LIQUID HYDROGEN AS A FUEL FOR GROUND, AIR AND NAVAL VEHICLES

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1. INTRODUCTION

Today, with the advancement of technology, man consumes enormous amount of fossil fuels to meet his growing energy needs. Petro-chemical industries have become the economic base of our society and the limited fossil fuel resources are fast depleting. It is estimated that at a nominal growth rate of 4% per year, the oil and gas reserves will be depleted within 30 years. Also, the steep rise in the prices of petroleum based fuels, is a pointer towards the possible energy crisis in the near future. This triggered many countries to think seriously about an alternative fuel which is abundantly available, safe, pollution-free and cost effective. For some time, the quick solution seemed to be coal, natural gas and nuclear fuel. But one has to think in terms of sources which will not lead to environmental pollution and face eventual depletion. This has led to the developments in the field of 'Hydrogen Energy' which is renewable, non-polluting and has all the characteristics of a good fuel.

This paper reviews the recent developments in some of the advanced countries in the use of hydrogen as an effective fuel for road and rail transportation, as well as the studies pertaining to its use in aircrafts and ocean vessels. Also, the technology goals for Hydrogen storage systems as well as the unconventional methods for its production are briefly highlighted.

2. DEVELOPMENT HISTORY OF LIQUID HYDROGEN

Liquid hydrogen (LH₂) technology was first developed in other countries for their space programmes. Liquid oxygen (LOX) and liquid hydrogen combination in rocket engines yields about 50% higher specific impulse when compared with that of conventional rocket fuels of storable liquids or solid types. This could reduce the lift-off weight of the launch vehicle considerably, thus achieving simplicity and economy. Some of the space exploration programmes such as space shuttle or lunar missions could not have been possible without the use of LH₂ as the fuel.
In 1950s, only USA was concentrating on this technology, whereas today there are many countries actively working in this area.

In USA, after the successful development of RL-10 engine to power the Centaur stage, they developed J-2 engine, for the Apollo programme, both of which used liquid Oxygen-liquid Hydrogen (LOX-LH₂) propellant combination. The large scale production of liquid hydrogen was initiated for these projects. With the introduction of space shuttle, LH₂ is needed in larger quantities. Similar is the case in Europe. ESA, based on their success with the comparatively small cryogenic engine and stage (HM7/H8) used on Ariane-1 is planning to develop a large LOX-LH₂ engine (HM-60) for their new Ariane-5 satellite launch vehicle. The production of LH₂ in Europe will have to be increased manifold for this programme. In Japan, the development of their first cryogenic engine (10.5 Tonnes thrust) is in the final phase and plans are being finalised to go ahead with a 100-Tonne class LOX-LH₂ engine for their future high capacity satellite launch vehicle. This will, obviously, call for substantial augmentation of their LH₂ production. Thus it can be seen that the space programmes in these advanced countries have triggered the large scale production, handling, transportation and utilization of LH₂, leading to the establishment of the infrastructure and augmentation of the production of related materials, components and equipments. It is certain that India will not be an exception to this.

Encouraged by the performance of liquid hydrogen as a high energy rocket fuel, utilization of this as an alternative fuel for aircrafts, automobiles and other applications were conceived. In addition, importance of liquid hydrogen as an energy carrier in power transmission has been well understood in the context of harnessing energy from unconventional sources. The spectrum of LH₂ technology utilization, is given in Figure 1, which is based on the 'Report submitted by a sub-committee in 1982'. Although lot of work in this direction has been carried out in many countries, to make it cost effective or at least comparable with that of petroleum based fuels, extensive developmental efforts are needed.

The problems of liquid hydrogen are related to comparatively higher production cost, low boiling point, low bulk density, and the lack of incentives to switch over to a new system in view of the huge investments already made in the existing petroleum based plants. It is foreseen that with the development of new techniques for the production of hydrogen by unconventional methods as well as with the rising cost and dwindling stock of fossil fuels, hydrogen technology utilization will come into prominence by the turn of this century and that the new areas for using hydrogen as an alternative fuel will be well established.

3. WHY HYDROGEN?

The potentiality of Hydrogen as the fuel for future is well recognised today. The reasons that led to this finding and its advantages are summarised in Figure 2 (see Report submitted by a Sub-Committee in 1982). The limitations of hydrogen are with respect to its low density, critical insulation requirements, necessity to restrict the choice of materials to a few types in order to avoid the problem of ductile to brittle transition