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THE EFFECT OF DIFFERENT INTAKE MANIFOLD GEOMETRIES ON SINGLE-CYLINDER DIESEL ENGINE SOOT FORMATION AND PERFORMANCE

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Abstract - Intake port geometry is the most important design parameter for air intake to the combustion chamber of engines. Particularly in diesel engines, it is desirable that the intake port geometry in the formation of the fuel-air mixture form a certain horizontal vorticity ratio since only the air is introduced into the combustion chamber and the fuel is injected into the air. In this study, the cylinder head manufactured with 3 different geometries of the intake port of a single cylinder compression ignition engine experimentally examined the effect of engine power, torque, and specific fuel consumption. As a result of the work, power, torque, specific fuel consumption is experimentally measured. In the study results, different types of intake port designs were found to be effective on power, torque, specific fuel consumption.

Keywords - Intake Manifold, İntake Port, Mold, Spade, Single Cylinder Diesel Engine

I. INTRODUCTION

The rapid decline in world oil reserves, rising prices in the supply-demand balance of such fuels and price instability are serious burdens especially for developing country economies. For such reasons, a lot of work has been done to make such fuels more economical. Indeed, the work on all internal combustion engines suggests that the combustion process is to be improved, with the aim of better utilization of the energy obtained from fuel burned in the cylinder, not in the mechanical field. For this reason, most of the work done to increase the efficiency and reduce the fuel consumption in internal combustion engines are aimed at increasing the combustion quality. Taking air into the cylinder in the diesel engine and the injection is made directly into the cylinder. The mixture within the cylinder is dominated by the geometry of the piston and the turbulence effect created in the intake air. In diesel engines, a very good mix of in-cylinder mixture directly affects the emission and combustion efficiency.

Therefore m otorrhea all working conditions and increasing the volumetric thermal efficiency, which are the current issues to be studied down to levels close to the minimum level of frictional losses in the current technology [1].

The effects of increasing the turbulence in the intake manifold on the engine performance were investigated in studies conducted by C.Sayın, İ.Kılıçaslan and his colleagues. As a result, it was observed that turbulence increased by 1.1% in engine power and decreased by 4.4% in specific fuel consumption [2].

I. Hits, D.Igorga, L.Mihon. N. Uricanu, G. Piciorea, and colleagues examined the performance of the intake manifold system with experimental tests and mathematical calculations on the engine e63 of the BMW N52 vehicle. With the help of CFD software, they have succeeded in optimizing the intake manifold, filling grade, hydraulic resistance, pressure drop and temperature [3].

In their studies on YL Qi, LC Dong, H. Liu, PV Puzinauskas, and KC Midkiff intake port designs, vortex formation was observed in the upper part of the intake port, and the rotation rate and volumetric efficiency decreased during the intake time. With a small modification, the vortex formation in the intake port was removed from the center, and the rate of rotation was observed to increase. At the same time, the new design showed a 20% increase in fuel evaporation [4].

The X. Zeng and J.Wang double-loop EGR engine air-orbit system are working on the control of the adjustable intake manifold; they used three different intake manifold designs and tried to determine the highest control and the fastest response during the transition process. Here, fuel efficiency is improved and emission values are reduced [5].

MA Walnut examined the effects of intake fill volume and effect on engine performance, cycle efficiency and emission characteristics. As a result of the study, it was observed that the engine performance of filling capacity was improved and the pollutant emission was reduced. It has also been found that increasing the fill volume between 1700 rpm and 2600 rpm improves break torque and associated performance. In addition, it has been observed that increasing the occupancy volume increases the intake runner's pressure, introduces a simpler mixture, increases the cycle efficiency, and interestingly reduces the average effective pressure (COVimep) [6].

Jemni, Kantchev, and Abid worked on the effects of diving and lightweight heavy-duty machines on another intake port design, not specified by anintake port design, working with the acoustic wave filling principle. It is seen here that the fuel mixture is more efficient and improves the combustion properties when the first manifold is used. For this reason, it has been shown that due to the reduction in load losses, the mixture in the cylinder is of proper homogeneity and growth [7].

Green and Moumtzis studied mathematical techniques on the flow behaviors of combustion devices on the upper side. They have also found that the volumetric flow distributions depend on variables such as manifold shape, length, and flow field. Which supports previous work [8].

Chen and colleagues conducted a study on the turbulence model for flow in the distribution manifold. The standard k-ε model (KF), renormalized group k-ε model (RNG) and realizable k-ε model (REAL) turbulence models for the same manifold flow were investigated. In the geometry (manifold), the most concordant result with the experimental results is the realizable k-ε model [9].

Walnut and Akin have done a study that examines the influence of inlet plenum length/volume effects on the performance characteristics of a spark-ignition engine with electronically controlled fuel injectors. The engine, which is a multiple fuel injection system that uses electronically controlled fuel injections, has only an air intake manifold and is injected through the fuel intake valve.

The supercharging effects of the inlet plenum of varying lengths, especially when the intake manifolds are airborne, will be different from carburetor motors. The engine tests have been done with a new variable-length intake manifold aiming to be a basic study for plenum design. Motor performance characteristics such as braking torque, braking power, thermal efficiency, and specific fuel consumption are taken into account to evaluate the effects of input plenum length change. As a result, the change in plenum length has determined that the system used in urban roads has improved the engine performance characteristics at low engine speeds and high fuel consumption. According to the test results, they found that the plenum length should be shortened at low engine speeds and shortened as engine speed increases. [10].

Karthikeyan et al. have emphasized that a properly designed intake manifold in their work is necessary for the internal combustion engine to perform well. Airflow in the intake manifold is one of the important factors driving engine performance and emissions. For this reason, the flow in the intake manifold must be optimized to produce more engine power and reduce emissions with better combustion. In this study, the pressure fluctuations for the intake manifold in the new engine development process were simulated using 1D AVL-Boost software to study the internal airflow characteristics of a 3-cylinder diesel engine in transient conditions.

Based on the 1D simulation results, the design of the intake manifold is optimized using 3D CFD software under steady-state conditions. As a result of this 3D CFD analysis, the disproportionate flow of air in the runners was determined and the pressure in the runner was experimentally examined on the engine test bench. The engine smoke level was also examined using an engine test bench for the initial and optimized manifold. As a result of the research, they determined that the pressure inside the runners was uniform and the smoke level decreased for the optimized intake manifold design [11].

Lee and Yoon have studied the variation of the factors affecting the volumetric effects such as a volume of the pressure chamber for the optimal design of the input system. They tried to determine the length of the pressure chamber of the intake manifold and the pipe lengths and of the equilibrium reservoir. Experimental tests have been carried out to obtain the intake manifold exceeding various engine speeds and the pressure history in volumetric efficiency. The optimal dimensions for the test motor input system were determined: 140 cm for the length of the intake pipe, 2000 cc for the volume of the pressure chamber and 90 cm for the length of the intake manifold. The optimum intake system and the volumetric efficiency of the motor obtained in this study are about 4 % higher than the original system operation [12].

Jemni et al. especially diesel engines for trucks and buses have caused many economic and ecological problems. Diesel exhaust emissions are a major source of pollution in urban centers most of the world. In addition, the price of crude oil continues to increase rapidly. The use of alternative fuels (liquefied petroleum gas, LPG and compressed natural gas, CNG) and combustion optimization provide effective results. Taking all this into account, they have argued that the improvement of the quake is related to the improvement of the direct intake system, especially the intake aerodynamic movements influenced by the intake manifold. In this study numerically and experimentally, two methods have investigated the effect of the geometry of two intake manifolds on the in-cylinder flows. These two manifolds are mounted on Sfax on a six-cylinder, fully equipped, 13,8 l displacement, heavy duty, IVECO engine in city buses. This engine has been tested with two fuel spark ignition engines for gasoline and gaseous fuel. The first manifold provides an indefinite geometry, while the second geometry provides the optimal filling geometry. Three-dimensional numerical modeling of turbulent cylinder flow with two manifolds was made. The model is based on solving Naviere-Stokes and energy equations together with the standard kernel turbulence model using 3D CFD code FloWorks. It is possible to do this modeling in order to examine the internal flow structures in order to examine the appropriate manifold. Experimental measurements are also made to verify this manifold by measuring significant engine performances at the same time.Brake force (BP), brake torque (BT) and brake heat (BTE) are increased by 16 %, 13,9%, and 12,5%, respectively, using the best manifold. Brake specific fuel consumption (BSFC) is reduced by 28 %. The benefits of the optimized manifold geometry on simulation and test results, in-cylinder flow, and engine performances have been verified [13].

Martinez-Sanz et al. they aimed to develop a high-performance new intake manifold design through the combination of CAD and FEM. First, FEA model was made.This model includes complete thermal and structural analyzes of the new intake manifold using CATIA, ANSYS, WORKBENCH, MATHCAD. Then some compound prototypes were made and analyzed. Different studies and studies have been carried out to model an intake manifold using new materials. Finally, when compared to some materials such as steel, alumina was chosen considering the properties to be used for thermal efficiency and low weight factors. In the case of adding interconnection for the wheel, there is a new problem. The correct solution to the problem has been identified as the attachment of both parts with an adhesive. In this case, the tension in the connection would be minimum and the fatigue value would be the usable value for the application [14].

In this study, three different cylinder heads experimented in which different intake port geometries were applied and the engine pressure, fuel consumption, volumetric efficiency, torque, power, pressure, and temperature of the oil, exhaust and control room, relative humidity and haze/data have been obtained on business issues.

II. MATERIAL AND METHOD

The experimental study made Anadolu Motor Production and Marketing Inc. was carried out at an engine test workshop connected to the R & D department of the company. The technical characteristics of the motor used in the experimental study are detailed in Table 1.
The test setup is shown in Figure 1. Engine parts and parts such as cylinder walls, piston surfaces, rings, cylinder lid, injectors are checked to prepare the engine for test conditions. Required parts have been changed. While the motor was preparing for the test conditions, no changes were made except for factory values. The purpose of these experiments is; with different types of intake port designs, to obtain engine performance and fuel consumption values at different speeds. Parameters measured directly during the experiment; strength, power, engine speed, fuel consumption is. The test motor is connected to the dynamometer as shown. The momentum of the engine crankshaft is transmitted to the dynamometer via a coupler group and appears as a load on the force arm of the dynamometer. The engine speed is measured by a tachometer mounted on the engine dynamometer. Due to the high consumption of the fuel engine during the first run, the constant regime waited until the measurements were made. The amount of fuel consumed is measured volumetrically.

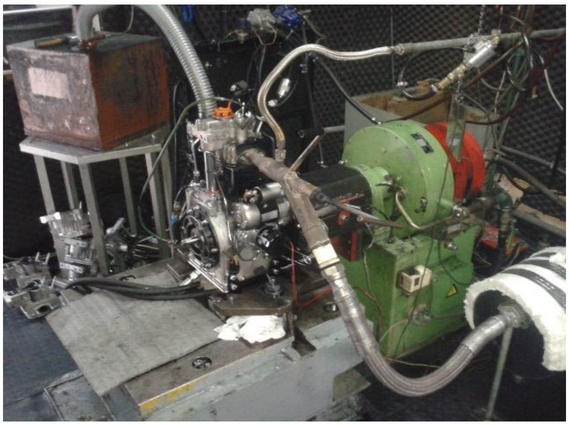

Figure 1.Experiment Setup View

Parameter	Value
Number of Cylinders	1
A volume of Cylinder	510 cm^3
Cylinder Diameter	85 mm
Stroke	90 mm
Compression Ratio	17,5:1
Engine RPM	3000 RPM
Engine Power	12 BG
Maximum Torque	3,35 Nm/1800RPM
Fuel Tank Capacity	5,5 l
Specific Fuel Consumption	190 g/BG.h
Oil Consumption	10 g/h
Crankcase Oil Capacity	1,75 l
Dry (Empty) Weight	60 kg

Tablo 1: The technical specifications of Antor 3 LD 510

Influence of geometric shape change on intake port, motor power and torque In order to investigate the effect on specific fuel consumption, three different intake port geometries as shown in Fig. 2 were prepared for the core and tests were carried out with the cylinder heads poured with them.

At the end of this geometric change made at the intake port, it is desired to obtain a more curved and smooth intake port design which will facilitate the flow of air.

The diesel engine is intended to change many of the changes in the intake manifold in a positive way. Perhaps the most important change from the targeted data is to increase the motor power. In the study, the effects of the cylinder head, which intake port geometries are different, on the motor power are examined. In the test setup, the engine, in which 3 different cylinder heads are mounted in total, the values obtained at 6 different cycles in the 2000-3000 rpm range have been examined.

Figure2. X, Y and P type view of the core of the intake ports

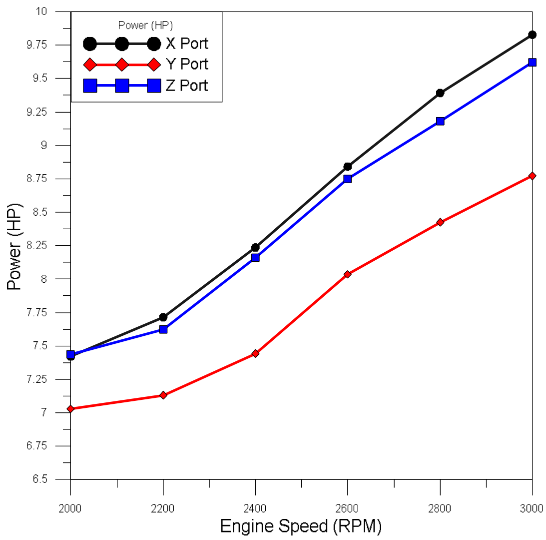

Figure 3. Power charts for 3 different intake manifolds

III. RESULTS

The results obtained from the experimental study are divided into the following categories.

Three different design values are presented here as X type, Y type, and P type. The design differences here are due to the difference in the geometry of the spins used in the production process. Each type of design was carried out in five separate runs and values were obtained, then the averages were obtained by programming.

Figure 3 shows the effect of 3 different intake ports on the motor power parameter. When the figure is examined, it is seen that the highest kind of gentle X type design is reached. While the P-type design shows fairly close values, the Y-type design shows low power values at recordable levels relative to the other two. The reason for this is thought to be due to the wider part of the swirl forming on the valve.

Another important data that we can specify is the change in the torque value curve with the speed shown in Figure 4. When the torque curves are examined, it is seen that the highest torque value is reached with the X type design. As the number of revolutions increases, the difference between the X type and the P type design is seen to be very close. The Y-type design showed low moment values at recordable levels compared to the other two designs. When the power parameter is examined, it is seen that similar results are obtained with the results we have compared.

Figure 5 shows the change of the intake air flow with the revolution. Since the volumetric rate willact,and the amount of air absorbed by a tiltmanometer connected to the intake manifold is measured.

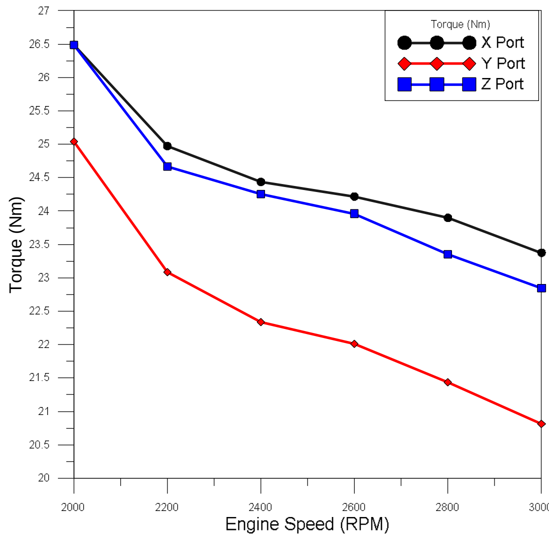

Figure 4. Torque charts for 3 different intake manifolds

When the intake air flow was examined, close values were obtained in all three types of designs. That is, the changing suction port geometry has not seemed to have a great effect on the flow of the absorbed air. Although no significant effect was observed, it was observed that at high revolutions it produced a difference of almost 10 kg / h. It was observed that the X type design exhibited higher consumption at lower speeds, but the state changed with increasing engine speed. After 2700 RPM, the P type design shows higher consumption.

Figure 6 shows the variation of the specific fuel consumption values with the engine speed. If the graph is examined, it is seen that the specific fuel consumption, in general, reaches an optimum value at 2400 rpm and then it goes to increase.

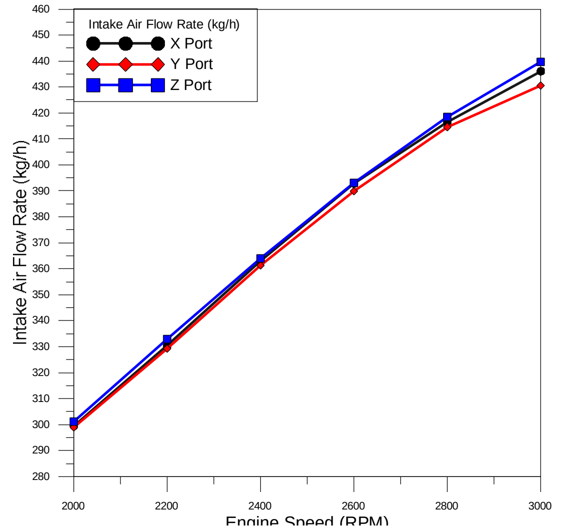

Figure 5. Intake air flow charts for 3 different intake manifolds

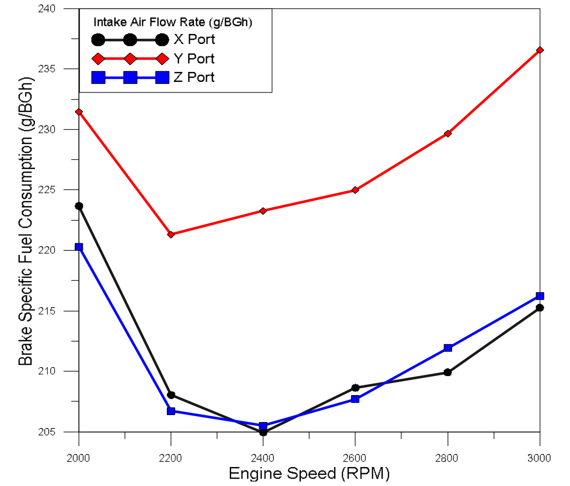

Figure 6. Specific fuel consumption charts for 3 different intake manifolds

It is understood that the X and P type intake port has the lowest specific fuel consumption value. In addition to low power and torque requirements for the Y-type intake manifold, the specific fuel consumption is higher than the others, which means that the design is bad.

CONCLUSION

Studies on the suction port geometry of single-cylinder diesel engines are limited in the literature and insufficient in scope. The intake port geometry directly affects the combustion efficiency, as the process of cylinder mixing is very important in diesel engines. It has been observed in the literature that simulation studies have been carried out in this regard and this experiment has been carried out experimentally. Future work is thought to be beneficial in making lighting and higher-performance, lower-fuel, environmentally friendly engine design work.

As a result of the performance tests on the engine of the X type, Y type, and P type designs produced with the old mold and the new mold poured,

- The highest power is achieved with P type and X type design. The Y type design gives the lowest power values.
- The lowest fuel consumption is seen in P type and X type designs.
- No significant effect on the manifold and intake port design has been observed in the intake air.
- However, it is understood from this study that the specific fuel consumption values of the intake port geometry are directly related to the combustion efficiency. This is because the turbulence generated by the intake port geometry and the turbulence generated inside is influenced more and it can be said that the improvement or deterioration occurs at this point.

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