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NEWSLETTER CHAIR MESSAGE

Why Attending ASHRAE gathering

Every January of every year ASHRAE invites all HVAC & R professionals from all over the world to attend high quality technical seminars and short courses presented by the ASHRAE Learning Institute and ASHRAE conference, and visit AHR Expo.

This ASHRAE winter meeting shall take place in Orlando, the Orange Country. The Meeting shall be held on 22 of January through 27, 2016, where the ASHRAE Leaders will meet to discuss ASHRAE Business and Technical Committees, and plan for the future.

ASHRAE Conference this year shall provide full day professional development seminars covering Energy Audits, Commissioning, ASHRAE Standards, Maintenance and Operation of High performance buildings, Noise and Vibration Control, Energy Modeling, Dedicated Outdoor Air, Energy Recovery, Refrigeration, and many more.

In Orlando, ASHRAE shall provide a half-day short course program full with technical paper sessions on current applications and research on fundamental concepts and basic theory.

HVAC & R professionals will benefit out from the technical and general tours and enjoy the social events and the plenary sessions.

Students always share part of the ASHRAE agenda where their program at Orlando shall cover technical seminars, training, social events and technical tour. Students are attending from many countries.

In parallel with ASHRAE meetings and conferences, ASHRAE is proud to sponsor the AHR Expo that is attracting over 60,000 professionals from more than 140 countries where AHR Expo provides the opportunities for engineers seeking solutions in today’s changing building environment.

The assembly of HVAC & R industry members will be at the EXPO from 25 January through 27 2016.

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Fady Abu Jamra – President Elect
Salah Nezar – Vice President
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Chinna Kannan

Hassan Sultan - Chair
Kinan Fahs - Member
Mostafa Hariri - Member
ASHRAE Certification Program is always available for everyone to high grade his reputation in the workplace which has become a must-have Credential for built-environment professionals.

All of the above mentioned and many more activities & events to attract more visitors to Orlando.

ASHRAE members at Qatar Oryx Chapter and the HVAC & R professionals in Qatar are invited to attend the world’s largest HVAC & R event. We would be delighted to welcome all the Contractors, Consultants, Engineers, Architects, Stakeholder, Government Engineers, Sales Engineers & Managers at this event.

Faithfully yours,

Hassan Sultan
Former President
ASHRAE Qatar Oryx Chapter
ASHRAE RAL SA, RVC
E&IEC Organizing Committee Chair
ARTICLE

New Induction Manifold Designs for High Performance and Low Emission Diesel Engine Running on Alternative Fuels

Dr. Samer F. Ahmed
Thermo fluids Group, Mechanical and Industrial Engineering Department, College of Engineering, Qatar University, P O Box 2713, Doha, Qatar

I. Introduction

The fluid motion in an internal combustion engine is induced during the induction process and later modified during the compression process. Intake charge enters the combustion chamber through the intake manifold. Then the kinetic energy of the fluid resulting in turbulence causes rapid mixing of fuel and air if the fuel is injected directly into the cylinder. The in-cylinder fluid motion governs the flame propagation in controlling the fuel-air mixing and premixed burning in diesel engines. Therefore, it is very much essential to understand the in-cylinder fluid motion thoroughly in order to optimize the combustion chambers for the modern I.C engines like GDI, HCCI engines etc. The kinetic energy of the fluid resulting in turbulence causes rapid mixing of fuel and air. In addition, Heywood has stated that generating a significant swirl and/or tumble motion inside the engine cylinder during the intake process was one of the promising ways to obtain high in-cylinder turbulent intensity. Prasad et al reviewed the PIV (particle image velocimetry) studies and had reported the basic components of PIV algorithms, optical considerations, tracer particles, illuminating lasers, recording hardware, typical errors associated and vector processing in order to investigate the induced flow motion in the induction manifolds.

In another work, the experiences with in-cylinder measurement using PIV, mainly with air seeding and multiple reflections on the glass liner have been described. It is reported that the PIV measurement was useful tool for evaluating in-cylinder flows especially when combined with numerical simulation. Other investigations have conducted PIV measurements on various engines and reported that the flow structure changes substantially along the cylinder length because of the geometry of the intake valve port and the tumble motion was generated during induction process. Moreover, it has been reported that the increase in the air flow rate at higher engine speed causes the vortex center to move right-upwards compared to the lower engine speeds. Li et al have investigated the instantaneous 2D velocity fields around the intake valve of an I.C engine under static and dynamic conditions by means of PIV. They have observed that for
the given intake valve lift and pressure drop across the intake valve, the static analysis showed higher jet velocity than the dynamic analysis.

Experimental investigations using the LDA technique have been carried out to study the engine in-cylinder flow characteristics. The results showed that the flow structure during the intake was very much affected by the intake valve lifts with the formation of up and down flows and a strong flow reversal below the intake valve generated during the intake closure period. Also, the addition of swirl into the engine was altering the flow structure, particularly below the intake valve.

Swirl is one of the principal means to ensure rapid mixing between fuel and air in Diesel Injection diesel engine, and is used in gasoline engines to promote rapid combustion. The swirl level at the end of the compression process depends upon the swirl generated during intake process and how much it is amplified during the compression process. In direct injection diesel engine, as fuel is injected, the swirl converts it away from the fuel injector making fresh air available for the fuel about to be injected. The induction swirl is generated either by tangentially directing the flow into the cylinder using directed ports or by pre-swirling the incoming flow by the use of a helical or spiral or helical-spiral ports. Helical ports are more compacted than normal manifold. They are capable of producing more swirl than directed ports at low lifts, but are inferior at higher lifts. Either design creates swirl at the expense of volumetric efficiency. In trying to optimize the port design for both good swirl and volumetric efficiency, current high swirl ports are in part of both directed and different technique inlet manifolds.

Controlling of flow through the manifold is critical for meeting the emission regulations and fuel economy requirements. Parameters like engine speed, manifold and combustion chamber configuration are directly influence the swirl in DI diesel engines and subsequently it plays a vital role in mixing air and fuel inside the cylinder. Bugrake presented a flow model to predict the swirl vortices and turbulence in an open chamber cup-in piston engine. The work was compared with experimental data over a range of engine intake manifold and combustion chamber configurations. A number of studies have been conducted on engine flow and the parameters that affect the turbulence, performance and emissions in a DI diesel engine. Kajiyama and Nishida carried out the modeling of flow distribution in exhaust manifold. Modifications were made on the inlet and exhaust manifolds based on the results obtained. They also conducted experiments and validated the performance and emissions of the engine.

Akira et al presented an experimental analysis for turbulence inside the combustion chamber of direct injection diesel engine. This study has showed clearly the effects of piston bowl shape, engine speed, manifold shape and compression ratio on the flow fields in a DI diesel engine. It was concluded that the manifold shape has a considerable effect on the flow structure inside the cylinder. Martin conducted a
study on the flow behavior in intake and exhaust system of an internal combustion engine and observed that the flow phenomenon inducts closely affecting the volumetric efficiency of the engine.

Other parameters such as the outlet angle of the manifold plays a major role of increasing engine efficiency in terms of brake specific fuel consumption (BSFC), brake means effective pressure (BMEP) and volumetric efficiency. Moreover, swirl induction and turbulence level are enhanced by varying the outlet angle to different degrees.

All of these previous investigations studied using conventional diesel fuel. On the other hand, fewer studies investigated the use of GTL Diesel with design parameters. It can be analyzed that the design of inlet manifold configuration is very important to improve the efficiency and reduce emissions in IC engines and in particular diesel engines. Hence, this work develops new designs of helical, spiral and helical-spiral combined configuration of the induction manifold and calculate the induced mean swirl velocity and the generated swirl number. Therefore, the main objectives of the study are to understand the effect of different (helical, spiral, helical-spiral) inlet manifold configurations on combustion performance and emissions in a DI diesel engine fueled with GTL fuel. The experimental methods are presented next while the results are presented and discussed in Section III.

II. Experimental Methods

The experiments were carried out on a T85D single cylinder, four-stroke, water cooled, direct injection, compression ignition engine attached to DIDACTA ITALIA engine test bed, Fig. 1. An electric dynamometer with motor and a load cell was coupled to engine. Engine specifications are shown in Table 1. Two fuel tanks were assembled in the test bed; one tank was used for conventional diesel fuel and the other was used for GTL Diesel. The properties of the used fuel are mentioned in Table 2.
Figure 1. A schematic diagram of the diesel engine test rig and the experimental setup.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Cylinders</td>
<td>single cylinder, 4-stroke</td>
</tr>
<tr>
<td>Engine Type</td>
<td>Compression ignited</td>
</tr>
<tr>
<td>Type of Cooling</td>
<td>Water-Cooled Engine</td>
</tr>
<tr>
<td>Bore (m)</td>
<td>0.082 m</td>
</tr>
<tr>
<td>stroke (m)</td>
<td>0.068 m</td>
</tr>
<tr>
<td>Max. Power (H.P.)</td>
<td>6.5 H.P.</td>
</tr>
<tr>
<td>Used Fuel</td>
<td>Diesel or GTL</td>
</tr>
</tbody>
</table>

Table 1. Engine specifications.

<table>
<thead>
<tr>
<th>Property</th>
<th>Diesel</th>
<th>GTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density at 15 C (kg/m^3)</td>
<td>866</td>
<td>760</td>
</tr>
<tr>
<td>Kinematic viscosity at 40 C (cSt)</td>
<td>1.6-7.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Flash point (1C) (closed cup)</td>
<td>55</td>
<td>&gt;55</td>
</tr>
<tr>
<td>Calorific value (MJ/kg)</td>
<td>44.3</td>
<td>47.3</td>
</tr>
<tr>
<td>Cetane No. (min)</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>Carbon content (% by weight)</td>
<td>86.98</td>
<td>94</td>
</tr>
<tr>
<td>Hydrogen content (% by weight)</td>
<td>12.99</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Table 2. Fuel properties.
The in-cylinder pressure was measured by using a water cooled piezoelectric pressure transducer AVL QH 33D which was mounted flush at cylinder head and connected via AVL charge amplifier. The output signal was displayed on Instek GDS-3152 Digital Storage Oscilloscope with 150 MHz sampling rate. Then, the data was transferred to a laptop which saved for further analysis. The crank shaft position was measured using a digital shaft encoder.

The engine speed was measured by using a speed tachometer that used the pulse counting principle to detect the crank shaft speed, while the fuel flow rate was measured by using a calibrated burette and a stopwatch. The engine torque was measured by using a load cell. Engine NOx emission was measured by a long life electrochemical sensor at NOVA-7465PK portable engine exhaust emission analyzer. This electrochemical sensor has anodes, cathodes and suitable electrolyte sealed inside it which, when exposed to gasses, produces a small output current. This output is directly proportionally to the amount of NO gas in the sample. A Pre-Amplifier board directly mounted on the top of the sensor boosts the small signal and converts it to an output of 1 mV per PPM. This output is then sent the main microprocessor board, corrected for the calibration then displayed on the LCD display meter. The resolution of the NOx sensor is ±1 PPM. The test rig is also equipped with a type-K thermocouples to measure air inlet manifold, engine cooling temperatures and exhaust temperatures which were mounted at relevant points. Normal engine test bed safety features are also included. Atmospheric conditions (temperature and pressure) were monitored during the tests.

The new induction manifold has been 3D designed using SolidWorks software which has helical and spiral shapes. The outlet angle of the manifold, relative to the inlet port are set to be 0°, 30° and 60° with two configurations of inner diameter: the red one is with one inner diameter turn of the standard intake manifold and the white one is with double inner diameter turn of the standard intake manifold, as shown in Fig. 2. The goal is to investigate not only the effect of main manifold configuration designs on the generated air swirl, but also the outlet angles of these manifolds relative to the inlet port. The modified intake manifolds have been manufactured using Fused Deposition Modeling (FDM) additive manufacturing Technology with a 3D printer for built our rapid prototype. UPrint SE Plus 3D printer with .254 mm layer thickness 203 x 203 x 152 mm working space was used. The material of manufactured parts from ABS filament which has a good mechanical and thermal property. ABS has a lot of advantages strength, flexibility, machinability, and higher temperature resistance properties which was the most proper rapid prototyping. This material is suitable for the new manifolds since the induced air passes through these manifolds at nearly ambient temperature and pressure.
III. Results and Discussion

In this section, a comparison between the new manifold designs and the standard manifold of the engine in terms of engine performance and emissions is presented. A number of experiments have been conducted when the engine runs at different loads and different speeds. In addition, the results of the best performance designs of the white color manifolds and the red color ones are shown when the engine uses diesel and GTL fuel to show the fuel effect with these new designs.

A. Engine Performance

Table 3 shows the values of the new design configurations with respect to the inner diameter, outlet angle and calculated geometrical swirl numbers. It can be observed that, the swirl number of helical-spiral manifold with 60° and double inner diameter is about 1.34, which is the highest value comparing to the other configurations. This indicated that this particular design configuration is expected to create high mixing level of the air-fuel mixture inside the combustion chamber.
Table 3: New intake manifold configurations used in the current experiments.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Color</th>
<th>Manifold type</th>
<th>Outlet angle</th>
<th>Manifold No</th>
<th>Swirl number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>black</td>
<td>Standard</td>
<td>0</td>
<td>1</td>
<td>0.091</td>
</tr>
<tr>
<td>2</td>
<td>Red</td>
<td>Helical and spiral with same inner normal diameter</td>
<td>0</td>
<td>2.a</td>
<td>0.093</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>2.b</td>
<td>0.385</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>2.c</td>
<td>1.155</td>
</tr>
<tr>
<td>3</td>
<td>White</td>
<td>Helical and spiral with doubled normal inner diameter</td>
<td>0</td>
<td>3.a</td>
<td>0.097</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td>3.b</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>3.c</td>
<td>1.34</td>
</tr>
</tbody>
</table>

Preliminary results have been obtained for the in-cylinder pressure versus crank angle when the engine runs with different manifold designs and different fuels. Figure 3 shows an example of the pressure profile inside a cylinder when the engine was running on diesel fuel at 1300 rpm at 3 N.m load. Similar curves will be obtained in the future work to compare the maximum in-cylinder pressure, pressure rise rate, knocking tendency and cycle-by-cycle variations for all the conditions under consideration. The comparisons of curves such as that in Fig. 3 helps to study the combustion characteristics of the new intake manifolds. Further improvement of the noise filter and analyze the output data of these curves will be included in the final submission of this paper.
Figure 3. In-cylinder pressure versus the crank angle degree for the standard intake manifold. The engine runs on diesel fuel at 1300 rpm.

The bsfc is a measure of engine efficiency. In fact, bsfc is inversely related to engine efficiency, so that the lower the bsfc the better the engine efficiency. The variations of brake specific fuel consumption at different load sand speeds for standard, spiral, helical and helical spiral inlet manifolds fueled by diesel and GTL fuels are shown in Fig. 4. It can be observed that brake specific fuel consumption of new inlet manifolds have a similar trend to the standard one. In general, bsfc decreases with load and speed. This trend is well established in the literature. It can be noted from Fig. 4 that brake specific fuel consumption for all new manifolds is less compared to the standard manifold. The values of brake specific fuel consumption of standard, spiral, helical with doubled diameter and 60 degree outlet angle was decreased significantly specially with increasing speeds and loads. This may be related to the high mixing enhancement with this new design, which improve the combustion efficiency of the fuel. As a result, the engine thermal efficiency increases especially when GTL diesel is used. This can partially attributed to the higher calorific value of GTL, which increases the engine power at the same fuel consumption. Moreover, the GTL has a lower density and viscosity and high cetane number in comparison to conventional diesel fuel as demonstrated in Table. 2. All these properties are in favor of improving fuel evaporation and mixing with air, which lead to better combustion efficiency.
A nitrogen oxide NOx emission is one of the major pollutants of diesel engine due to high pressure and temperature inside the cylinder. The majorly of this pollutant comes from nitrogen oxide (NO). Figure 5 shows the comparison of NOx emission with different speeds and loads between the best performance new inlet manifolds and the standard inlet manifold. The NOx emissions for diesel engine with the new inlet manifolds No. 2c and No. 3c with GTL fuel are the lowest emissions among all other manifold designs, including the standard one. This is due to the low level of fuel injected with these cases, which tends to decrease the maximum temperature in the cylinder by the leads to less NOx formation.
Figure 5. NOₓ emissions comparison between the best performance red manifolds No. 2 and the best performance white manifolds No. 3 with diesel and GTL fuel. 3(a) at constant load and 3(b) at constant speed 1300 rpm.

Figure 6 depicts the variation of exhaust gas temperature for diesel engine of different inlet manifolds. As before, the new manifold designs are compared with the standard manifold No. 1 at variable loads and speeds. Exhaust gas temperature is an indication for conversion of heat into work that takes place in the cylinder. The exhaust gas temperature is higher for diesel engine with the standard manifold than that of the new designs. At various load conditions, it is observed that the exhaust gas temperature increases with load because more fuel is burnt to meet the power requirement. Moreover, it can be seen that, in the case of the engine with the standard inlet manifold, the exhaust gas temperature is about 298°C, while temperature decreases to 214°C with manifold No. 2c with GTL fuel.

Figure 6. Exhaust gas temperature comparison between the best performance red manifolds No. 2 and the best performance white manifolds No. 3 with diesel and GTL fuel. 3(a) at constant load and 3(b) at constant speed 1300 rpm.
ASHRAE NEWS

PAPERS SOUGHT FOR IAQ 2016

IAQ 2016 Conference builds upon the success of the previous IAQ Conference in 2013 in Vancouver. The call for papers for IAQ 2016, “Defining Indoor Air Quality: Policy, Standards and Best Practices,” has been extended until Nov. 30, 2015. The conference is co-organized by ASHRAE and AIVC and takes place Sept. 12 – 14, 2016 in Alexandria, Virginia. Abstracts (up to 400 words) on a number of topics are requested. Upon acceptance, papers are due March 14, 2016.

REGISTER FOR ORLANDO

Have you registered for the ASHRAE 2016 Winter Conference?

New technical program tracks, more than 200 Professional Development Hour opportunities and the world's largest HVAC&R marketplace are just a few highlights of the Conference and AHR Expo that will take place in Orlando, Florida in January.

LEGIONELLOSIS RISK STANDARD

New ASHRAE Standard 188 establishes minimum legionellosis risk management requirements for building water systems and provides descriptions of environmental conditions that promote the growth of Legionella. Standard 188 is essential for anyone involved in design, construction, installation, commissioning, operation, maintenance, and service of centralized building water systems and components. Informative annexes and an informative bibliography contain suggestions, recommendations, and references to additional guidance.
ASHRAE Photos Gallery

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Sponsored by M/s Jersey Group

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