An Overview of Acetylene Gas

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Abstract. The aim of this paper is to use Acetylene gas as a primary fuel in the combustion chamber. Various studies have been done to use Acetylene gas for producing required energy in the combustion chamber. Nowadays, use of conventional fuels is being reduced due to pollution concerns. Hence, there is need to find an alternative fuel to operate IC engine. As a result, Acetylene gas is used in spark engine.

Keywords: Acetylene gas, Conventional

1 Introduction

In the present context, the world is confronted with the twin crisis of fossil fuel depletion and environmental degradation. Conventional hydrocarbon fuels used by internal combustion engines, which continue to dominate many fields like transportation, agriculture, and power generation leads to pollutants like HC (hydrocarbons), SOx (sulphur oxides), and particulates which are highly harmful to human health [1-2]. CO2 from Greenhouse gas increases global warming. This crisis has stimulated active research interest in non-petroleum, a renewable and non-polluting fuel, which has to promise a harmonious correlation with sustainable development, energy conservation, efficiency, and environmental preservation.

Promising alternate fuels for internal combustion engines are natural gas, liquefied petroleum gas (LPG), hydrogen, acetylene, producer gas, alcohols, and vegetable oils. Among these fuels, there has been a considerable effort in the world to develop and introduce alternative gaseous fuels to replace conventional fuel by partial replacement or by total replacement. Many of the gaseous fuels can be obtained from renewable sources. They have a high self-ignition temperature; and hence are excellent spark ignition engine fuels. They cannot be used directly in diesel engines.

Ignition of homogeneous mixture of air and gas is achieved by timed injection of small quantity of diesel called pilot fuel near the end of the compression stroke. The pilot diesel fuel auto-ignites first and acts as a deliberate source of ignition for the primary fuel air mixture. The combustion of gaseous fuel occurs by flame propagation similar to SI engine combustion. Thus dual fuel engine combines the features of both SI and CI engine in a complex manner. The dual fuel mode almost comparable to the diesel version at medium and at high loads. However, major drawback with these engines are higher NOx emissions, poor part load performance, and higher ignition delay with certain gases like biogas and rough engine operation near full load due to high rate of combustion [3].

Karim [4] has done extensive research to understand the nature of the combustion process in the dual fuel. He has used variety of gases like methane, ethane, propane, butane, hydrogen, ethylene, and acetylene as primary fuel. It is generally accepted that performance of dual fuel engines, irrespective of the type of gaseous fuel employed, is better at medium and high loads. However, it has been reported that at low outputs efficiency is slightly inferior to the base line diesel engine. Researchers have stressed the need to control the quantity of both pilot and gaseous fuel depending on load conditions for better performance.

Haragopala Rao et al. [5] investigated performance of diesel engine in dual fuel mode by inducting small quantity of hydrogen diesel. At higher loads, the efficiencies attained are close to diesel with notable reduction in smoke, soot formation, and exhaust temperature. NOx emissions are increased with increase in peak pressure.

Gunea, Razavi, and Karim [6] conducted experiments on a four-stroke, single cylinder, direct injection diesel engine fueled with natural gas. Tests were conducted with diesel as the pilot fuel having different cetane numbers in order to find the effects of pilot fuel quality on ignition delay. They concluded that ignition delay of a dual fuel engine mainly depends on pilot fuel quantity and quality. High cetane number pilot fuels can be used to improve performance of engines using low cetane value gaseous fuel.

Das [7] suggested that hydrogen could be used in both SI engine and CI engine without any major modification in the existing system. He studied different modes of hydrogen induction by carburetion, continuous manifold injection (CMI), timed manifold injection (TMI), low pressure direct injection (LPDI), and high pressure direct injection (HPDI); and suggested to use manifold injection method for induction of gases to avoid undesirable combustion phenomenon (back fire) and rapid rate of pressure rise.

Wulff et al. [8] used mixture of acetylene and alcohol to burn in spark ignition engine and in compression ignition engine in a controllable way in dual fuel mode. It exhibited higher efficiency than conventional engine, with cleaner burning better than that of fossil fuels. The combustion was under lower temperature, and this prolonged the life expectancy of the engine.

Ashok Kumar et al. [9] studied suitability of acetylene in SI engine along with EGR, and reported that emission got drastically reduced on par with hydrogen engine with marginal increase in thermal efficiency.

Swami Nathan et al. [10] had conducted experiment in CI engine by using acetylene as a fuel in HCCI mode along with preheated take charge heating. The efficiencies achieved were very near to diesel. NOx and smoke level were reduced drastically. However, HC level was increased.

2 Methodology

2.1 Production of acetylene gas:

Calcium carbide (CaC2) is manufactured from lime and coke in 60:40 ratio in electric furnace at 2000 deg C to 2100 deg C temperature. The size of the calcium carbide is first reduced to fine powder in pulveriser. The pulverized calcium carbide is then added though a gas tight hopper valve arrangement to the acetylene gas generator in which the quantity of water used is sufficient to discharge the calcium hydroxide as lime slurry containing 85 % to 90 % water. In the gas generator the temperature is kept below 90 deg C while the pressure is maintained at 2 atm.

Acetylene is produced in the gas generator by the hydrolysis reaction of calcium carbide with water. During hydrolysis the following chemical reaction take place.

$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$ Delta H = – 32.5 kcals

The crude acetylene gas from generator contains traces of H_2S, NH_3 and PH_3. It is scrubbed with water in a scrubber then sent to purifier where the gas is purified and dried with iron oxide and silica gel. The dry gas is filled into cylinders or sent through pipe line to continuous casting machines.

2.2 Acetylene Cylinder

Acetylene cylinders differ from other compressed cylinders in that they contain a porous filler material (or mass), and a solvent in which the acetylene is dissolved. If acetylene were to be stored as a compressed gas in cylinders (in the same way as other gases) it would be very unstable and could decompose explosively. For this reason, it is dissolved in a solvent, which allows greater quantities of the gas to be stored at a lower pressure in a safe manner.

Decomposition is a chemical reaction whereby acetylene breaks down into its constituent elements, carbon and hydrogen. This reaction gives out a great deal of heat, which can cause the gas to effectively ignite without the presence of air or oxygen. Decomposition can be initiated by a flash back from welding or cutting equipment, or by exposure to intense heat. It requires heat in excess of 400 °C which is normally only achieved by the direct impingement of flames on a cylinder. There is also a theoretical possibility of decomposition initiated from a severe shock to the cylinder, such as dropping the cylinder from a height of several storey's off a building. This could result in damage to the cylinder shell and an internal cavity being created in the monolithic mass. This would then leave the cylinder prone to decomposition from any subsequent shocks. Acetylene cylinders contain a number of features to minimize the potential for decomposition. Acetylene is stored in maroon-colored cylinders with left-hand connections. The robust steel cylinder shell contains the internal gas pressure and protects the porous mass against damage. All acetylene cylinders contain a porous honeycomb material called a monolithic mass. They also contain a solvent (acetone) which is absorbed by the porous mass. The acetylene dissolves in the acetone and holds the acetylene in a stable condition. The function of the porous mass is to evenly distribute the acetone throughout the cylinder and prevent the presence of large internal voids, thereby reducing the likelihood of decomposition and controlling decomposition should it occur. The porous mass contains thousands of small pores, which act as a stabilizer by dividing the acetylene into small units. If decomposition were to occur, the acetylene in some of the units would decompose slowly but the walls of the cells would absorb heat to the stage where decomposition can no longer continue. If a flame were to develop, the small pores would act as arrestors. Experiments have shown that should decomposition occur and the cylinder left to cool down naturally, then the porous mass does extinguish the flame and the cylinder no longer represents a hazard. This storage method also allows the cylinder to hold more acetylene at a lower pressure. The cylinder features a copper-alloy valve for controlling the gas flow. The cylinder‘s bursting discs release any potentially dangerous pressure safely. So if the cylinder pressure builds, this outlet minimizes the risk of the cylinder rupturing or exploding.

2.3 How to use Acetylene?

Only use acetylene in well-ventilated areas. Acetylene is lighter than air, which means it can rise into roof spaces and empty areas. Detecting acetylene gas is easy because it has a distinctive garlic like smell, even in concentrations below 2%.Always use an acetylene cylinder in an upright position. If the cylinder has been transported horizontally, place it in an upright position for 12 hours prior to use, or for at least as long as the cylinder has been laid flat. This will allow the acetone to re-settle within the cylinder. Only use regulators designed and labeled for use with acetylene. Never interchange the regulator with those for other fuel gases or use left to right hand adapters. This is because cylinder pressure and properties are different for each gas. Only use hoses that comply with European standard ENSS9(formally BS 51 20) – the hose will be colored red for acetylene. Never try to repair damaged hoses, replace them with new ones. Ensure a hose check valve is fitted. This will prevent oxygen and acetylene mixing in the hoses. Hoses from BOC Trad equip centres come fitted with check valves. During use hoses must be fully extended. A fire in a coiled hose would be very intense. When the cylinder is in use keep it away from sources of heat and prevent any hot metal dripping onto it. Ensure the flame from the torch is never directed onto the cylinder. Never use a leaking cylinder or connect it to leaking equipment. Never roll the cylinder across the ground always use a cylinder trolley. Cylinders may be churned for short distances only. Never drop or damage an acetylene cylinder.

3 Preparation for Use

It is important that the correct procedure for lighting up is followed in order to prevent a flashback or backfire.

3.1 Lighting up procedure

- Ensure the cylinders are located so that, where possible, they are within view of the operator and are restrained to avoid them being knocked over.
- If the cylinders are on a trolley, ensure the fuel gas regulator outlet is pointing away from the oxygen cylinder.
- Check all equipment including regulators, safety devices, hoses and torches, for damage and insure the equipment is in a good condition
- Assemble the equipment in accordance with manufacturer’s instructions.
- Ensure the pressure adjusting screws on both regulators are fully wound out.
- Pressurize the system by slowly opening each cylinder valve in turn. Never open a valve completely, one and a half turns is sufficient.
- When using a cylinder key to open the valve, leave the key fitted to the valve while the cylinder is in use.
- Leak test assembled equipment (using leak detector fluid). Check for leaks on all connections from the regulators to the torch. If a leak is present turn the cylinder off, vent the equipment of gas, then tighten or refit the piece of equipment. Never use tape or a sealing compound to stop leaks.
- Set gas pressures to manufacturer‘s recommended values.
- Open valves on the torch and purge oxygen and acetylene hoses in turn. This should be conducted in a well ventilated area and away from any source of ignition.

3.2 Safe Shut down

- Extinguish the flame by closing the acetylene torch valve.
- Close the oxygen at the torch valve.
- Close both cylinder valves.
- Open the torch valves, in turn, to vent hoses.
- Once regulator outlet gauges read zero, turn the pressure adjustment screws anticlockwise to prevent damage to the regulator diaphragm.
- Close the valves on the torch.
- Visually check equipment for any damage.
- Return cylinders to the storage area.

4 Safety Procedures

4.1 Avoiding Flashbacks

A flashback occurs when acetylene and oxygen mixes and burns in the hose, either because the recommended procedures haven‘t been observed, the nozzle is blocked, the equipment is leaking, or through back feeding (when a higher pressure gas feeds back up a lower pressure stream). The flame travels back to the gas source and can lead to a fire or explosion in either or both the oxygen and acetylene cylinders.

- Always ensure your acetylene and oxygen cylinders are fitted with flashback arrestors downstream of pressure regulators. This ensures compliance with BCGA (British Compressed Gas Association) code of practice .
- The flashback arrestor must be designed to comply with BS EN 730.
- Flashback arrestors should be replaced every five years, or at the manufacturer‘s recommended interval .
- Acetylene manifolds must also be fitted with a flashback arrestor.

4.2 Avoiding Backfires

A backfire occurs when the flame from the torch regresses into the body or neck of the blowpipe and rapidly self extinguishes. A backfire will become sustained when the flame remains alight. This can be identified by a “popping” or “squealing” sound. Again this can be caused though not using the correct pressures, lighting up procedures or damaged and blocked equipment.

4.3 Leaking Cylinders

If the cylinder has a leak that is not ignited and the cylinder is not getting hot, try:

- Closing the valve.
- Never try to tighten the cylinder valve in the body or tamper with safety devices.

Should this not work, take the following actions immediately:

- Extinguish all ignition sources.
- Evacuate uninvolved personnel from the area.
- Take the cylinder outside to a well ventilated area
- Call the BOC Customer Service Centre on 0800 I I I 333.
- Ensure the work area is thoroughly ventilated before returning.
- If the cylinder is hot, please see, In the event of fire on your premises‘. Do not move the cylinder or open the valve.

5 Storing of Acetylene cylinders

- The storage area should be outside in a well-ventilated area.
- The store should be located 5 metres from other buildings, or separated by a double brick wall to give fire resistance of at least 30 mins. It should also be away from boundary fences. (see BCGA code of practice CP6 for separation distances).
- Store cylinders in a structure that prevents any damage from physical impact, protects cylinders from extreme weather conditions and is away from potential heat and ignition sources .
- The structure should be constructed from non-combustible materials
- Ensure ease of access in and around the structure, considering access for deliveries and emergency services.
- Ensure the store is secure and restrict access to authorized personnel only.
- Ensure the store features good warning signs, including the type of gas stored, no smoking, and labelled areas for full and empty cylinders.
- Always store cylinders in an upright secured position on a welldrained and level surface. Never stack acetylene horizontally. Store all full and empty cylinders with the cylinder valves closed, except MCPs, where the individual valves should be left open and the outlet valve closed.

- Separate full from empty cylinders.
- Segregate all full and empty acetylene cylinders from oxidizing gases (such as oxygen).
- Periodically check stored cylinders for general condition and leaks.

6 Conclusion

Acetylene is the most flexible oxy-fuel gas and is used across multiple welding and metal cutting applications. Put simply, there is no replacement for it and when handled, stored and transported correctly, Acetylene is perfectly safe and has been invaluable to industry for over one hundred and sixty year

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