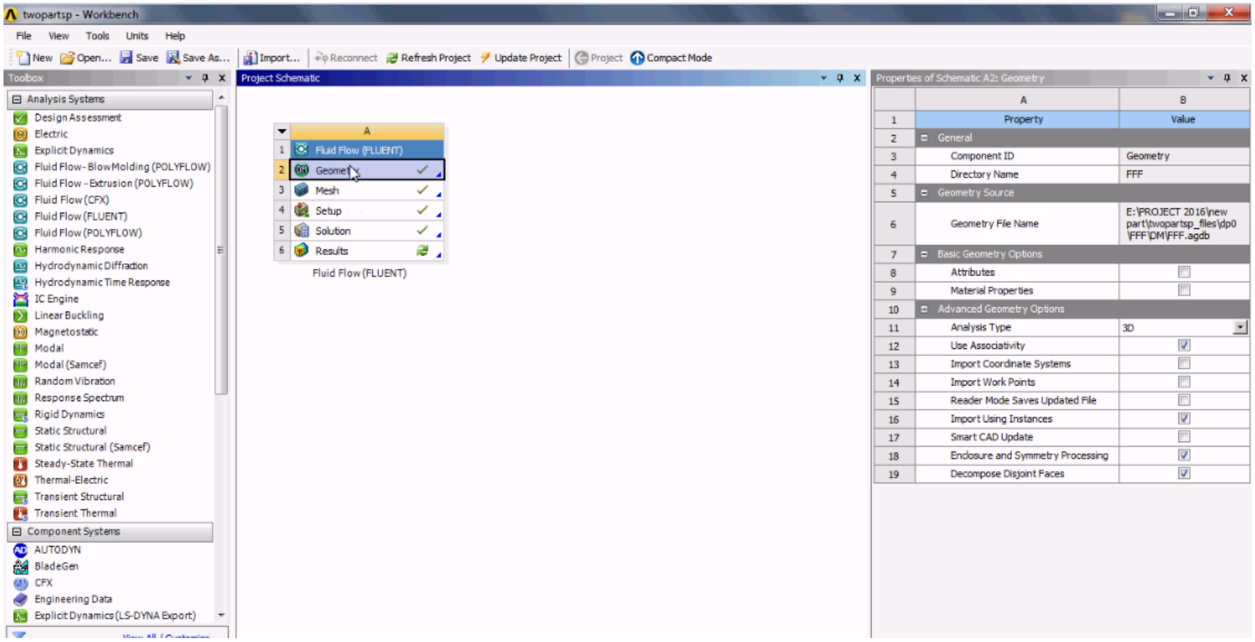
DESIGN PARAMETERS:

Serial no.	**Parameter**	**Unit (mm)**
1)	LENGTH	140
2)	DIAMETER	52
3)	PARTICLE DIAMETER	1.5
4)	DIAMETER OF HOLES	1.1

3.2 ANSYS SIMULATIONS:

We used the ANSYS Fluent software for Simulations. Various steps are involved in this process which are discussed below.

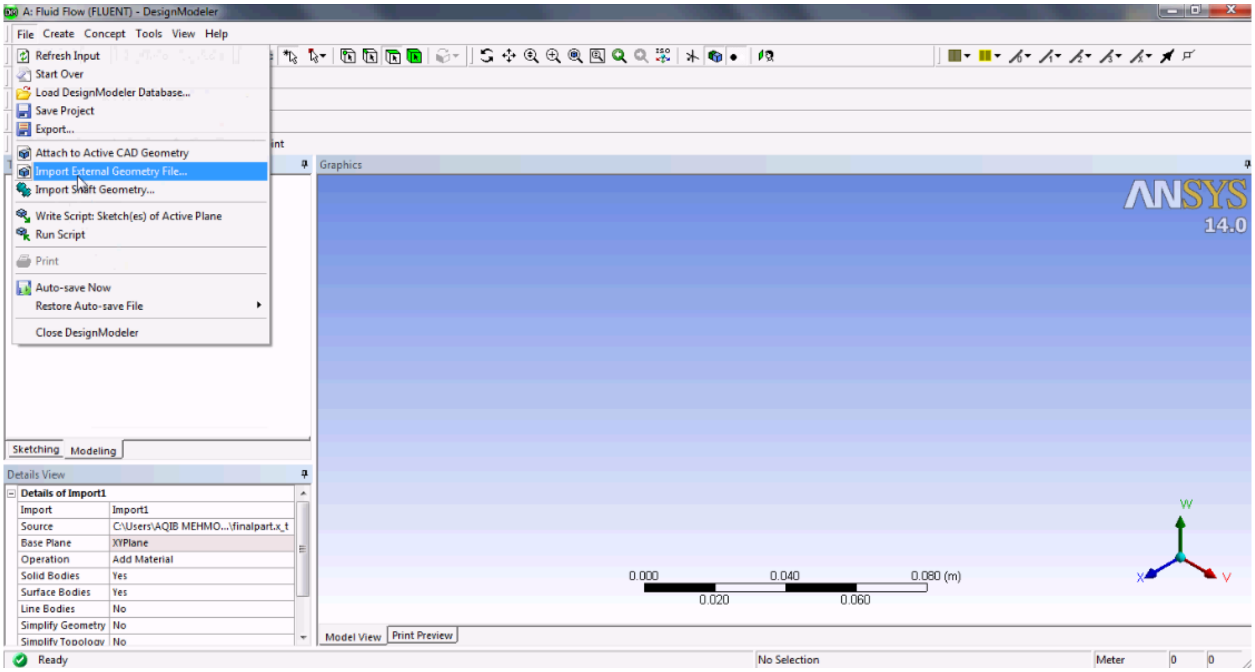
STEP 1: Drag the “Fluid Flow (fluent)” module into the project schematic. Then double click to geometry to start it.



Properties of Schematic A2: Geometry

	A	B
1	Property	Value
2	⊟ General	
3	Component ID	Geometry
4	Directory Name	FFF
5	⊟ Geometry Source	
6	Geometry File Name	E:\PROJECT 2016\new part\twopartsp_files\dp0\FFF\DM\FFF.agdb
7	⊟ Basic Geometry Options	
8	Attributes	☐
9	Material Properties	☐
10	⊟ Advanced Geometry Options	
11	Analysis Type	3D
12	Use Associativity	☑
13	Import Coordinate Systems	☐
14	Import Work Points	☐
15	Reader Mode Saves Updated File	☐
16	Import Using Instances	☑
17	Smart CAD Update	☐
18	Enclosure and Symmetry Processing	☑
19	Decompose Disjoint Faces	☑

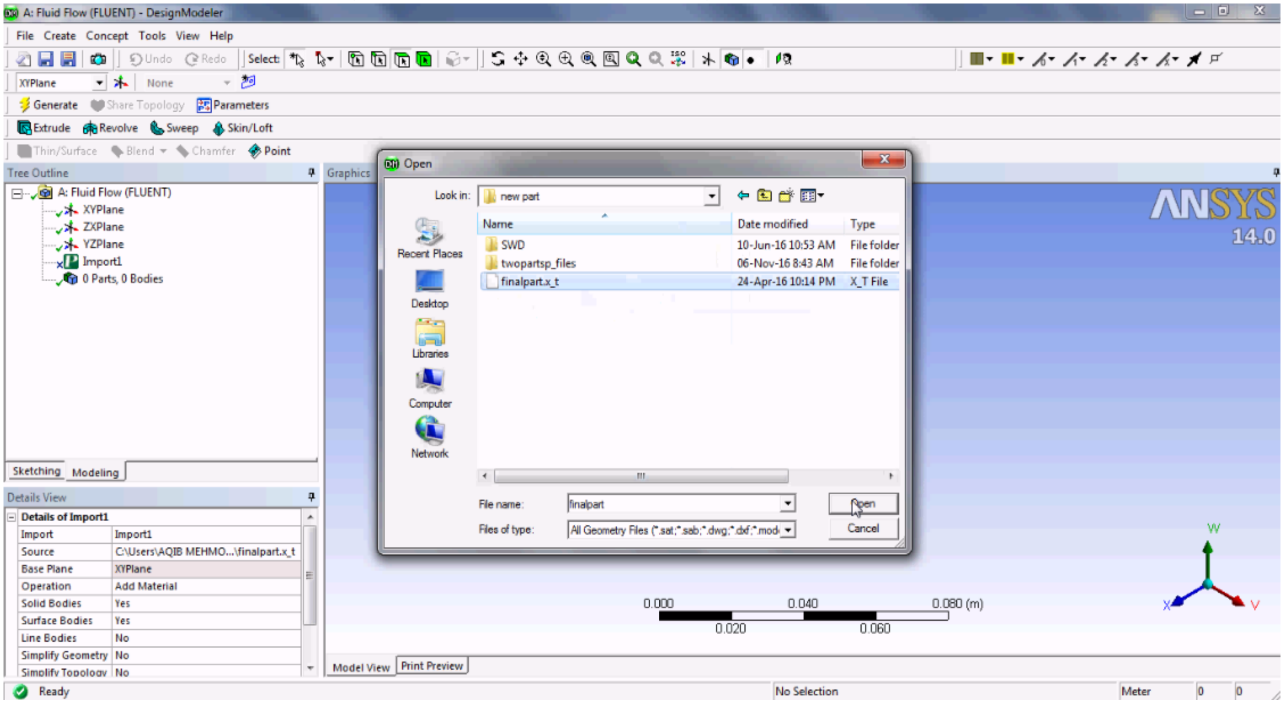
STEP2: File>>”Import External geometry Files”



Details View

Details of Import1	
Import	Import1
Source	C:\Users\AQIB MEHMO...\finalpart.x_t
Base Plane	XYPlane
Operation	Add Material
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Simplify Geometry	No
Simplify Topology	No

STEP 3: Solid works Design file is selected from designated folder.



Look in: new part

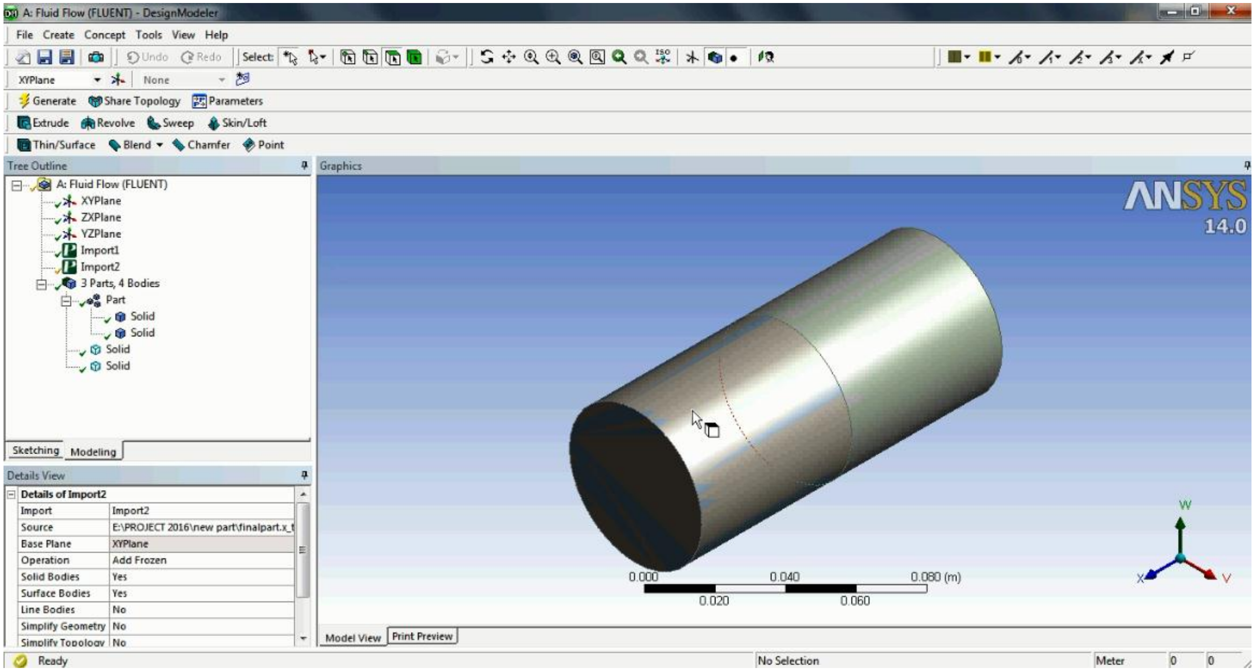
Name	Date modified	Type
SWD	10-Jun-16 10:53 AM	File folder
twopartsp_files	06-Nov-16 8:43 AM	File folder
finalpart.x_t	24-Apr-16 10:14 PM	X_T File

File name: finalpart

Files of type: All Geometry Files (*.sat;*.sab;*.dwg;*.dxf;*.mod

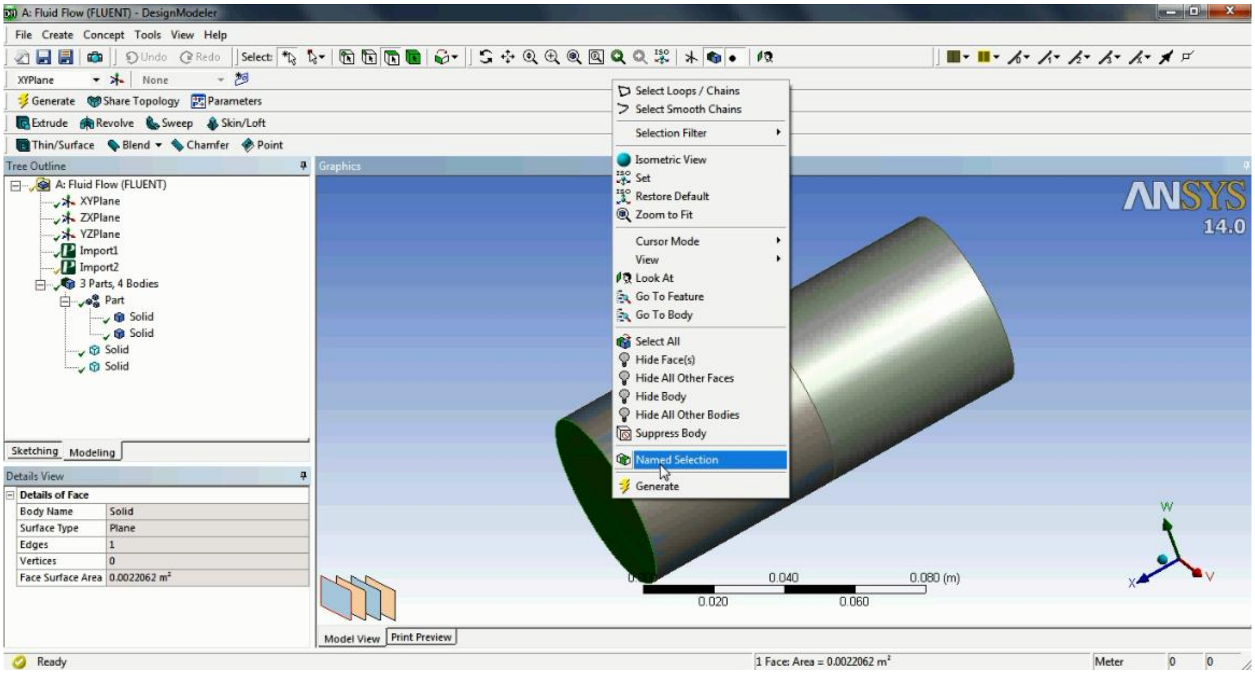
Details of Import1	
Import	Import1
Source	C:\Users\AQIB MEHMO...\finalpart.x_t
Base Plane	XYPlane
Operation	Add Material
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Simplify Geometry	No
Simplify Topology	No

STEP 4: Design generated from the imported design file. Hence it looks like this as follow.



Details of Import2	
Import	Import2
Source	E:\PROJECT 2016\new part\finalpart.x_t
Base Plane	XYPlane
Operation	Add Frozen
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Simplify Geometry	No
Simplify Topology	No

STEP 5: After right clicking on desired face “Named selection “to declare different surfaces. Proper name should be declared so that the next step will be easier. Finally that name selection needs to be generated.

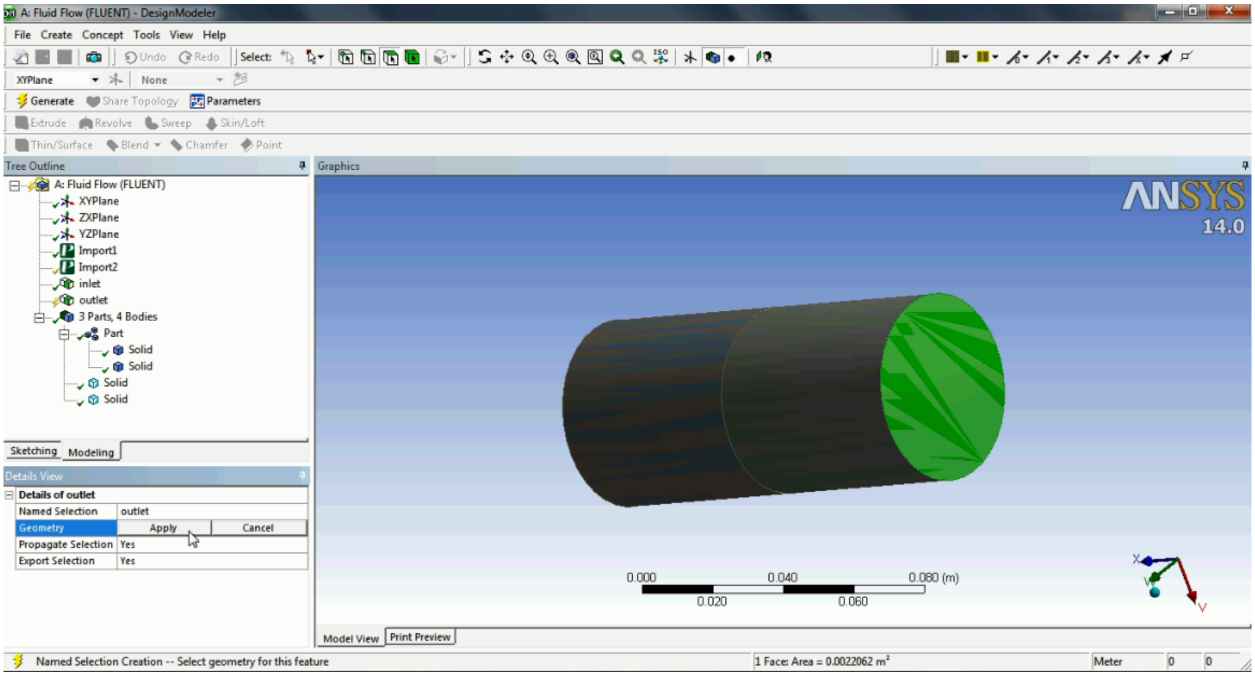


Details View

Details of Face	
Body Name	Solid
Surface Type	Plane
Edges	1
Vertices	0
Face Surface Area	0.0022062 m²

1 Face: Area = 0.0022062 m²

Name selection for inlet.



Details View

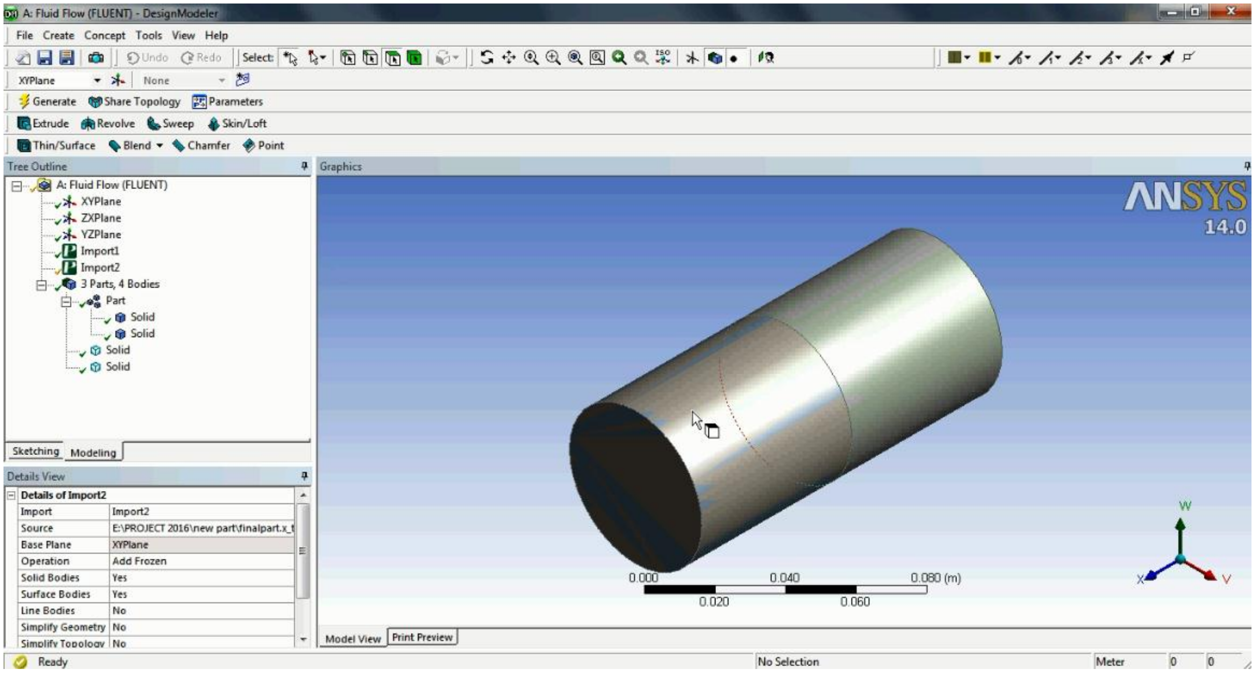
Details of outlet	
Named Selection	outlet
Geometry	Apply Cancel
Propagate Selection	Yes
Export Selection	Yes

Named Selection Creation -- Select geometry for this feature

1 Face: Area = 0.0022062 m²

Name selection for outlet.

STEP 6: Finally the whole body will be selected and named as shown below.

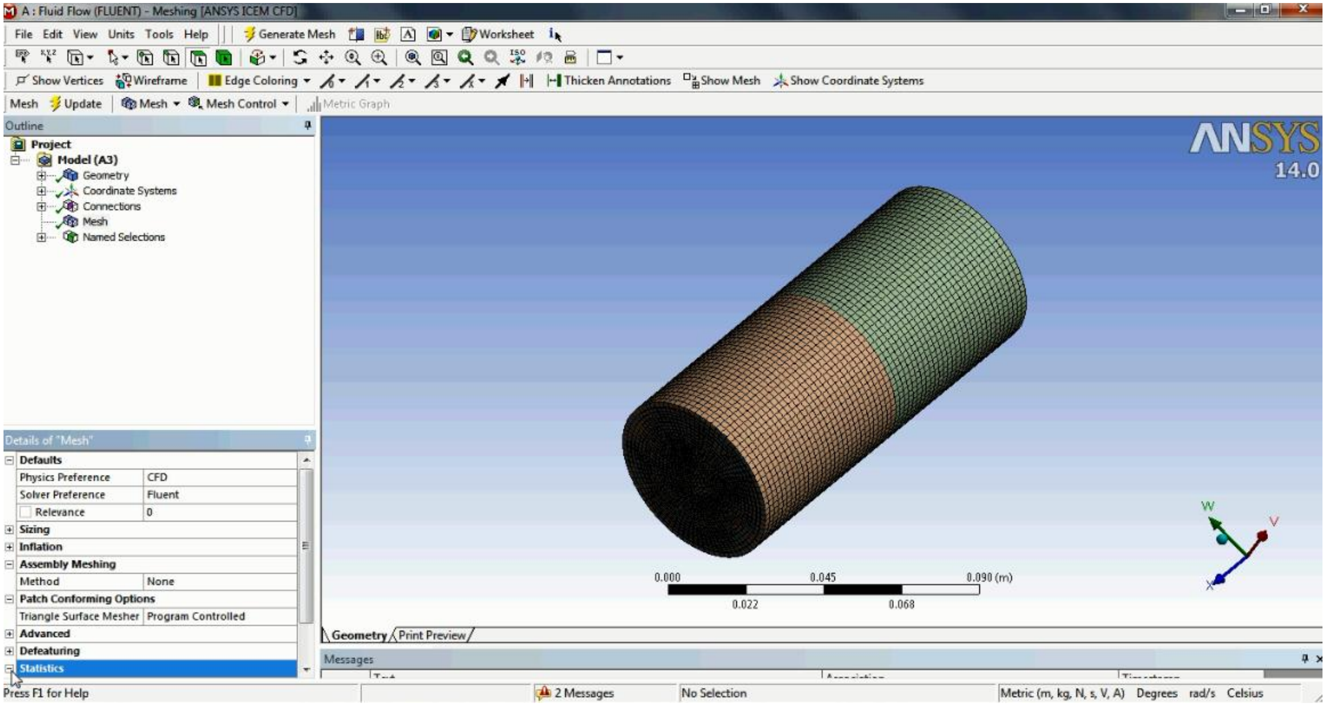


Details View

Details of Import2	
Import	Import2
Source	E:\PROJECT 2016\new part\finalpart.x_t
Base Plane	XYPlane
Operation	Add Frozen
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Simplify Geometry	No
Simplify Topology	No

Name selection for the whole body.

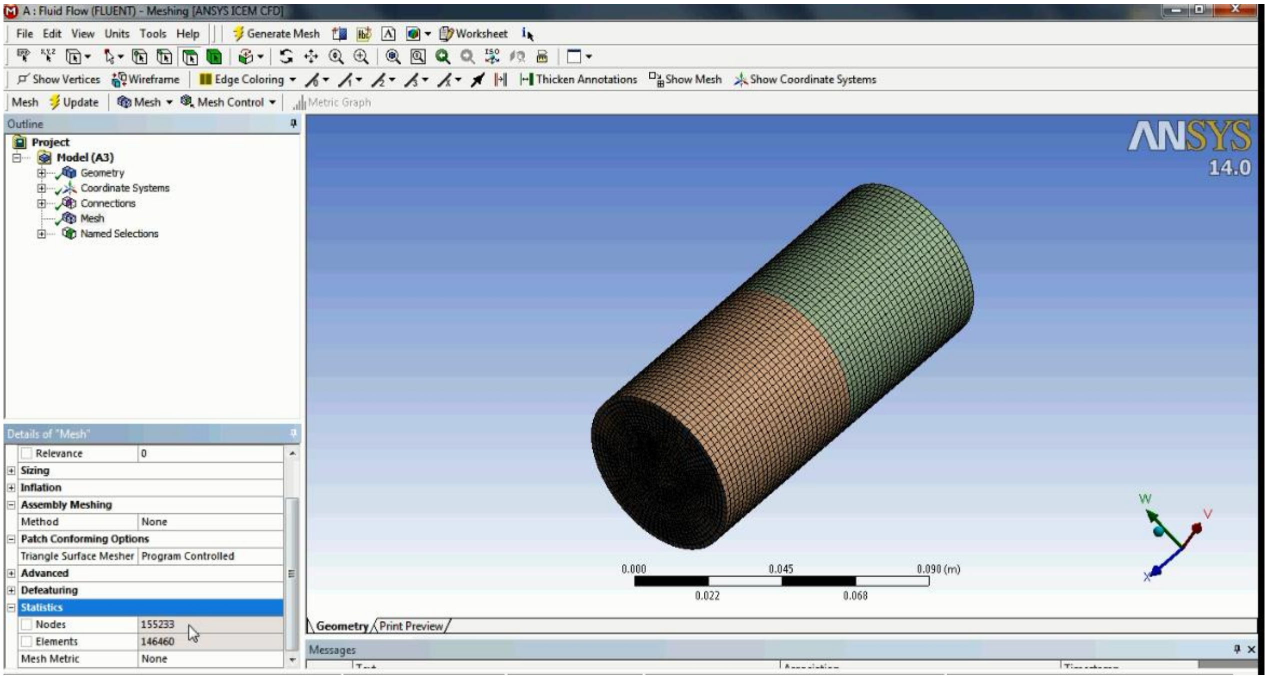
STEP 8: After finishing the geometry "Mesh" module needs to open to make proper mesh of the design. After opening the "Mesh module", there is an option "Max size" in "Sizing". That is marked as "1" as shown in figure. This value should be 3mm or less for this type of simulation. For this case 2.4mm is been used. Then finally update the mesh. Then click on "Generate" to generate mesh.



Details of "Mesh"

Defaults	
Physics Preference	CFD
Solver Preference	Fluent
☐ Relevance	0
Sizing	
Inflation	
Assembly Meshing	
Method	None
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Advanced	
Defeaturing	
Statistics	

Default Mesh.

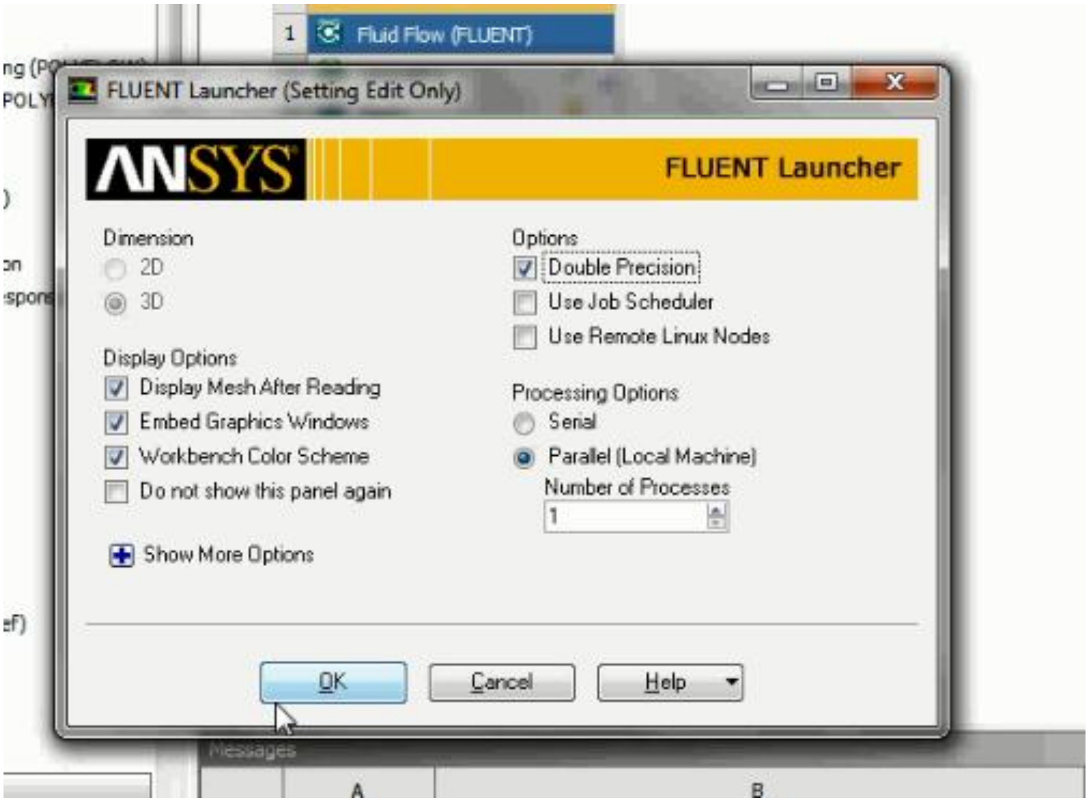


Details of "Mesh"

☐ Relevance	0
Sizing	
Inflation	
Assembly Meshing	
Method	None
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Advanced	
Defeaturing	
Statistics	
☐ Nodes	155233
☐ Elements	146460
Mesh Metric	None

Mesh statistics.

STEP 9: After finishing mesh launch the "Setup" module by double clicking on it. Select the "parallel" mode.



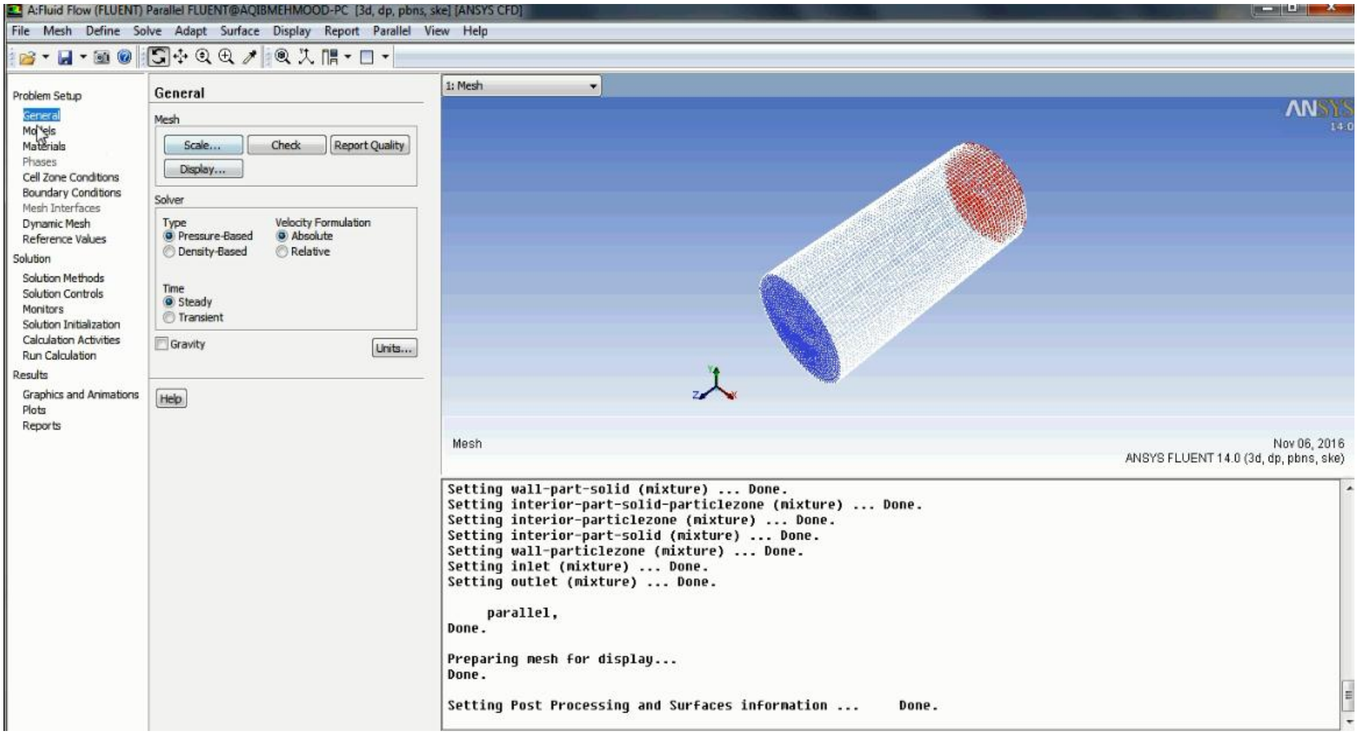
Dimension
○ 2D
● 3D

Display Options
☑ Display Mesh After Reading
☑ Embed Graphics Windows
☑ Workbench Color Scheme
☐ Do not show this panel again

Options
☑ Double Precision
☐ Use Job Scheduler
☐ Use Remote Linux Nodes

Processing Options
○ Serial
● Parallel (Local Machine)
Number of Processes
1

Fluent launcher



Type
● Pressure-Based
○ Density-Based

Velocity Formulation
● Absolute
○ Relative

Time
● Steady
○ Transient

☐ Gravity

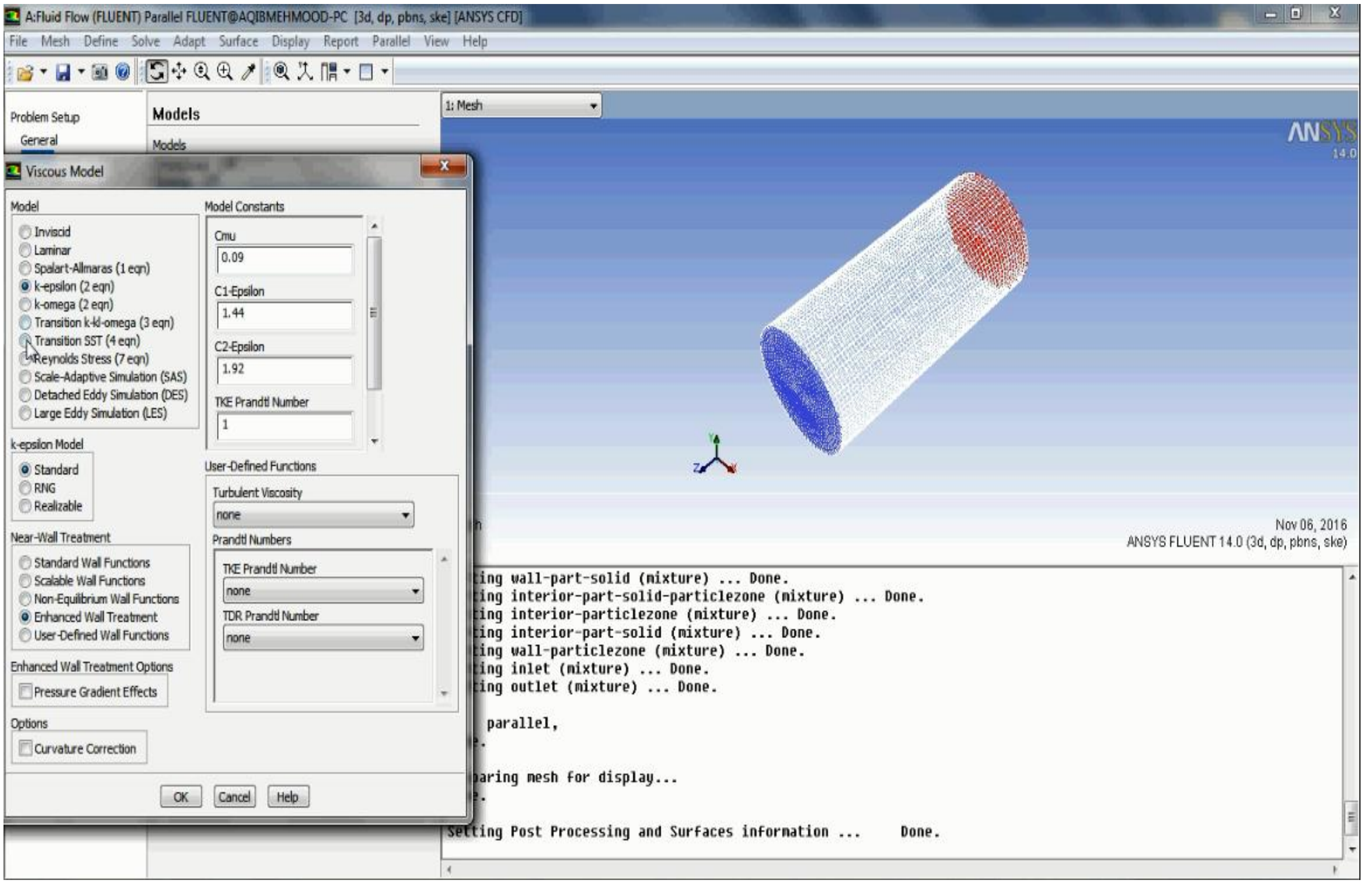
```
Setting wall-part-solid (mixture) ... Done.
Setting interior-part-solid-particlezone (mixture) ... Done.
Setting interior-particlezone (mixture) ... Done.
Setting interior-part-solid (mixture) ... Done.
Setting wall-particlezone (mixture) ... Done.
Setting inlet (mixture) ... Done.
Setting outlet (mixture) ... Done.

     parallel,
Done.

Preparing mesh for display...
Done.

Setting Post Processing and Surfaces information ...     Done.
```

Fluent Model.



Model
○ Inviscid
○ Laminar
○ Spalart-Allmaras (1 eqn)
● k-epsilon (2 eqn)
○ k-omega (2 eqn)
○ Transition k-kl-omega (3 eqn)
○ Transition SST (4 eqn)
○ Reynolds Stress (7 eqn)
○ Scale-Adaptive Simulation (SAS)
○ Detached Eddy Simulation (DES)
○ Large Eddy Simulation (LES)

k-epsilon Model
● Standard
○ RNG
○ Realizable

Near-Wall Treatment
○ Standard Wall Functions
○ Scalable Wall Functions
○ Non-Equilibrium Wall Functions
● Enhanced Wall Treatment
○ User-Defined Wall Functions

Enhanced Wall Treatment Options
☐ Pressure Gradient Effects

Options
☐ Curvature Correction

Model Constants
Cmu: 0.09
C1-Epsilon: 1.44
C2-Epsilon: 1.92
TKE Prandtl Number: 1

User-Defined Functions
Turbulent Viscosity: none
Prandtl Numbers
TKE Prandtl Number: none
TDR Prandtl Number: none

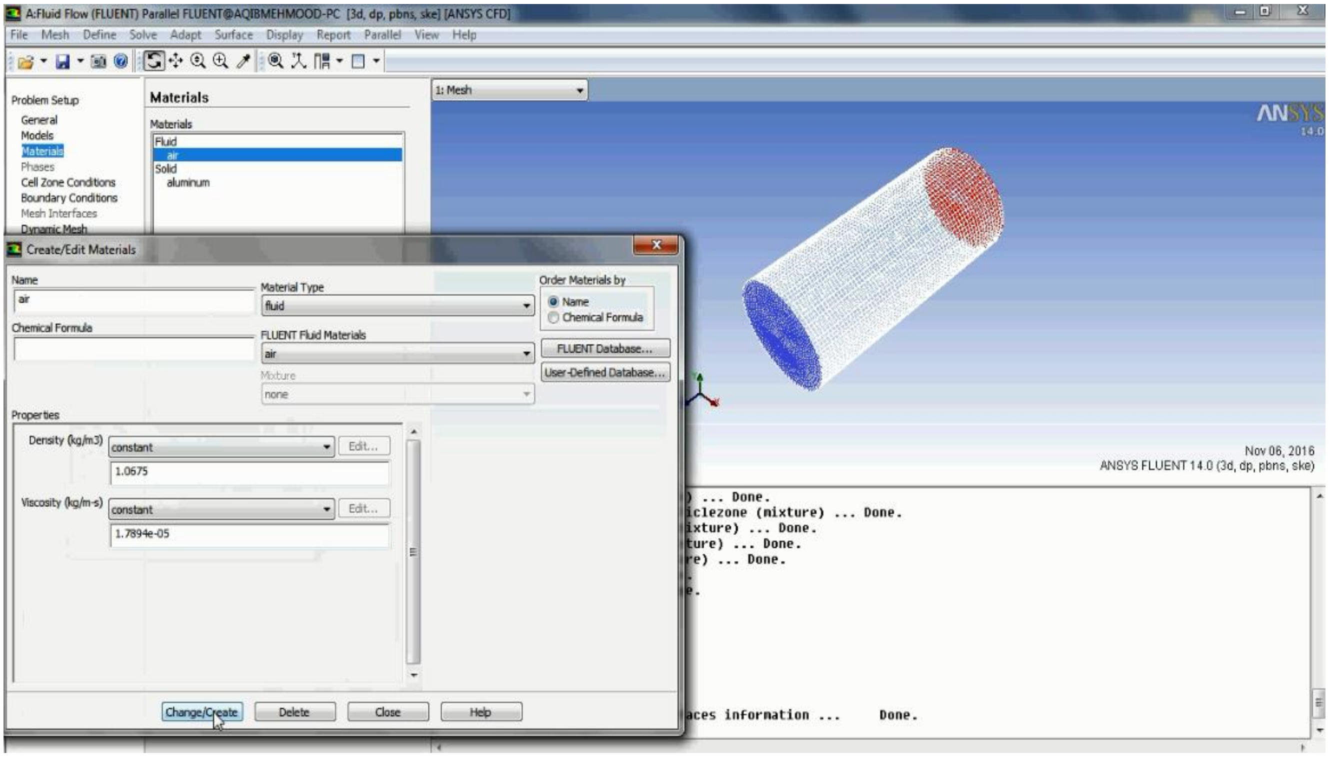
```
ing wall-part-solid (mixture) ... Done.
ing interior-part-solid-particlezone (mixture) ... Done.
ing interior-particlezone (mixture) ... Done.
ing interior-part-solid (mixture) ... Done.
ing wall-particlezone (mixture) ... Done.
ing inlet (mixture) ... Done.
ing outlet (mixture) ... Done.

 parallel,

aring mesh for display...

Setting Post Processing and Surfaces information ...     Done.
```

Select K-epsilon Model.



Materials

Materials: Fluid – air; Solid – aluminum

Create/Edit Materials

Name: air

Chemical Formula:

Material Type: fluid

FLUENT Fluid Materials: air

Mixture: none

Order Materials by: ● Name ○ Chemical Formula

Properties

Density (kg/m3): constant — 1.0675

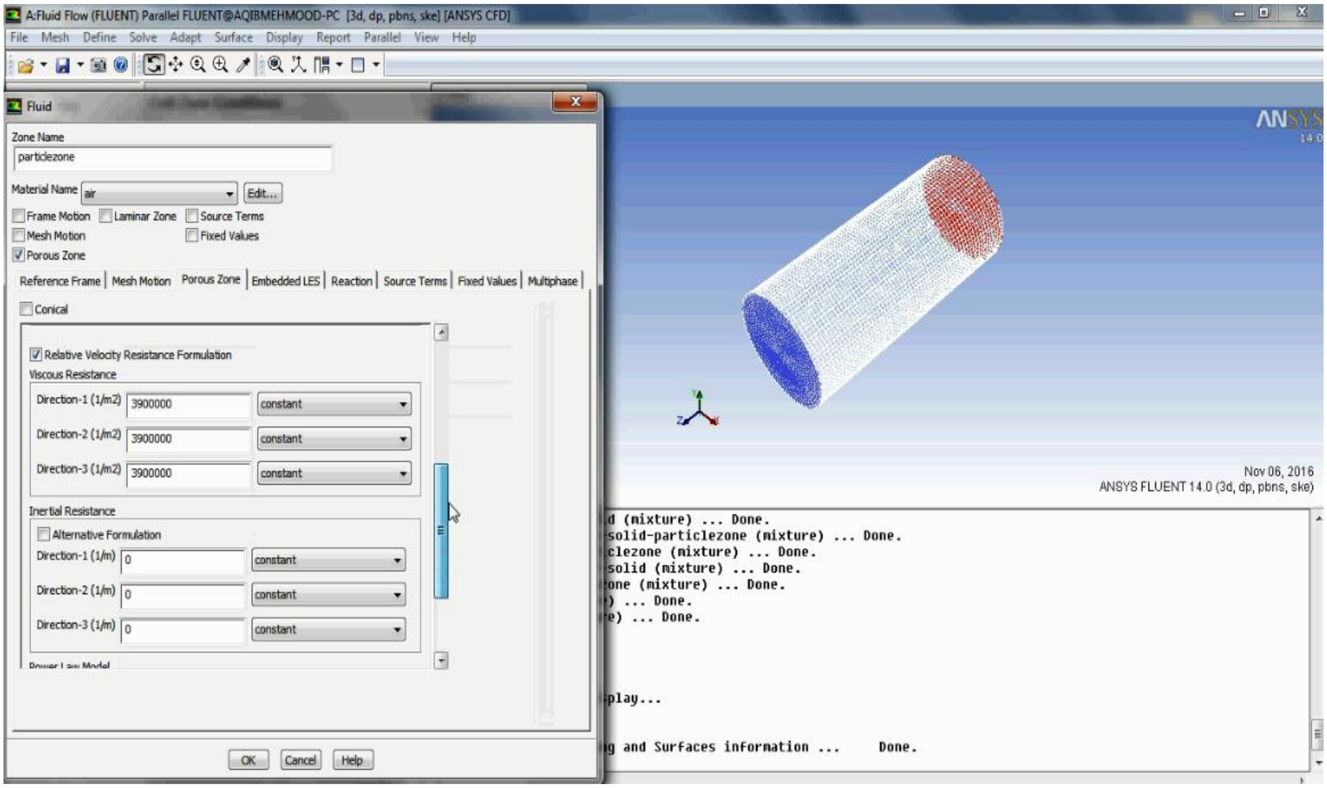
Viscosity (kg/m-s): constant — 1.7894e-05

Nov 06, 2016
ANSYS FLUENT 14.0 (3d, dp, pbns, ske)

```
) ... Done.
iclezone (mixture) ... Done.
ixture) ... Done.
ture) ... Done.
re) ... Done.
.
e.

aces information ...     Done.
```

Select material.



Fluid

Zone Name: particlezone

Material Name: air

☐ Frame Motion ☐ Laminar Zone ☐ Source Terms
☐ Mesh Motion ☐ Fixed Values
☑ Porous Zone

☐ Conical

☑ Relative Velocity Resistance Formulation

Viscous Resistance

Direction-1 (1/m2): 3900000 — constant

Direction-2 (1/m2): 3900000 — constant

Direction-3 (1/m2): 3900000 — constant

Inertial Resistance

☐ Alternative Formulation

Direction-1 (1/m): 0 — constant

Direction-2 (1/m): 0 — constant

Direction-3 (1/m): 0 — constant

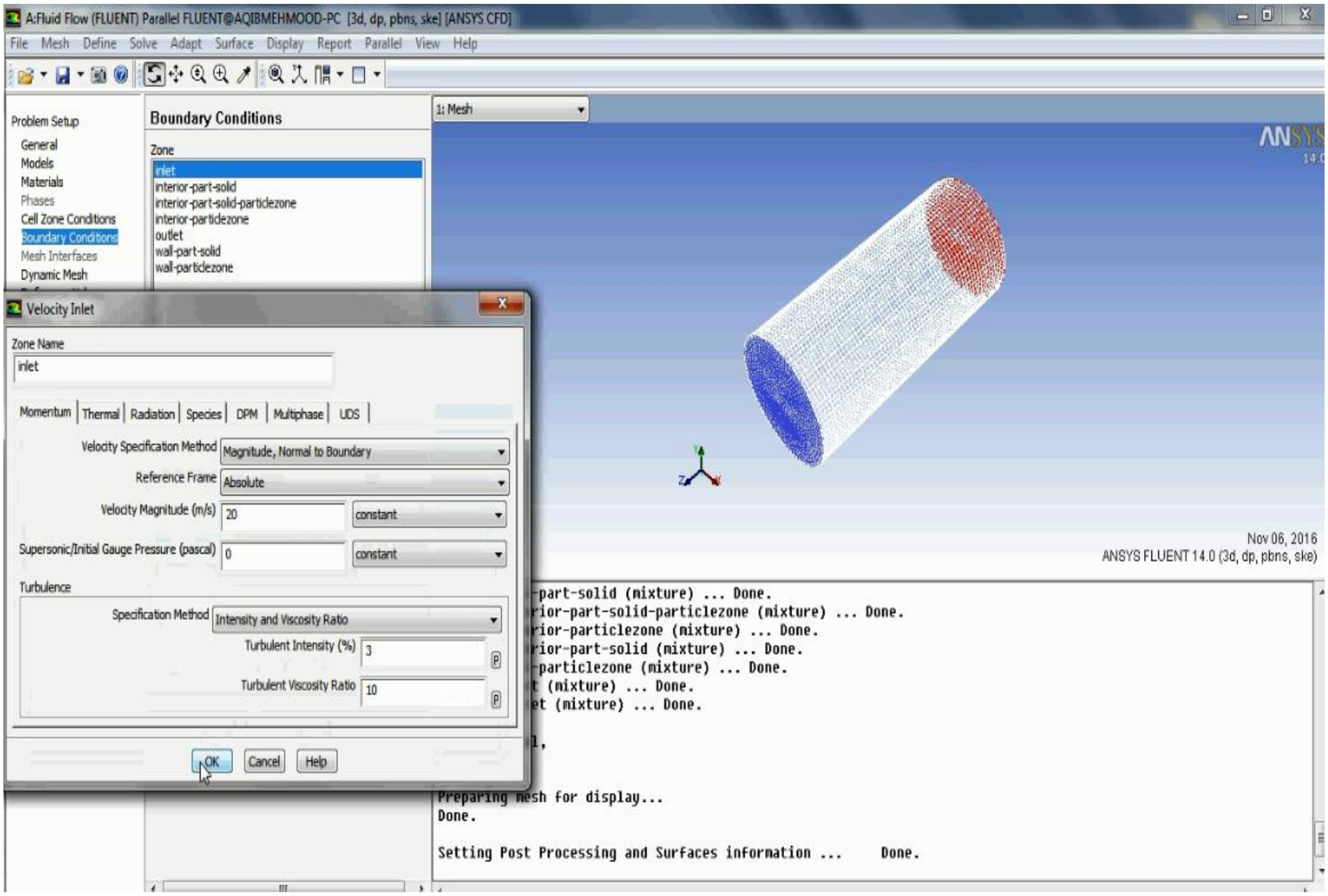
Nov 06, 2016
ANSYS FLUENT 14.0 (3d, dp, pbns, ske)

```
d (mixture) ... Done.
solid-particlezone (mixture) ... Done.
clezone (mixture) ... Done.
solid (mixture) ... Done.
one (mixture) ... Done.
) ... Done.
e) ... Done.

play...

g and Surfaces information ...     Done.
```

Cell zone conditions.



A:Fluid Flow (FLUENT) Parallel FLUENT@AQIBMEHMOOD-PC [3d, dp, pbns, ske] [ANSYS CFD]

Boundary Conditions

Zone

- inlet
- interior-part-solid
- interior-part-solid-particlezone
- interior-particlezone
- outlet
- wall-part-solid
- wall-particlezone

Velocity Inlet

Zone Name: inlet

Velocity Specification Method: Magnitude, Normal to Boundary

Reference Frame: Absolute

Velocity Magnitude (m/s): 20 constant

Supersonic/Initial Gauge Pressure (pascal): 0 constant

Turbulence

Specification Method: Intensity and Viscosity Ratio

Turbulent Intensity (%): 3

Turbulent Viscosity Ratio: 10

Nov 06, 2016
ANSYS FLUENT 14.0 (3d, dp, pbns, ske)

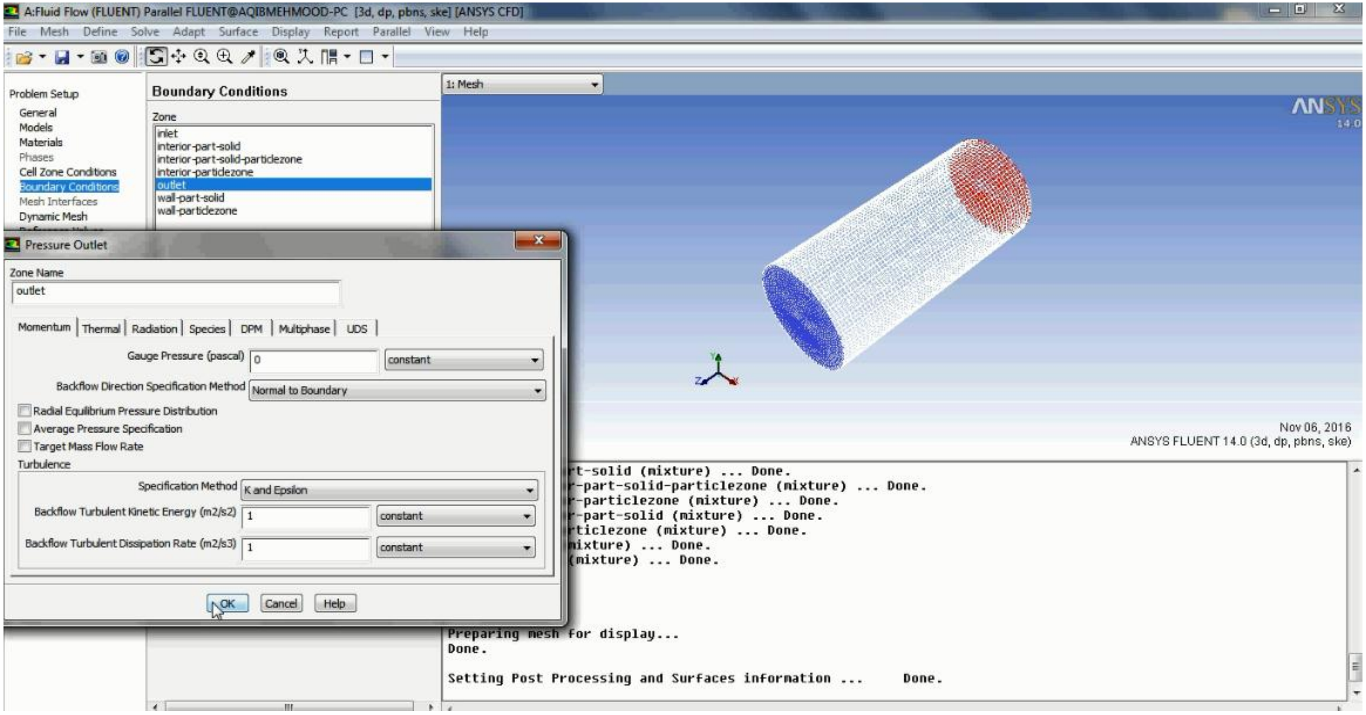
```
-part-solid (mixture) ... Done.
rior-part-solid-particlezone (mixture) ... Done.
rior-particlezone (mixture) ... Done.
rior-part-solid (mixture) ... Done.
-particlezone (mixture) ... Done.
t (mixture) ... Done.
et (mixture) ... Done.

1,

Preparing mesh for display...
Done.

Setting Post Processing and Surfaces information ...     Done.
```

Inlet Boundary conditions.



A:Fluid Flow (FLUENT) Parallel FLUENT@AQIBMEHMOOD-PC [3d, dp, pbns, ske] [ANSYS CFD]

Boundary Conditions

Zone

- inlet
- interior-part-solid
- interior-part-solid-particlezone
- interior-particlezone
- outlet
- wall-part-solid
- wall-particlezone

Pressure Outlet

Zone Name: outlet

Gauge Pressure (pascal): 0 constant

Backflow Direction Specification Method: Normal to Boundary

☐ Radial Equilibrium Pressure Distribution

☐ Average Pressure Specification

☐ Target Mass Flow Rate

Turbulence

Specification Method: K and Epsilon

Backflow Turbulent Kinetic Energy (m2/s2): 1 constant

Backflow Turbulent Dissipation Rate (m2/s3): 1 constant

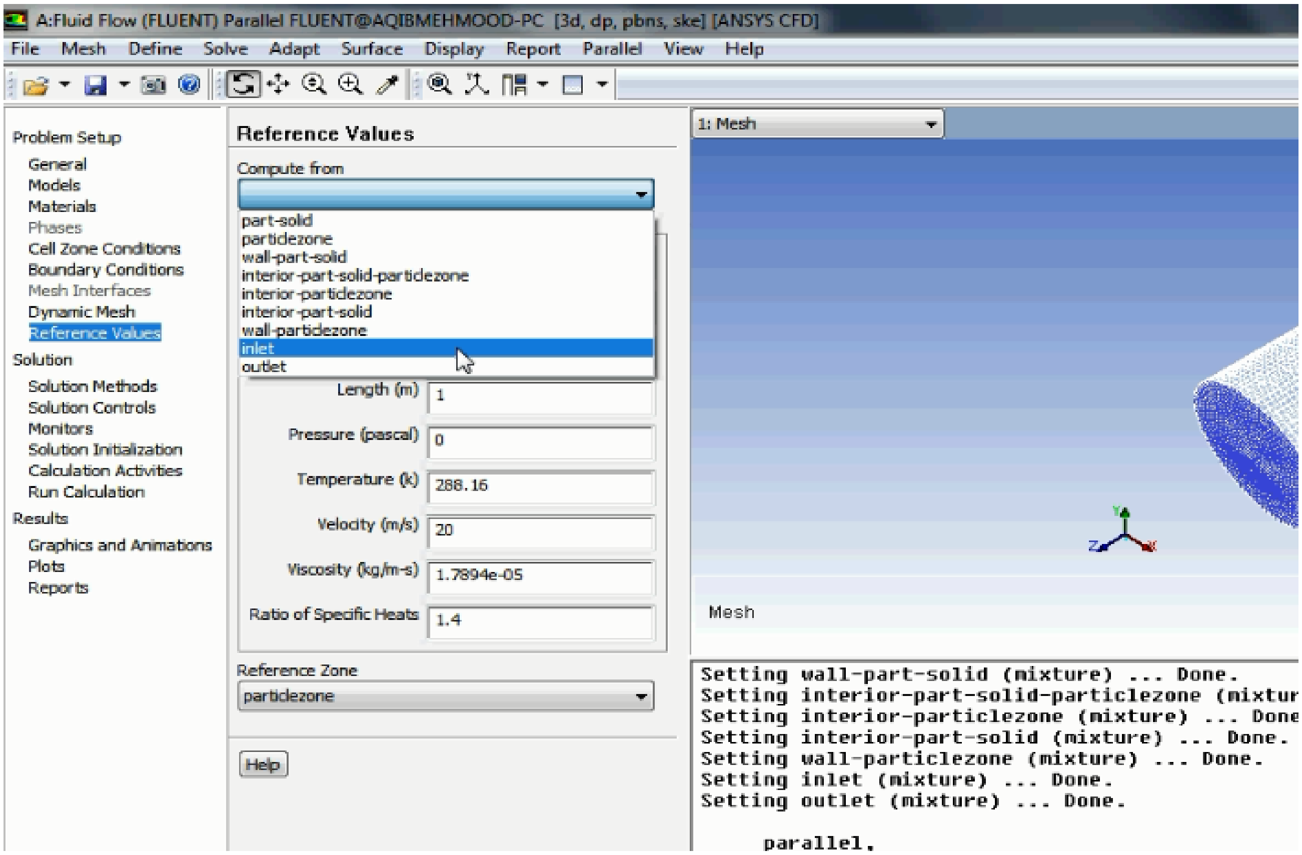
Nov 06, 2016
ANSYS FLUENT 14.0 (3d, dp, pbns, ske)

```
rt-solid (mixture) ... Done.
r-part-solid-particlezone (mixture) ... Done.
r-particlezone (mixture) ... Done.
r-part-solid (mixture) ... Done.
rticlezone (mixture) ... Done.
mixture) ... Done.
(mixture) ... Done.

Preparing mesh for display...
Done.

Setting Post Processing and Surfaces information ...     Done.
```

Outlet Boundary conditions.



Compute from: inlet

- part-solid
- partidezone
- wall-part-solid
- interior-part-solid-partidezone
- interior-partidezone
- interior-part-solid
- wall-partidezone
- inlet
- outlet

Length (m): 1

Pressure (pascal): 0

Temperature (k): 288.16

Velocity (m/s): 20

Viscosity (kg/m-s): 1.7894e-05

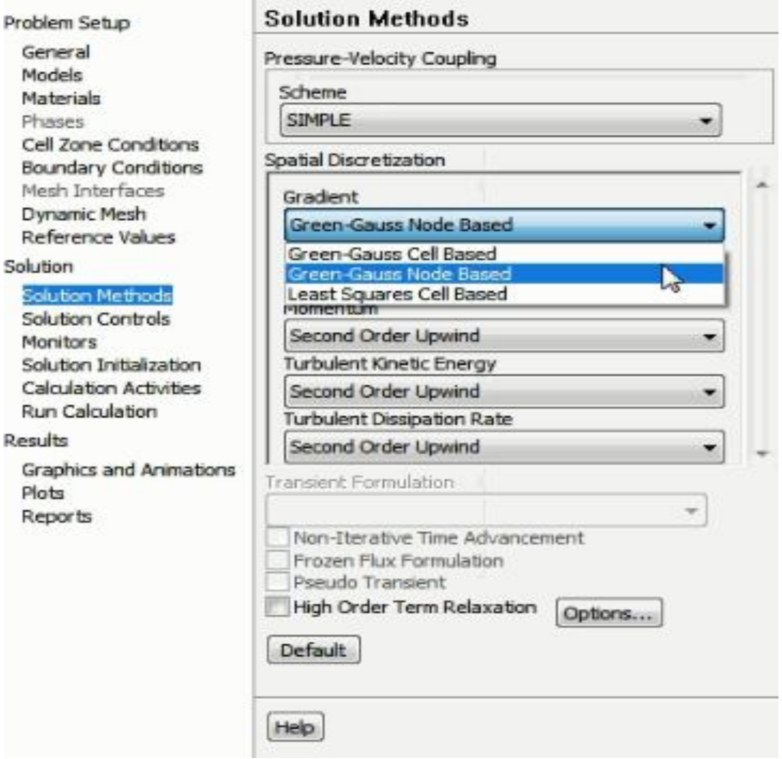
Ratio of Specific Heats: 1.4

Reference Zone: partidezone

```
Setting wall-part-solid (mixture) ... Done.
Setting interior-part-solid-particlezone (mixtur
Setting interior-particlezone (mixture) ... Done
Setting interior-part-solid (mixture) ... Done.
Setting wall-particlezone (mixture) ... Done.
Setting inlet (mixture) ... Done.
Setting outlet (mixture) ... Done.

     parallel,
```

Reference conditions.



Pressure-Velocity Coupling

Scheme: SIMPLE

Spatial Discretization

Gradient: Green-Gauss Node Based

- Green-Gauss Cell Based
- Green-Gauss Node Based
- Least Squares Cell Based

Momentum: Second Order Upwind

Turbulent Kinetic Energy: Second Order Upwind

Turbulent Dissipation Rate: Second Order Upwind

Transient Formulation

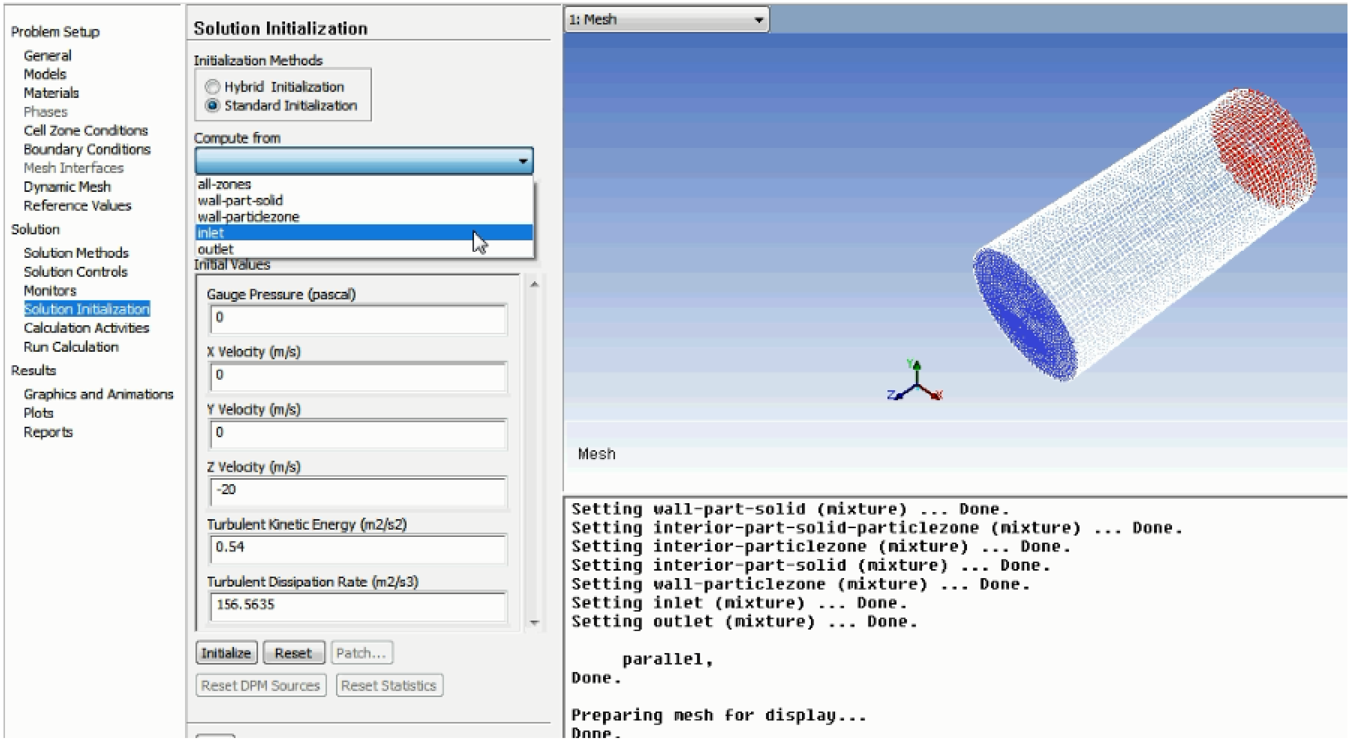
☐ Non-Iterative Time Advancement

☐ Frozen Flux Formulation

☐ Pseudo Transient

☐ High Order Term Relaxation

Solution Methods.



Initialization Methods
○ Hybrid Initialization
● Standard Initialization

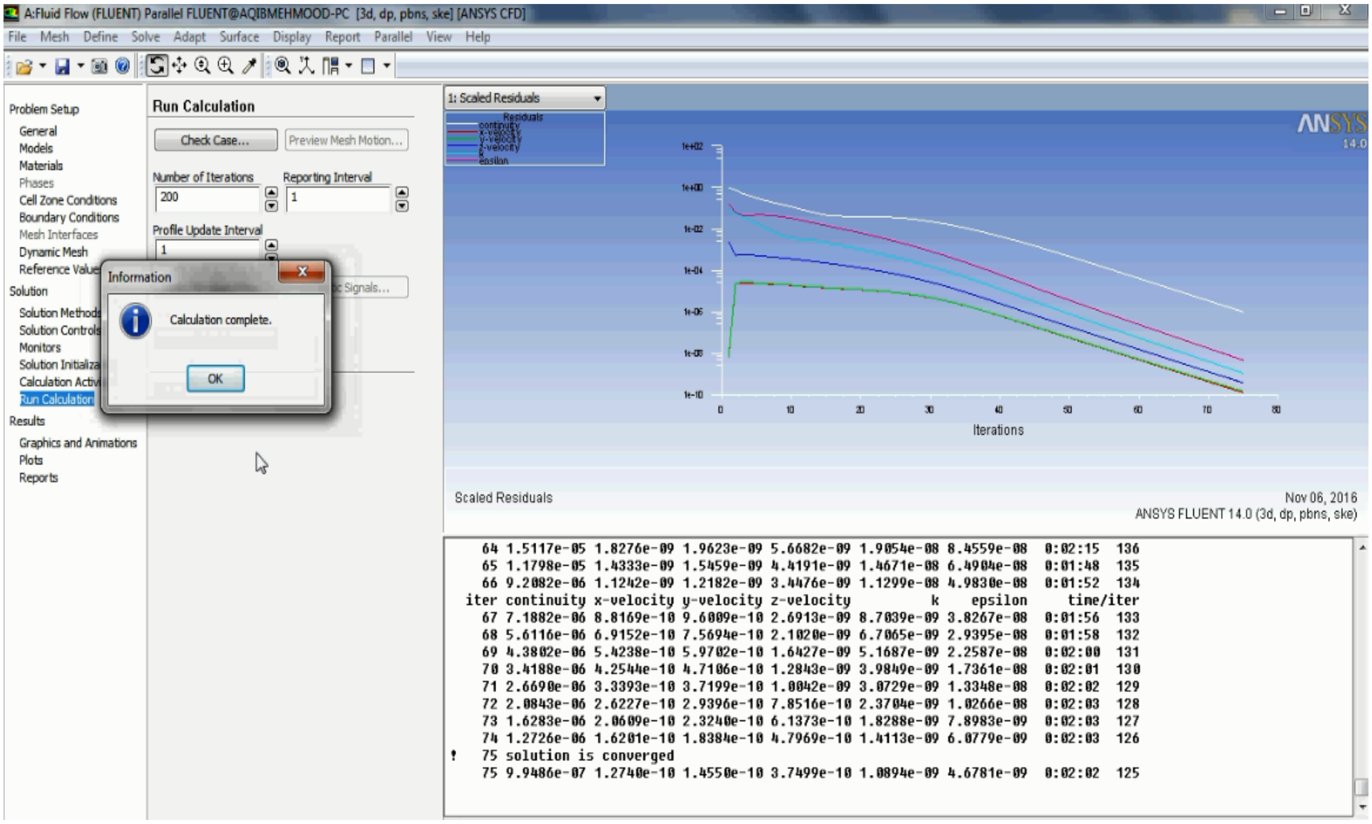
Gauge Pressure (pascal): 0
X Velocity (m/s): 0
Y Velocity (m/s): 0
Z Velocity (m/s): -20
Turbulent Kinetic Energy (m2/s2): 0.54
Turbulent Dissipation Rate (m2/s3): 156.5635

```
Setting wall-part-solid (mixture) ... Done.
Setting interior-part-solid-particlezone (mixture) ... Done.
Setting interior-particlezone (mixture) ... Done.
Setting interior-part-solid (mixture) ... Done.
Setting wall-particlezone (mixture) ... Done.
Setting inlet (mixture) ... Done.
Setting outlet (mixture) ... Done.

     parallel,
Done.

Preparing mesh for display...
Done.
```

Solution Initialization.

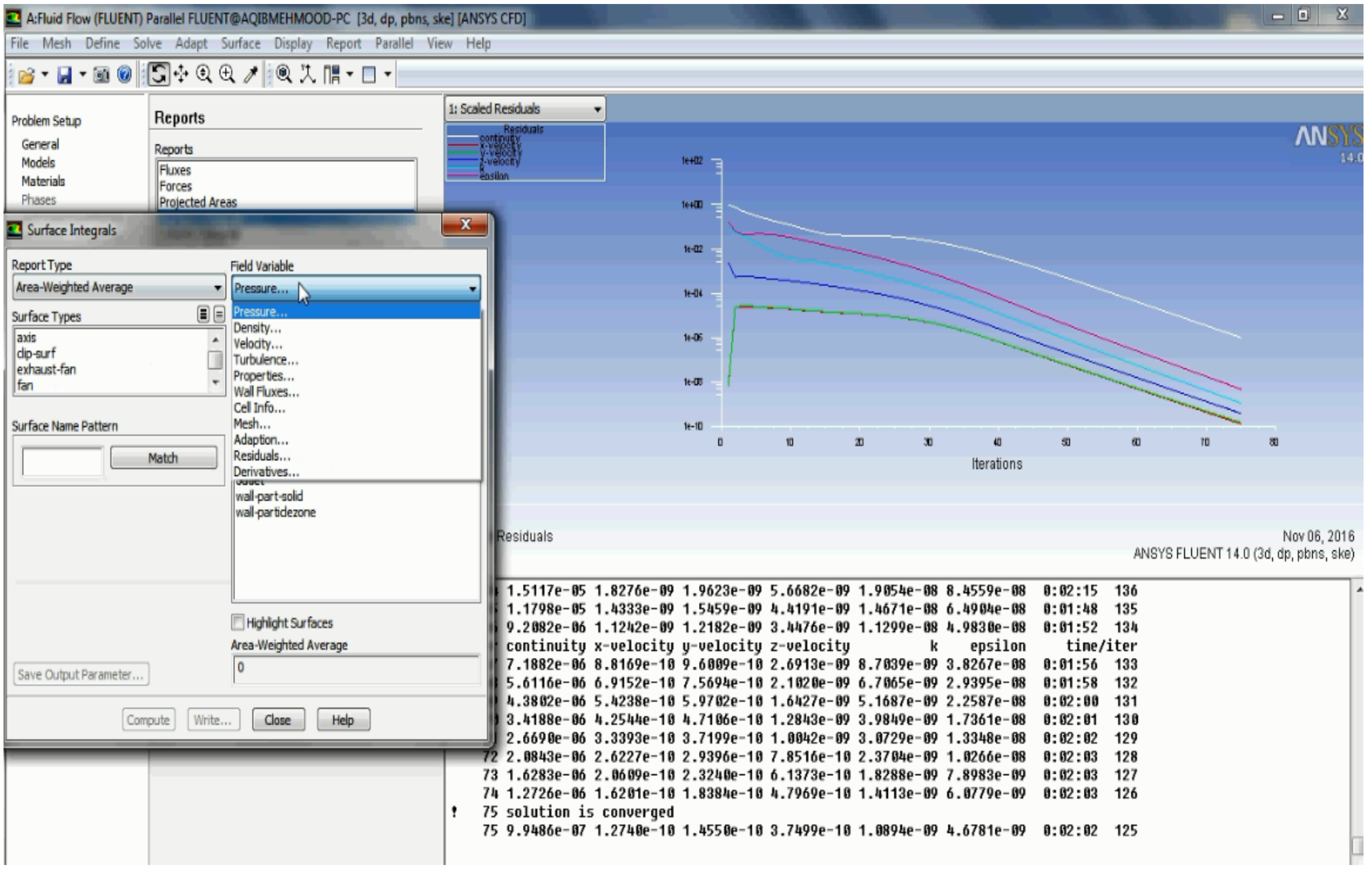


Number of Iterations: 200
Reporting Interval: 1
Profile Update Interval: 1

Calculation complete.

```
   64 1.5117e-05 1.8276e-09 1.9623e-09 5.6682e-09 1.9054e-08 8.4559e-08  0:02:15  136
   65 1.1798e-05 1.4333e-09 1.5459e-09 4.4191e-09 1.4671e-08 6.4904e-08  0:01:48  135
   66 9.2082e-06 1.1242e-09 1.2182e-09 3.4476e-09 1.1299e-08 4.9830e-08  0:01:52  134
 iter continuity x-velocity y-velocity z-velocity          k    epsilon     time/iter
   67 7.1882e-06 8.8169e-10 9.6009e-10 2.6913e-09 8.7039e-09 3.8267e-08  0:01:56  133
   68 5.6116e-06 6.9152e-10 7.5694e-10 2.1020e-09 6.7065e-09 2.9395e-08  0:01:58  132
   69 4.3802e-06 5.4238e-10 5.9702e-10 1.6427e-09 5.1687e-09 2.2587e-08  0:02:00  131
   70 3.4188e-06 4.2544e-10 4.7106e-10 1.2843e-09 3.9849e-09 1.7361e-08  0:02:01  130
   71 2.6690e-06 3.3393e-10 3.7199e-10 1.0042e-09 3.0729e-09 1.3348e-08  0:02:02  129
   72 2.0843e-06 2.6227e-10 2.9396e-10 7.8516e-10 2.3704e-09 1.0266e-08  0:02:03  128
   73 1.6283e-06 2.0609e-10 2.3240e-10 6.1373e-10 1.8288e-09 7.8983e-09  0:02:03  127
   74 1.2726e-06 1.6201e-10 1.8384e-10 4.7969e-10 1.4113e-09 6.0779e-09  0:02:03  126
!  75 solution is converged
   75 9.9486e-07 1.2740e-10 1.4550e-10 3.7499e-10 1.0894e-09 4.6781e-09  0:02:02  125
```

Solution Convergence.



Report Type: Area-Weighted Average

Field Variable: Pressure...

Area-Weighted Average: 0

```
 1.5117e-05 1.8276e-09 1.9623e-09 5.6682e-09 1.9054e-08 8.4559e-08  0:02:15  136
 1.1798e-05 1.4333e-09 1.5459e-09 4.4191e-09 1.4671e-08 6.4904e-08  0:01:48  135
 9.2082e-06 1.1242e-09 1.2182e-09 3.4476e-09 1.1299e-08 4.9830e-08  0:01:52  134
 continuity x-velocity y-velocity z-velocity          k    epsilon    time/iter
 7.1882e-06 8.8169e-10 9.6009e-10 2.6913e-09 8.7039e-09 3.8267e-08  0:01:56  133
 5.6116e-06 6.9152e-10 7.5694e-10 2.1020e-09 6.7065e-09 2.9395e-08  0:01:58  132
 4.3802e-06 5.4238e-10 5.9702e-10 1.6427e-09 5.1687e-09 2.2587e-08  0:02:00  131
 3.4188e-06 4.2544e-10 4.7106e-10 1.2843e-09 3.9849e-09 1.7361e-08  0:02:01  130
 2.6690e-06 3.3393e-10 3.7199e-10 1.0042e-09 3.0729e-09 1.3348e-08  0:02:02  129
72 2.0843e-06 2.6227e-10 2.9396e-10 7.8516e-10 2.3704e-09 1.0266e-08  0:02:03  128
73 1.6283e-06 2.0609e-10 2.3240e-10 6.1373e-10 1.8288e-09 7.8983e-09  0:02:03  127
74 1.2726e-06 1.6201e-10 1.8384e-10 4.7969e-10 1.4113e-09 6.0779e-09  0:02:03  126
!  75 solution is converged
75 9.9486e-07 1.2740e-10 1.4550e-10 3.7499e-10 1.0894e-09 4.6781e-09  0:02:02  125
```

Results.

3.3 Automobile Exhaust Gas Analyzer.

Analysis of exhaust gas from combustion engines can help evaluate engine performance and diagnose problems.

Engine exhaust gas analyzer can measure Oxygen (O2), Carbon Monoxide (CO), Carbon Dioxide (CO2), Nitrogen Oxide (NO), Nitrogen Dioxide (NO2), and Hydrocarbons (HC's).

Oxygen: Filtered ambient air enters the engine and forms part of the fuel mixture. Ambient air contains 20.9% O2. Ideally, in most engine types, this O2 should be consumed as the fuel is burned. Oxygen levels analyzed at the tailpipe indicate unburned O2, and represent a lean air/fuel mixture.

Hydrocarbons: the HC's channel is calibrated as hexane or propane depending on the vehicle type the analyzer is to be used on. The measurement itself represents unburned fuel and is measured in the ppm (parts per million). Modern automobiles in good running order frequently show 10ppm or less. Trucks and forklifts may have higher levels due to fuel type or engine style.

Carbon Dioxide: the level of CO2 is a product of combustion and represents the amount of fully burned fuel. Therefore, a higher CO2 level indicates a higher engine efficiency. Many fuel injection engines will show approximately 15% CO2.

Carbon Monoxide: Partially burned fuel results in CO. High CO levels indicate a ‘rich’ fuel mixture. A perfect fuel mixture meters in exactly enough fuel to consume all of the O2 entering the engine. A perfect ratio is not sustainable in real-life operation. A fuel mixture that contains excess fuel is usually referred to as a ‘rich’ condition. A ‘lean’ condition refers to an excess of O2.

NOx: NOx generally refers to NO and NO2 (nitric oxide and nitrogen dioxide). This measurement is in ppm and represents the combustion products of burning nitrogen. This occurs at the higher engine temperatures associated with a lean fuel mixture or being under load. Of the NOx output of a typical engine, the NO component will usually make up the highest proportion. Diesel engines are generally associated with higher NOx and particulate emissions.

The following gas analyses are available:

Oxygen (O2)
Carbon Monoxide (CO) (in percent or ppm)
Carbon Dioxide (CO2)
Nitrogen Oxide (NO)
Nitrogen Dioxide (NO2)
Hydrocarbons (calibrated as hexane or propane)

Exhaust Gas Analyzer

CHAPTER 04

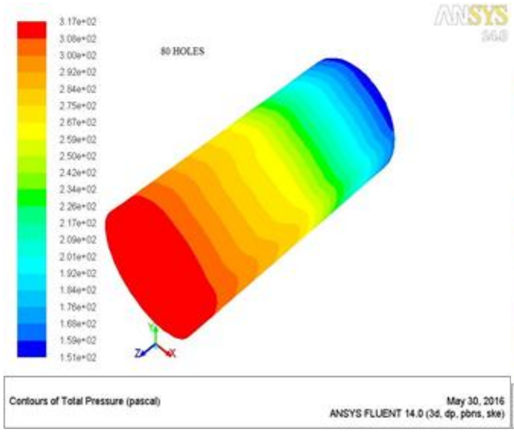
RESULTS AND DISCUSSIONS.

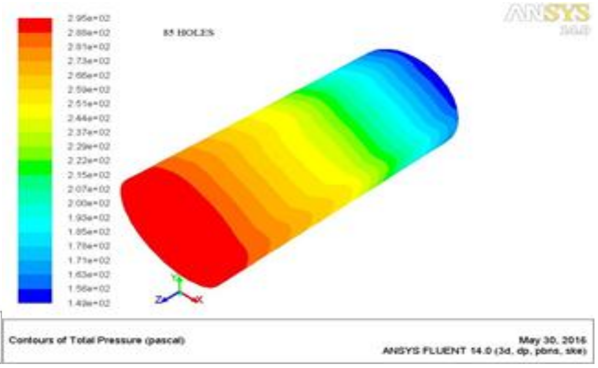
In this section we will discuss the results obtained from Ansys fluent. Here the results are being discussed considering the pressure drop in adaptor capsule. At first design optimization is being done considering the number of holes in the inlet and outlet plates. From the Graph shown below, we have found that by increasing the number of holes in the plates, Pressure drop is decreasing up to considerable level. Following this, Design optimization is being done by considering the distance between the plates. As the distance increases pressure drop in the device also decreases. Here is one thing that we need to discuss that, at a distance of 62-63mm turbulence is found in the device which basically results from recirculation of the air in the capsule.

4.1 DESIGN OPTIMIZATION (Considering no. of Holes in plates)

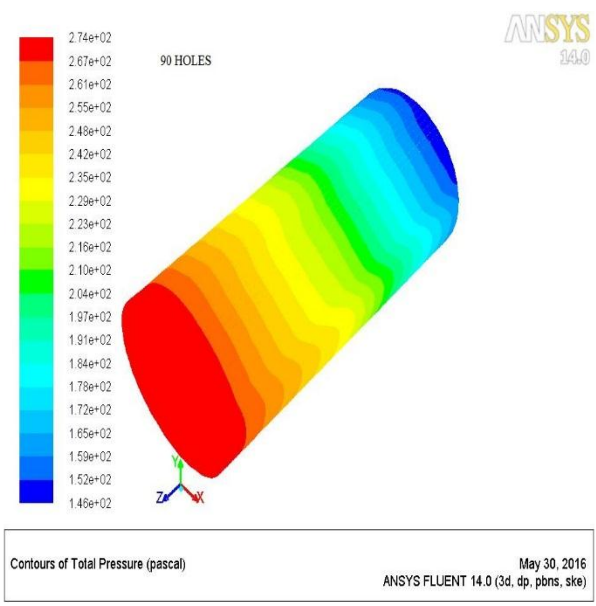
Serial No.	No. of Holes	Viscous Resistance	Inlet Pressure (kPa)	Outlet pressure (KPa)	Pressure difference (KPa)
1)	80	4e+06	315	215	100
2)	85	3e+06	293	215	78
3)	90	2e+06	272	215	57
4)	95	1e+06	250	214	36
5)	100	1e+05	231	214	17

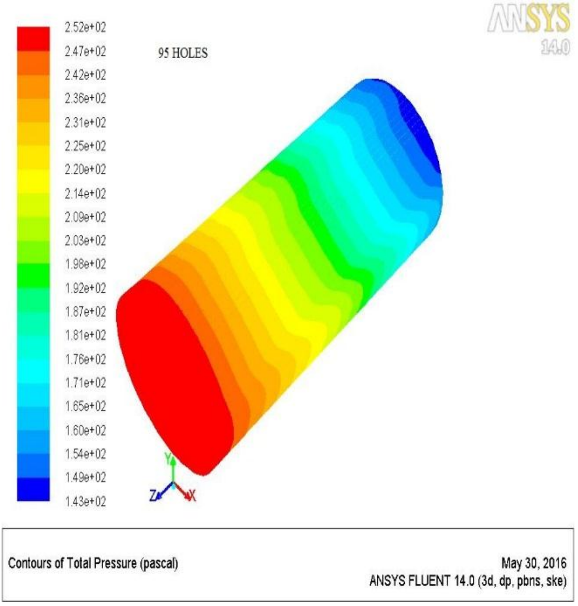
4.2 CONTOURS OF TOTAL PRESSURE:



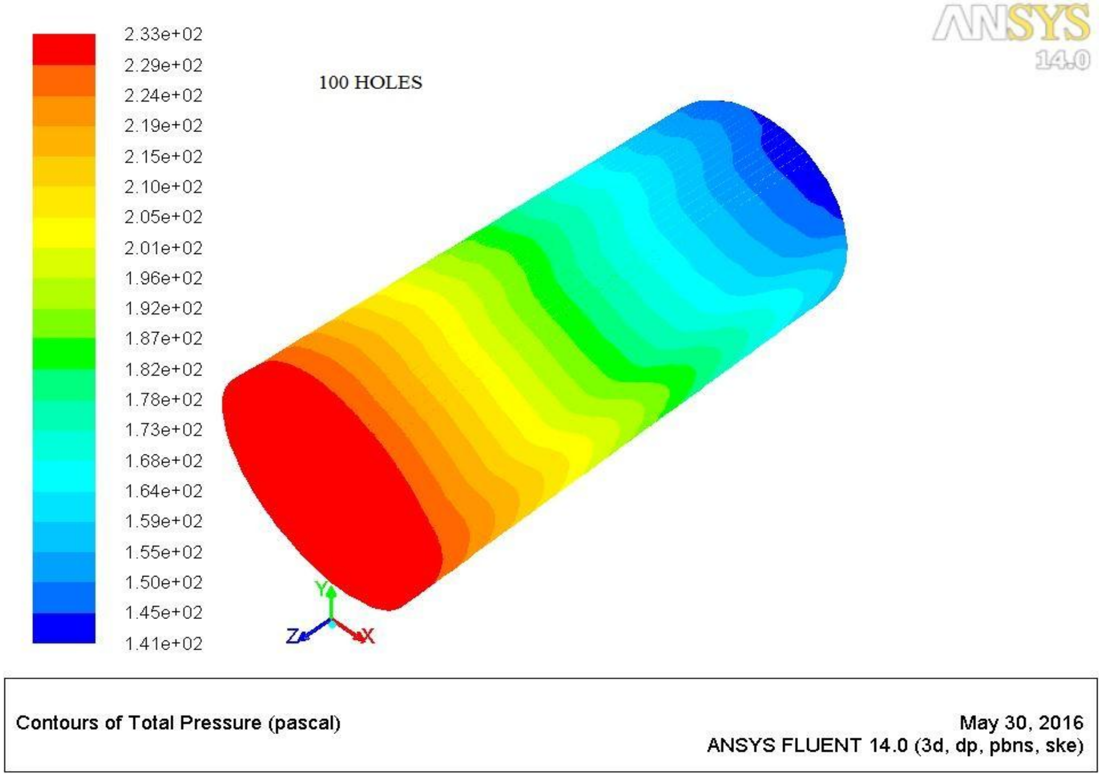


80 Holes 85 Holes



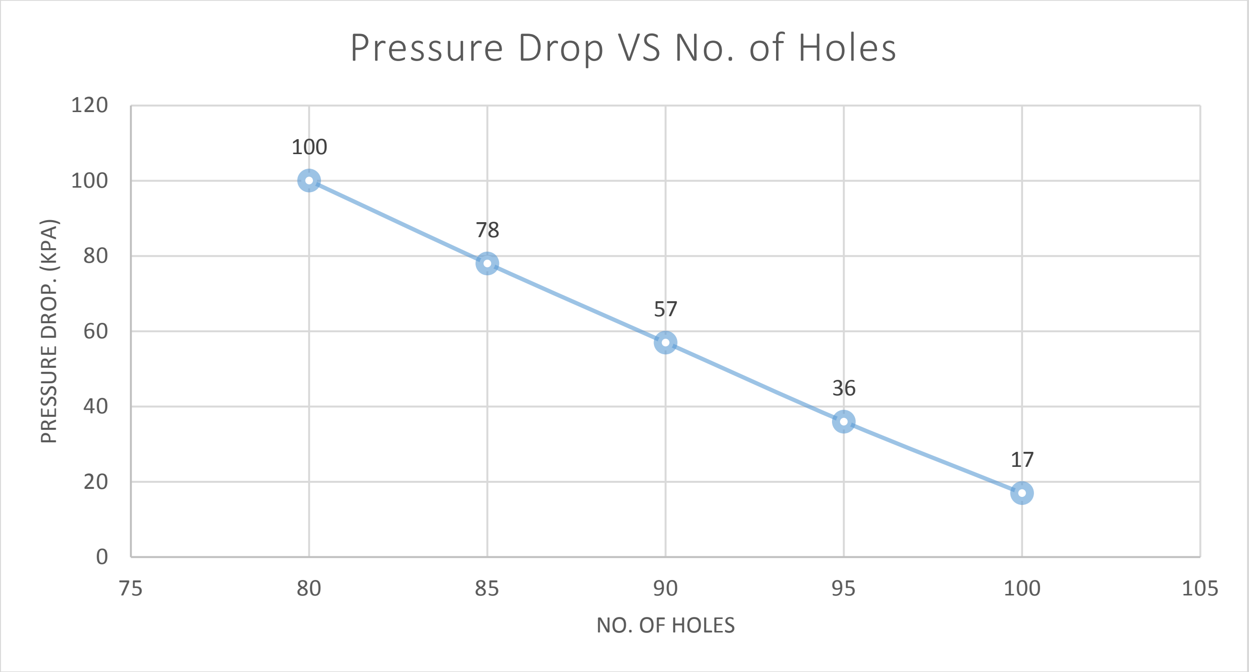


90 Holes 95 Holes.



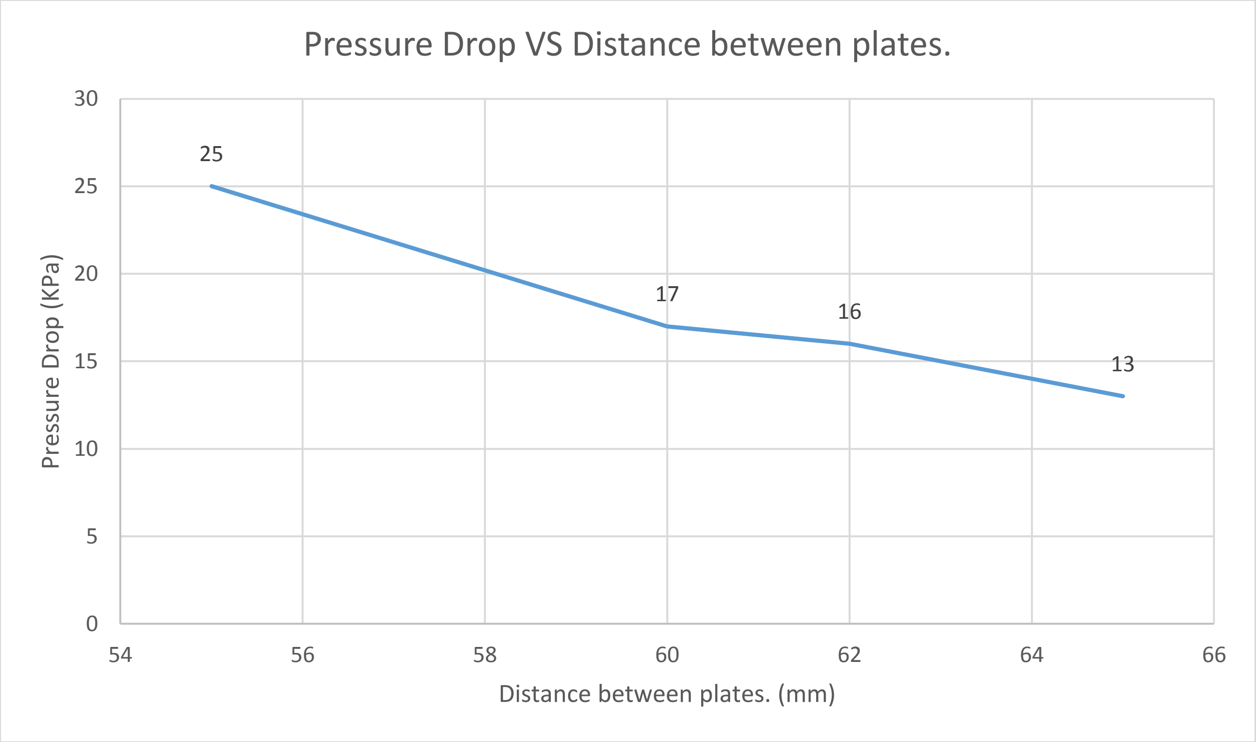
100 Holes.

4.3 GRAPH: PRESSURE DROP VS NO. OF HOLES.



The above graph shows that with the increase of number of Holes, Pressure drops is decreasing.

4.4 DESIGN OPTIMIZATION :(Considering the distance between plates.)



4.5 RESULTS.

- Holes/plate = 100 Holes
- Distance between plates = 65mm
- Pressure Drop = 13 KPa
- Activated carbon: 10% of total cylinder volume.

With the above mentioned results we have designed an emission control device which is shown below.

SMART EXHAUST TECHNOLOGY.

Installation.

****

CHAPTER 05

CONCLUSIONS AND RECOMMENDATIONS.

5.1 Conclusion and recommendations:

The **SET (Smart Exhaust Technology)** is an important component on modern automobiles. This vital addition to a vehicle exhaust system was a response to growing public concern over carbon monoxide, hydrocarbons, and other toxic emissions associated with internal combustion engines. Although cars are by no means the only source of environmental pollution, **SET** help ensure that vehicle emissions are responsible for as little of the damage as possible. For this reason, many governments mandate that all vehicles have a properly installed and functioning **SET.**

Car owners typically install new SET for one of two reasons: failures and theft. In many cases, a failure is caused by engine issues, electrical issues, or issues related to neighboring exhaust components. Theft is also an issue, as SET are a valuable source of scrap metal. If it is time to replace a malfunctioning or missing SET, buyers may want to begin with an understanding of how this important component works. A system in itself, knowledge of the various parts within it can help buyers better determine the cause of failure. SET are important vehicle exhaust components. They convert harmful engine emissions, such as hydrocarbons, carbon monoxide, and nitrogen oxides into less harmful compounds. Many governments mandate the installation of SET on all vehicles in an attempt to reduce the level of vehicle emissions polluting the atmosphere.

Replacing a SET is a simple process for buyers who go into it equipped with some basic knowledge. Shoppers need to consider the make and model of vehicle when purchasing a SET. There are a number of different aftermarket brands to select from, or shoppers can purchase parts manufactured by the company that made the car. Before replacing a faulty SET, buyers should troubleshoot the engine and exhaust system to ensure there are no other underlying causes for the failure. Due to government regulations and emissions testing, replacing a SET and related parts is not something that can be put off. Driving a vehicle with a faulty SET is damaging to the vehicle and the environment. Shoppers who go into it armed with a basic knowledge of how SET work, why they fail, and how to select the right one, find purchasing one an easy task.

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