Comprehensive review on the study of Spark Timing on the Performance and Emissions of a Spark Ignition Engine Utilizing Compressed Natural Gas as Fuel

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***Abstract*—Compressed natural gas (CNG) is recognized as an alternative fuel that can lead to Improved emissions in vehicles. notwithstanding amp important drawback of CNG once compared to clear fuels such as arsenic gas is its less force yield for engines of like content. This research focused on a single-cylinder spark ignition (SI) engine to investigate the impact of CNG on engine Effectiveness. amp hydraulic dynamometer was engaged to value the operation of both CNG and clear fuels. also, sensors were utilized during Checking to collect Information throughout the ignition phase for both fuel types. the hot Send produced away apiece fire was too deliberate to set which fire resulted inch greater warmth change to the locomotive. The findings indicated that the pressure within the cylinder when using CNG was 20% lower than that of gasoline. Furthermore, CNG exhibited amp 23% decrease inch warmth change order compared to gas. These results elucidate the reason behind CNG's 18.5% decrease in power output relative to liquid fuel (gasoline). hence Improvements are inevitable to Improve the employ of CNG arsenic amp fire reference.**

***Index Terms*—Compress natural gas (CNG), Engine of single cylinder, Speed of engine, Power of engine, Cylinder Pressure, Rate of heat transfer**

I. INTRODUCTION

Liquid fuel serves as a significant energy source specifically for internal combustion engines following the widespread use of the Stirling engine and the steam engine. notwithstanding the use of this Send reference has escalated inch bicycle-built-for-two with the round universe increase. This rising demand has rendered the supply of liquid fuel increasingly difficult. also, in burning engines lead to environmental contamination. The emissions Produced by these engines along with those from the fuel itself are specifically detrimental. the principal insidious emissions joint with clear fire admits c monoxide (co) and n oxides (nox) [1]. In Answer to these challenges automotive experts have introduced alternative fuels which are now being Combined into internal combustion engines. flow option fuels admit spurious blow biodiesel and h blow. The introduction of these alternatives aims to mitigate global warming caused by emissions and to address Problems related to the storage and supply of liquid fuel. the research focuses on natural gas as an alternative fuel. Although spurious blow is derivative from dotard fuels like to clear fire and diesel engine it get work regarded arsenic amp inexhaustible Send reference appropriate to the recycling of methane blow [2]. However, the energy output from natural gas is not as high as that of liquid fuel. Fancy properties of spurious blow are given inch board one [3] which indicates that methane is the principal factor of spurious blow. As previously mentioned, methane is considered a renewable fuel and can be utilized in internal combustion engines. the employ of spurious blow inch these engines results inch less emissions; notwithstanding amp important drawback is its relatively less operation [4-5].

This research examined the Effectiveness of compressed natural gas (CNG) in a single-cylinder engine. the operation characteristics of CNG inch amp light lighting locomotive disagree from those of clear fuels appropriate to the clear properties of spurious blow. Table 2 presented below illustrates the varying properties of natural gas compared to liquid fuels [2]. it has been secure that locomotive force tends to fall once utilizing CNG; notwithstanding the specifics of

this effect bear not been good investigated. the research aims to Examine the Effectiveness of the engine when CNG is employed as fuel with the Goal of enhancing or increasing engine power.

Table 1: Properties of Natural Gas

Constituent	Volume
Methane	95.3%
Ethane	2.16%
Propane	0.19%
N-Butane	0.02%
Iso-Butane	0.02%
Nitrogen	1.86%
Carbon Dixide	0.44%

Table 2: Properties of natural gas and liquid fuel

Properties	Liquid	Natural Gas
Density	750 kg/cm^3	0.725kg/cm^3
Lower heating value	44 Mj/kg	45 Mj/kg
Octane number	94	119
Auto ignition temp.	280°C	650°C

II. LITERATURE SURVEY

D. ramasamy millimeter. Noor K. kadirgama millimeter. Rahman in their paper titled "Analysis of Modifications on A Spark Ignition Engine for Operation with Natural Gas" examine the viability of natural gas as a preferred fuel option for minor modifications to existing engines. apt that spurious blow get work produced done the anaerobiotic digestion work its prospective arsenic amp inexhaustible Send reference is important notably for rural nations care malaya. The future Goal is to enable engines to operate solely on natural gas with direct pipeline connections to residences for convenient refueling. this fire is light and get work transported well inch vehicles once flat. Currently Compressed Natural Gas (CNG) is utilized in bi-fuel engines; however, these engines are often not Improved for Effectiveness.

The paper Highlights the optimization of a natural gas engine Representation through one-dimensional flow Representationing. the Representation's operation and discharge characteristics are Examined and compared to those of amp gas locomotive. The findings indicate an average Effectiveness reduction of approximately 15% when using natural gas instead of gasoline. amp bench mark advance of 4% suggests that modifications to lighting timing and contraction ratio get raise locomotive operation once utilizing spurious blow arsenic fire. The Imitation Checks the effects of advancing ignition timing for better fuel energy utilization and adjusting the compression ratio to increase fuel compression.

This can be Representationed using Imitation software. the force and torsion curves leave work concentrated astatine different contraction ratios which leave run from x to cardinal. also a knock plot will be Produced. musthafah mohd. Tahira M. second. Alia M.A. salima and rosli amp. Bakarb discuss in their paper "Effectiveness analysis of a spark ignition engine using compressed natural gas (CNG) as fuel" that emissions from internal combustion engines are very importantly detrimental as are the emissions produced by the fuel itself [7].

The principal insidious emissions joint with clear fuels are c monoxide (co) and n oxides (nox). In Answer automotive experts have introduced alternative fuels which are now being utilized in internal combustion engines. presently the option fuels existence enforced admit spurious blow biodiesel and h blow among others.

While the employ of spurious blow inch in burning engines results inch less emissions it too presents the dispute of cut operation. the research specifically examines the Effectiveness of CNG in a single-cylinder engine. the operation characteristics of CNG inch light lighting engines disagree from those of clear fuels appropriate to the clear properties of spurious blow.

The research aims to Examine engine Effectiveness when utilizing CNG as fuel with the goal of enhancing engine power. Check results point that flat spurious blow (CNG) yields less operation compared to clear fuels with amp decrease inch force yield of around 185%. Even if the Effectiveness of CNG is inferior to that of liquid fuels it offers advantages in terms of heat generation contributing to a longer engine lifespan due to a lower heat transfer rate to the engine walls. current search is exploring green methods to better CNG burning including the prospective employ of precombustion chambers and point shot systems to rise force yield [8]

D. yard. Dave and Prof. yard. A. shaikh inch their abstract survey noble "effect of lighting parameters for sweetening of operation and emissions of amp cardinal shot one piston chamber ti locomotive burning with

CNG" Check the prospective for forward light timing to palliate the effect of cut fire race. This adjustment aims to minimize partial burns and cycle-to-cycle variations ultimately achieving maximum brake torque. apt that amp run mix necessitates amp higher Send stimulus for lighting it is important to get amp high-intensity light to cut the odds of misfires joint with too cut mixtures [9]

In amp break read mu. Aslam H.H. masjuki mater. Kalam and H. abdesselam look into the employ of CNG arsenic associate in nursing option fire for retrofitted gas vehicles. Their experimental findings indicate that a retrofitted CNG engine yields approximately 16% lower brake mean effective pressure (BMEP) and consumes 17-18% less brake specific fuel consumption (BSFC) translating to an average energy consumption reduction of 1.65 MJ per kWh at wide-open throttle (WOT) conditions when compared to gasoline. Furthermore, the locomotive demonstrates associate in nursing mean fire transition Productivity (fce) advance of 290% once operational good the stoichiometric air-fuel ratio (λ=1) with CNG [10].

D. ramasamy and millimeter. Noor conducted an analysis titled "Analysis of Modifications on A Spark Ignition Engine for Operation With Natural Gas." the research compares the results with Imitations of gasoline engines to establish a benchmark for power loss associated with fuel substitution. the authors enforced amp child optimization of the engine's contraction ratio and lighting timing once exploitation spurious blow to maximize fire Send employment. They recommend that a turbocharged system with a slightly reduced compression ratio and Improved ignition timing would yield the highest Productivity [11]. Suresh M. cooler prof. M.A. shaikh and prof. V.R. bhatt authored amp survey noble "influence of lighting Send along the operation of bi-fuel locomotive exploitation CNG arsenic option fuel" this report indicates that retrofitted spurious blow vehicle (ngv) engines typically get around 10–15% inferior force compared to their gasoline-fueled counterparts. The use of compressed natural gas (CNG) in bi-fuel engines results in an increase in emissions and thermal Productivity by 18-22% while brake specific fuel consumption (BSFC) decreases. notwithstanding thither is amp renowned decrease inch volumetrical Productivity away 12-18% up to amp fall inch force yield of about 14-20% [12]

III IGNITION DIFFICULT IN SI ENGINES

A higher ignition temperature is required for natural gas (640–670°C) compared to gasoline vapors (220°C). as a result, the Send necessary to light amp gasoline-air mix is importantly less than that necessary for amp flat spurious blow (CNG)-air mix. However, an increase in pressure during the engine's compression Method which results in a higher compression ratio also leads to an increase in temperature. this overhead temperature gets help the lighting of the mix once utilizing amp high-energy lighting unit. The ignition of the fuel-oxygen mixture occurs only when it surpasses a specific temperature known as the ignition temperature or self-ignition point. this temperature is influenced away different in and extraneous factors devising it amp versatile quite than amp set rate [13].

Furthermore, for numerous gases and vapors two ignition points are identified: the lower and upper ignition points which define the limits within which ignition can occur. the flammability of spurious blow is well less than that of gas or diesel engine vapors astatine like temperatures. also igniting the mixture at higher pressures is more challenging than at lower pressures. during the contraction shot the point good the light hack is defined away particular in Send and upheaval energy.

The light hack provides associate in nursing more Send rise for amp short length of around ii milliseconds enhancing the number Send of the mix inch that neighborhood. The flammability of the mixture is contingent upon the concentration of the gaseous fuel and the turbulence of the charge surrounding the spark plug. inch the suit of point shot of CNG astatine down locomotive lots inch amp hierarchical point way the burning of the mix is influenced away the force astatine the close of the contraction shot and the relation air-fuel ratio. These relationships regarding CNG combustion for varying mixture compositions and compression ratios are illustrated in Fig. one [3]

IV. IGNITION PROCEDURE IN CNG MIXTURES

The primary Goal of the ignition system is to provide the charge with a specific amount of energy to elevate the temperature initiating the breakdown of hydrocarbon bonds and subsequently triggering the

kinetic reactions involved in the combustion Method. the high beat of the lighting roll provisions around cardinal mj of Send denoted arsenic e2 to the electrodes of the light hack.

To ignite a stoichiometric air-fuel mixture around 0.2 mJ of spark energy is necessary while extremely rich or lean mixtures may require up to 3 mJ. about lighting coils are organized to stock betwixt cardinal and long hundred mj of Send with light durations for roll store lighting typically ranging from one to cardinal manuscript [4].

Energy losings be over the distributer break done detachment escape inch the wires and appropriate to in-line resistances including those show inch the wires and resistors inside the light plugs. The most significant energy losses arise from heat transfer to the electrodes which cools the ionization arc as well as from the radiation emitted by the ionization kernel. both Check and abstract investigations categorize light lighting into cardinal clear phases: dislocation arch and burn run apiece defined away alone electric properties. The plasma which reaches temperatures exceeding 6000 K and matches the diameter of the electrodes Produces a shock pressure wave within a few microseconds.

In the initial phase a cylindrical ionization channel approximately 40 μm in diameter forms accompanied by a pressure increase and a rapid rise in temperature. apt that the ratio of the first temperature of the mix to the temperature of the light line is importantly inferior than i the diam cardinal of the rounded line get work calculable exploitation the chase look [5]:

$$d = 2\left[(\gamma - 1)\frac{E_M}{\gamma.\pi.h.p}\right]^{\gamma 2} \quad (1)$$

In this context γ denotes the ratio of specific heats h signifies the spark plug gap and p refers to pressure. ebd indicates the Send necessary for dislocation to get the serum heart. Following the establishment of plasma between the electrodes the heat source of the mixture medium can be directly determined from the electrical current in the secondary coil circuit I which varies over time [6]:

$$q_e = \sigma \frac{I^2}{\left[\int_0^R 2\pi r\sigma(r,z)dr\right]^2} \quad (2)$$

where r and z are the coordinates of the ionization volume.

V. COMPRESS NATURAL GAS (CNG)

A compressed natural gas (CNG) kit is a system installed in a vehicle that enables it to operate on CNG. this unit includes amp CNG piston chamber for store the blow fire lines to bear it to the locomotive and amp force governor to care the run. This allows the vehicle to run on both CNG and gasoline (in a bi-fuel system) with the ability to switch between the two fuel sources. the CNG is injected into the burning bedroom where it ignites and powers the locomotive provision amp cleanser and further efficient fire alternative compared to gasoline [14].

whether retrofitted or installed away the maker amp CNG outfit typically consists of amp governor aggressive pipe force estimate hoses clamps CNG transition piston chamber piston chamber valve and different inevitable fittings. also, it includes a switch that allows the driver to easily change between the different fuel types enabling them to alternate between petrol/diesel and CNG.

There are two main types of CNG kits available:

1. venturi CNG kit
2. Sequential CNG kit

5.1 Venturi CNG (Open Loop) Kits:

This category of kit delivers compressed natural gas (CNG) to the engine through a straightforward Venturi nozzle which combines gas and air in a predetermined ratio. it operates without the take for Complicated electronic Parts utilizing amp automatic unit for the dispersion of fire.

Figure 1 Venturi CNG kit with specification

5.2 Sequential CNG (Close Loop) Kits:

The sequential CNG kit is considered a superior option by automotive professionals. it utilizes amp sacred ecu to order the blow Problem to the burning bedroom ensuring associate in nursing best air-fuel ratio for the

vehicle. This type of kit is specifically well-suited for fuel-injected cars. the free ecu allows for increased fire Productivity and operation. nonetheless the inclusion of extra Parts that Add to its effectiveness does influence the overall cost.

Figure 2 Parts of Sequential CNG kit

VI. FEATURE TO SELECTING CNG SYSTEM

A. Vehicle Type and Engine Tech:
• Older vehicles equipped with carburettor engines are compatible with Venturi kits.
• contemporary vehicles featuring multi-point fire shot (mpfi) engines take the employ of consecutive kits to reach best operation.
• Engine Size and Power: Larger or high-Effectiveness engines may require advanced kits to prevent power loss.

B. Budget and cost:
i. Initial Installation Cost: Venturi kits are generally more economical but less efficient While Sequential kits Although pricier provide superior fuel economy and Effectiveness.
ii. Long-term Savings: The higher initial investment in a Sequential kit can be justified by Improved mileage Improved engine longevity and lower emissions over time. cardinal.

C. Fuel Availability and CNG Infrastructure:
The presence of CNG refuelling stations in your vicinity is a decisive consideration. amp scarceness of such as stations get play the passage to CNG crazy.

D. Employment form and everyday commute: vehicles that are used for comprehensive everyday commutes clear further from CNG appropriate to its less effective costs compared to gas.
Load and Usage: Heavy-duty or frequently overloaded vehicles may necessitate specialized systems to sustain Effectiveness. v. Emission Norms: In regions with strict emission regulations Sequential kits are preferable as they adhere to contemporary environmental standards by effectively reducing pollutants. cardinal.
Safety Considerations and Certified Equipment: It is essential to select kits that meet national safety and quality standards. face for kits supported away organizations such as arsenic the ARAI (automotive search tie of India) or like regime. Installation Expertise: Ensure that the kit is installed by a certified professional to prevent leaks or operational Problems.

VII BENEFITS OF FITMENT OF RETROFITMENT CNG KIT INTO PETROL VEHICLE

Retrofitting a Compressed Natural Gas (CNG) kit into a petrol vehicle presents numerous advantages specifically for those who are budget-conscious and environmentally responsible. under is amp general overview of the benefits:
1. Financial Advantages Reduced Operating Expenses: CNG is considerably less expensive than petrol resulting in lower fuel costs. this is notably good for individual's world health organization run extensively. Improved Fuel Productivity: CNG typically offers greater distance per unit of fuel compared to petrol further contributing to overall savings.
2. environmental advantages cut emissions: CNG burning is cleanser than that of gas consequent inch less emissions of insidious pollutants such as arsenic c monoxide hydrocarbons and n oxides. also it has a reduced impact on greenhouse gas emissions making it a more sustainable choice. bond to discharge standards: vehicles retrofitted with CNG much adhere with further tight contamination check standards specifically inch metropolitan areas
3. Dual-Fuel Roleality Versatility: A retrofitted CNG system enables the vehicle to operate on both CNG and petrol providing flexibility. drivers get well change to gas once CNG fueling stations are not accessible.
4. Prolonged Vehicle Longevity Cleaner Combustion: The combustion of CNG results in fewer residues and deposits within the engine minimizing wear and tear and prolonging engine durability. less care expenses: with cut c collection Parts such as arsenic light plugs

beat systems and locomotive anoint take inferior shop care

5. Politics incentives and subsidies: many governments world render incentives for the acceptance of flat spurious blow (CNG) arsenic amp further environmentally intimate option to conventional fuels. CNG vehicles frequently benefit from advantages such as reduced toll fees and access to low-emission zones.

6. safety: CNG is defined away amp higher lighting temperature than gas which importantly decreases the odds of chance lighting thereby enhancing safety

7. Easy Availability of Retrofitting: The retrofitting of vehicles with CNG kits is readily accessible in many areas supported by a multitude of certified workshops that offer this service. in addition, retrofitting is mostly amp further cost-effective quality compared to buying vehicles that get with factory-installed CNG systems

8. Contribution to Energy Security: Utilizing CNG which is often sourced domestically aids in diminishing reliance on imported oil products thereby bolstering national energy security.

9. resale value: vehicles that bear been retrofitted with secure CNG kits get bid amp higher resale cost notably inch regions where CNG employment is current and the fueling base is well-established

VIII CONCLUSION

The analysis indicates that compressed natural gas (CNG) represents the most viable alternative for contemporary internal combustion (IC) engines. CNG importantly reduces emissions of hydrocarbons (hc) c dioxide (co2) and c monoxide (co). The conEdition of spark ignition (SI) engines to CNG is generally more advantageous and cost-effective compared to converting compression ignition (CI) engines. presently amp bulk of vehicles are existence reProduce to CNG exploitation bi-fuel engineering which get work achieved done retrofitting or away utilizing factory-installed CNG kits. However, many of these kits fail to fully harness the potential of CNG as a spark ignition fuel. it has been determined that the force yield from CNG engines is around 14-18% less than that of gas engines with Productivity reductions of leading to 20%. To Improve Effectiveness to levels comparable to petrol engines it is essential to Improve various parameters that influence engine Effectiveness.

Applying lean burn Tech is an effective Plan to Improve fuel Productivity and minimize nitrogen oxide (NOx) emissions. the limits of run fire Method are influenced away factors such as arsenic burning bedroom plan lighting timing lighting Send and upheaval levels

Search indicates that the nominal light Send necessary for the lighting of light methane ranges from c mj to long hundred mj which is greater than that necessary for gas. as an result converting an engine to operate on CNG necessitates a more robust ignition system. the ionization of the light break once exploitation CNG requires higher Send appropriate to the hyperbolic opposition compared to petrol

apt that CNG possesses amp less flammability race higher lighting temperature and greater force than gas it necessitates amp higher lighting Send for good burning

lighting Send get work increased done different methods including Constructing the light break reduction the diam of the light hack electrode fixing the matter of the light hack electrode and modifying the cast of the electrode. also enhancing the capacity of the ignition coil and employing multiple spark plugs can also Add to this increase. away Constructing the lighting Send the run fire content of the fire get work better thereby positioning the operation of amp bi-fuel locomotive operational inch CNG way with that of gas way.

This adjustment allows for the effective utilization of CNG. the aim of this survey is to show that away modifying lighting Send done whatever of the said methods spell maintaining different parameters astatine best levels i get raise the operation of CNG inch bi-fuel way to reach rapport with gas operation

REFERENCES

[1] H. E. Jääskeläinen and J. S. Wallace, "Performance and Emissions of a Natural Gas-Fueled 16 Valve DOHC Four-Cylinder Engine," SAE International, SAE Technical Paper Series, 930380, 1993.

[2] T. Korakianitis, A. M. Namasivayam, and R. J. Crookes, "Natural-gas fueled spark-ignition (SI) and compression-ignition (CI) engine performance and emissions," Progress in Energy and Combustion Science, vol. 37, pp. 89-112, 2011.

[3] M. A. Sera, R. A. Bakar, and S. K. Leong, "CNG Engine Performance Improvement Strategy Through Advanced Intake System," SAE International, JSAE 20030229, SAE 2003-01-1937, 2003.

[4] Heywood, J., Internal Combustion Engine Fundamentals, Mc Graw-Hill, New York 1988.

[5] Thiele, M., Selle, S., Riedel, U., Warnatz, J., Maas, U., Numerical simulation of spark ignition including ionization, Proceedings of the Combustion Institute, Vol. 28, pp. 1177-1185, Pittburgh 2000.

[6] Thiele, M., Selle, M., Riedel, U., Warnatz, J., A detailed Two-Dimensional Numerical Study of Spark Ignition Including Ionization, SAE Paper 2002-01-1110, Warrendale 2002.

[7] K. Kadirgama1, M.M. Rahman1, D. Ramasamy, M.M. Noor "ANALYSIS OF MODIFICATIONS ON A SPARK IGNITION ENGINE FOR OPERATION WITH NATURAL GAS", W.G.B. Horizon MATEC Web of Conferences 74, 00031 (2016) ICMER 2015

[8] Musthafah Mohd. Tahira, M. S. Alia, M.A. Salima, Rosli A. Bakarb, "Performance analysis of a spark ignition engine using compressed natural gas (CNG) as fuel" Energy Procedia 68 (2015) 355 – 362 ICSEEA 2014

[9] D. M. Dave, Prof. M. A. Shaikh, "Effect Of Ignition Parameters For Enhancement Of Performance And Emissions Of A Four Stroke Single Cylinder SI Engine Fueled With CNG: A Technical Review",Volume 02, Issue 04 (April 2013)

[10] M.U. Aslam, H.H. Masjuki, M.A. Kalam, H. Abdesselam, "An experimental investigation of CNG as an alternative fuel for a retrofitted gasoline vehicle", T.M.I. Volume 85, Issues 5–6, March–April 2006, Pages 717-724

[11] D. Ramasamy, M.M. Noor, "Analysis of Modifications on A Spark Ignition Engine for Operation with Natural Gas", 7400031, ICMER 2015. DOI: 10.1051/ 00031 (2016) matecconf/2016, MATEC Web of Conferences.

[12] Suresh M. Tank, Prof. M A Shaikh, Prof. V R Bhatt, "Influence of Ignition Energy on the Performance of Bi-Fuel Engine Using CNG: as Alternative Fuel : A Review", IJERT, Volume 03, Issue 01 (January 2014), DOI : 10.17577/IJERTV3IS10542

[13] Musthafah Mohd. Tahira, M. S. Alia, M.A. Salim "Performance analysis of a spark ignition engine using compressed natural gas (CNG) as fuel" 2nd International Conference on Sustainable Energy Engineering and Application, ICSEEA 2014

[14] T. Korakianitis, A. M. Namasivayam, and R. J. Crookes, "Natural-gas fueled sparkignition (SI) and compression-ignition (CI) engine performance and emissions," Progress in Energy and Combustion Science, vol. 37, pp. 89-112, 2011