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A Survey on Combustion Engine Using Compressed Natural Gas-Diesel Fuel System

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ABSTRACT: Developmental practices of internal combustion engines using compressed natural gas (CNG) mix with diesel and petrol engines have been presented in this review paper.

KEYWORDS: natural gas, compression ignition engine, spark ignition etc.

I. INTRODUCTION

Md. Ehsan and Shafiquzzaman Bhuiyan[1] presented in their technical paper quantitatively evaluate dual fuel operation of small diesel engines with the simplest possible change of hardware, which could be suitable for applications where loads are changing less frequently or an engine attendant is already employed. For using natural gas a cross-flow gas mixing chamber was added to the air intake. All the diesel settings including fuel injection timing were kept at the factory defaults to retain instant interchangeability to diesel-only operation, in case natural gas is unavailable. Natural gas could be fed from line supply for urban users or a low pressure CNG package (LPCNG) developed by the author for rural or remote users. The maximum achievable diesel replacement by natural gas was found to vary with engine loads. The engine showed very similar performance compared to diesel-only operation near up to 90% of rated load with up to 88% replacement of diesel by natural gas being possible. The cost analysis showed promising socio-economic feasibility of running such engines in dual fuel mode in remote locations. The arrangement is currently engaged in field trials.

Abhay Tiwari [2] presented in their technical paper over the past many years, large numbers of car buyers have been opting for a petrol car with a compressed natural gas (CNG) kit fitted by the company. The most important thing was that the petrol engines cause global warming by having a large amount of toxic gases exhausted by the petrol cars. However, by the introduction of catalytic converters (a catalytic converter was a vehicle emissions control device that converts toxic pollutants in exhaust gas to less toxic pollutants by catalyzing a redox reaction) we have been able to reduce the toxic emissions. Use of Catalytic converters in internal combustion engines fuelled by either petrol or diesel, which reduces pollutants such as CO to a much less harmful gas, such as CO₂. Because of this, a catalyst car also consumes slightly more fuel, thus reducing its performance. However, by having these improvements, petrol engine cars with catalysts still exhaust more CO and HC than cars with diesel engine, and by using a CNG kit there are other problems such as starting problems and jerks. Therefore, CNG kit was not as useful as it was expected to be. An alternative to this was a diesel engine (dual fuel engine). However, a question arises that, Why Should one Choose a Diesel Powered dual fuel Engine over other. So the answer was Diesel fuel contains more energy per litre than petrol. Thus, making more efficient than petrol engine car. Diesel fuel contains no emissions of the regulated pollutants like (carbon monoxide, hydrocarbons and nitrogen oxides) which are quite less than those from petrol cars without a catalyst.

Therefore, diesel engines are attracting greater attention due to higher efficiency and cost effectiveness. Now, the main objective of this paper was to convert a diesel engine into dual fuel engine with compressed natural gas, which will overcome the problem of cost and global warming. This paper presents a dual fuel system for diesel-natural gas operation for a diesel engine, and analysis of the operating characteristics of the engine. Semin, R. A. Bakar and A.R. Ismail [3] presented in their technical paper the Compressed Natural Gas (CNG) was a gaseous form of natural gas, it has been recognized as one of the promising alternative fuels due to its substantial benefits compared to gasoline and diesel. Natural gas is produced from gas wells or tied in with crude oil production. Approach: Natural gas is promising alternative fuel to meet strict engine emission regulations in many countries. Compressed

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Natural Gas (CNG) has long been used in stationary engines, but the application of CNG as a transport engines fuel has been considerably advanced over the last decade by the development of lightweight high-pressure storage cylinders. Results: The technology of engine conversion was well established and suitable conversion equipment was readily available. For petrol engines or spark ignition engines there are two options, a bi-fuel conversion and use a dedicated to CNG engine. The diesel engines converted or designed to run on natural gas, there were two main options discussed. There are dual-fuel engines and normal ignition can be initiated. Natural gas engines can be operated at lean burn and stoichiometric conditions with different combustion and emission characteristics. Conclusions: In this study, the low exhaust gas emissions of CNG engines research and development were highlighted. Stoichiometric natural gas engines were briefly reviewed. To keep the output power, torque and emissions of natural gas engines comparable to their gasoline or diesel counterparts. High activity for future green CNG engines research and development to meet future stringent emissions standards was recorded in the study.

Mahesh M.Patil, Dr.R.R.Arakerimath [4] presented in their technical paper to analyze the performance, emission, and combustion characteristics of variable compression ratio (VCR), compression ignition (CI) engine using a suitable biodiesel as a fuel. The biodiesel is selected to conduct this experimental investigation is Compressed Natural Gas and Palm oil as a biodiesel in diesel dual fuel operation is regarded as one of the best ways to control emissions from diesel engines and simultaneously saving petroleum based diesel fuel. In the present work an experimental research was carried out on a laboratory single cylinder, four-stroke variable compression ratio, direct injection diesel engine converted to CNG-Diesel dual fuel mode and then blended with palm oil to analyze the performance and emission characteristics of pure diesel, CNG substitution rates and blended. The results reveal that brake thermal efficiency, brake specific fuel consumption, of dual fuel engine is in the range of 20%-60% at the rated load of 2,4 and 6kg which is Brake thermal efficiency is higher than pure diesel engine for 20%, 40% and 60% CNG substitution rates and slightly less in B20, B40, and B60. Brake specific fuel consumption of dual fuel engine is found better than pure diesel engine at all engine loads and for both CNG substitution rates but by applying biodiesel slightly greater than pure diesel due to its lower calorific value. It is found that there is drastic reduction in CO, CO₂, and HC, emissions in the exhaust of dual fuel engine at all loads.

Y.H.Basavarajappa, N.R.Banapurmath, A.J. Sangameshwar[5] presented in their technical paper energy was an essential requirement for economic and social development of any country. Sky rocketing of petroleum fuel costs in the present day has led to growing interest in alternative fuels like vegetable oils, alcoholic and gaseous fuels. At the same time there is continuous pressure on emission control through periodically tightened regulations particularly for metropolitan cities. In this situation there is an urgent need to promote use of alternative fuels as substitutes for high speed diesel (HSD). Dual fuel mode of operation employing CNG (Compressed Natural Gas) and methyl esters of plant oils like Honge and Jatropha oils is an attractive option for countries having a large agriculture base that can be used as a feed stock to obtain newer fuels. Use of such fuels can ease the burden on the economy by curtailing the fuel imports. The current paper presents the results on the performance of a dual fuel engine fuelled with Honge and Jatropha oils methyl esters (HOME/JOME) as injected fuels along with CNG induction. Effects of Injection timing, CNG flow rate, compression ratio and Exhaust Gas Recirculation (EGR) on the performance of dual-fuel engine has been presented. From the experimental evidence it is found dual fuel engine operated with optimized parameters of injection timing of 27° BTDC, compression ratio of 17.5, 6 mm carburetor and 10% EGR resulted in overall improved performance.

Stephen Tambari, Ibor Benjamin, Dokibo Daso, Kanee Sorbari, Allison John [6] presented in their technical paper petrol driven engines are the major contributor of environmental pollution. Environmental problems are well talked and written about but public and private sectors sensitivity remains very high. However, amidst the understanding that petrol driven engines contributes to about 15% green house gases, petrol shows no sign of quitting the energy scene. Therefore, one wonders if petrol engines offer better performance than CNG engines?. This paper is intended to answer this question by not just revealing the limitations delaying the full utilization of CNG but by carefully evaluating recent studies carried out on comparative studies of CNG engines and petrol engines. The evaluation is done based on; Performance, Storage and Safety, Maintenance, Emissions, Economy and Cost, Technology, Refueling, Refueling Station Cost, Engine Conditions, Legislation and Incentives, Adequacy of fuel supply, process efficiency, ease of transport and safety of storage, modifications needed in the distribution/refueling network in the vehicle, fuel compatibility with vehicle engine (power, emissions, ease of use, and durability of engine) and the Market place which is drawn from experimental results and conclusions made from recent studies.

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J.C. Egúsqiza S.L. Braga C.V.M. Braga [7] presented in their technical paper the performance and emissions characteristics of a turbocharged and aftercooled diesel engine operated with natural gas as primary fuel, and diesel fuel as ignition source. In such dual fuel operation, much of the energy released comes from the combustion of the gaseous fuel, while only a small amount of diesel fuel provides ignition through timed cylinder injection. The effects of diesel-natural gas substitution ratios, engine speed, and load on the equivalent brake specific fuel consumption and gaseous emissions of hydrocarbons, carbon monoxide and nitrogen oxides are examined for natural gas-diesel fuel operation and, afterward, compared with the original diesel operation. The results show that, over a wide range of operating conditions (engine speed, load), the dual fuel engine clearly shows the benefits of reduced NOX emissions. However, under low loads, the results indicate high CO and HC emissions and a higher BSFC when compared to those of the corresponding diesel engine.

Miqdam Tariq Chaichan[8] presented in their technical paper the characteristics of single cylinder diesel engine Ricardo E6 performance and emissions run with natural gas and diesel in dual fuel mode. In dual fuel operation, the major part of the energy released resulted from the combustion of the gaseous fuel. In the other hand, the small amount of diesel fuel provides an ignition source. Equivalence ratios, engine speed, and injection timing effects on the brake specific fuel consumption and engine exhaust emissions were examined for natural gas-diesel fuel operation and compared with neat diesel operation. The results demonstrate that, the dual fuel engine reduced NOX emissions clearly over a wide range of operating conditions. However, under lean equivalence ratios and low loads, the exhausted CO and HC emissions were high. Also, a higher BSFC resulted when compared to those of the diesel engine.

N.M.Chudasama, Prof. A.B.Patel , Vijay R. Chavda[9] presented in their technical paper the performance results of a 5.5kW Crompton Greaves make GL-400 diesel engine which was converted into spark ignition mode and run on compressed natural gas (CNG) at different compression ratios in range of 10 to 13.1 at load varying from 18% to 72% at 1800 rpm. Performance of engine found better at 12.4 CR for modified diesel engine fuelled by CNG. Modified engine efficiency found lower compare to diesel engine in range of 6 to 22% at 1800 rpm. Emission of CO, CO₂ and HC were reduced for modified engine compare to diesel engine.

P. M. Darade R. S. Dalu [10] presented in their technical paper the development of alternative fuels such as natural gases has become very essential because of the continuously decrease in the petroleum reserves and also their contribution for pollutants. In this paper, a survey of research papers on the utilization of Compressed Natural Gas in the Internal Combustion engines along with its effects on the performance and emissions is done. It is revealed that the performance characteristics except thermal efficiency and exhaust temperature, various other performance parameters like brake mean effective pressure, power, torque and brake specific fuel consumption are decreased for CNG fuelled engine while the emission characteristics of unburnt hydrocarbon, Carbon monoxide and Carbon-di-oxide except nitrogen oxides are better for CNG compared to petrol and diesel engines. The improvement in performance is observed with the addition of hydrogen.

Munde Gopal G., Dr. Dalu Rajendra S.[11] presented in their technical paper the research on alternative fuels for internal combustion engine has become essential due to depletion of petroleum products and its major contribution for pollutants, where Natural gas is one of the most promising fuel alternatives for the future. Independent of vehicle category, natural gas will help to bring down harmful emissions. Compressed natural gas (CNG) has long been used in stationary engine , but the application of CNG as a transport engine fuel has been considerably advanced over the last decade by the development of lightweight high pressure storage cylinder. There are various methods which use the compressed natural gas in IC engine with little modification. It is revealed that the performance characteristics are lower while the emission characteristics of CO, CO₂ HC are better for Natural gas compared to petrol or diesel and improvement is seen with the increasing of density. In this paper, a comprehensive review of the CNG engines research and development fuelled using CNG are highlighted to keep the output power, torque and emissions of natural gas engines comparable to their gasoline or diesel counterparts. The high activities for future CNG engines research and development to meet future CNG engines is recorded in the paper.

Ashok A. Mandal, Dr. R. S. Dalu [12] presented in their technical paper that fossil crude oil reserve was depleting fast will not last for a very long period. Hence there is a pressing need to find and develop new suitable ways to use alternative fuels driven by various factors such as cost, availability, performance and exhaust emissions as par with emission legislation. The major alternative fuels under consideration are propane, methanol, ethanol and natural gas. Natural gas clearly stands out as one of the best alternative fuels currently available having substantial benefits

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compared to gasoline and diesel. These include lower cost, higher octane number, lower maintenance cost and produce cleaner exhaust emissions. Ethanol is one another alternative fuel that can be used in SI engine especially as an additive in gasoline. Its use in engine is characterized

by improved power output, efficiency and fuel economy with lower exhaust emissions. In this paper, a comprehensive review on various aspects of S.I engines suited to CNG and gasoline-ethanol fuel has been highlighted. These alternative fuels hold the key to replace crude oil to a considerable extent

Vijay C Patel Bhavik B. Hirapara Prof. M A Shaikh [13] presented in their technical paper the research on alternative fuels for internal combustion engine has become essential due to depletion of petroleum products and its major contribution for pollutants, where Natural gas is one of the most promising fuel alternatives for the future. Compressed natural gas (CNG) has long been used in stationary engine as well as a transport engine fuel. There are various methods which use the compressed natural gas in IC engine with little modification. However, the brake thermal efficiency is increased with a compression ratio up to a limit of 12 at high engine loads. The maximum cylinder gas pressure is increased with increase in the compression ratio. The exhaust hydrocarbon (HC) and carbon monoxide emissions decreased with increase in the compression ratio, while the exhaust nitrogen oxide (NO_x) emission is increased with increase in the compression ratio. In this study, a natural gas spark-ignition engine employing cooled exhaust gas recirculation (EGR) strategy in a high pressure inlet condition was optimized. Both engine compression ratio and start of combustion timing were optimized in order to obtain the lowest fuel consumption accompanied with high power and low emissions. It was found that cooled EGR can significantly reduce NO_x emission at high compression ratio conditions.

Alberto A. Boretti [14] presented in their technical paper the turbocharged direct injection lean burn Diesel engine was the most efficient engine now in production for transport applications. CNG was an alternative fuel with a better carbon to hydrogen ratio therefore permitting reduced carbon dioxide emissions. It is injected in gaseous form for a much cleaner combustion almost cancelling some of the emissions of the Diesel and it permits a much better energy security within Australia. The paper discusses the best options currently available to convert Diesel engine platforms to CNG, with particular emphasis to the use of these CNG engines within Australia where the refuelling network is scarce. This option is determined in the dual fuel operation with a double injector design that couples a second CNG injector to the Diesel injector. This configuration permits the operation Diesel only or Diesel pilot and CNG main depending on the availability of refuelling stations where the vehicle operates. Results of engine performance simulations are performed for a straight six cylinder 13 litres truck engine with a novel power turbine connected to the crankshaft through a constant variable transmission that may be by-passed when non helpful to increase the fuel economy of the vehicle or when damaging the performances of the after treatment system.

Suresh M. Tank Prof. M A Shaikh Prof. V R Bhatt [15] presented in their technical paper fossil fuel reserves all over the world are diminishing at an alarming rate and a shortage of crude oil expected at the early decades of this century. Probably in this century, it believed that crude oil and petroleum products become very scare and costly to find and produce. Alternative fuel technology, availability and use must and will become more common in the coming decades. Nowadays in automotive industry, the applying of gaseous fuels and particularly compressed natural gas both in SI and CI engines is more frequent. Application of CNG in the spark ignition internal combustion engines is more real than never before. Most of its used was limited to retrofitted engines by conversing Bi-fuel engine. In this paper influence of ignition energy on the performance and emission was discuss. It was found that increasing the ignition energy one can increase the lean combustion capacity. And also increase in the performance and emission of the Bi-fuel engine in CNG mode comparable to petrol mode. . Objective of this study was to capability utilisation of CNG in Bi-fuel with little modification in ignition energy

II. CONCLUSIONS

1.It was found that the performance characteristics are lower while the emission characteristics of CO, CO₂ HC are better for Natural gas compared to petrol or diesel. The compression ratio has a large influence on the engine performance, combustion, and emissions.

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2. It was found that power produced by such Bi-fuel engine in CNG mode was found 14-18% less than gasoline mode. Because of the low volumetric efficiency, low compression ratio, low spark energy, and not sufficient spark advance in the bi-fuel engine

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