Usage of alternative fuel in boiler for cost reduction in a chemical industry

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Abstract- Overall cost reduction is the important objective of every industry. In a chemical industry electricity and fuel are the important raw materials. From this study it is found that furnace oil is the mainly used fuel in chemical industry. Mainly it is used in the operation of boilers, as steam is an important requirement in every chemical industry. It is found that during every financial year the amount spend on purchasing furnace oil goes on increasing. Several studies say that cost of furnace oil (low grade diesel) increases in the coming years and also there is a chance of fuel scarcity. In this chemical industry, during the process study it is found that hydrogen is formed as a byproduct during production process, and a part of this hydrogen is getting wasted. This paper aims in study the opportunities of using hydrogen as fuel in place of furnace oil. This study is very important for Government sector chemical industries for reducing the overall production cost.

Index Terms- Boilers, chemical industry in India, cost reduction, furnace oil, hydrogen gas.

I. INTRODUCTION

This study was carried out in a public sector chemical industry located at Kerala state in India. The main products of the plant are Caustic soda, chlorine, hydrochloric acid, caustic soda flakes and sodium hypochlorite. The main raw materials of the company are sodium chloride (rock salt), electricity and water. The plant has an installed capacity to produce 175 metric tons of caustic soda per day. To produce one metric ton of caustic soda, it requires 1.72 metric ton of sodium chloride. Company uses membrane cell technology in the production.

The first step is to identify the amount of furnace oil use in boiler. Then we suggest hydrogen in place of existing fuel in boiler. The its comparative cost analysis is carried out. After that we studied whether existing boiler is able to use hydrogen as fuel, and whether any replacement of the firing burner system is required. And at last if replacement of the burner system is required, then its payback period is calculated.

II. DATA COLLECTION

It is found that amount spend on purchasing furnace oil is increasing every financial year. Furnace oil is a low grade diesel and its requirement is also increasing every year. The graph shows the increase in purchase price of furnace oil for last five years.

During 2011-2012 financial year, company spends Rs.111452000 on purchase of furnace oil.

Annual consumption of furnace oil = 3391.41 metric ton
Average cost of furnace oil per ton = 111452000/3391.41
= Rs 32853.02 per ton
Gross calorific value of furnace oil = 41858 KJ/Kg

Energy from furnace oil = furnace oil consumed * GCV of furnace oil
= 3391410Kg * 41858 KJ/Kg
= 141957639800 KJ

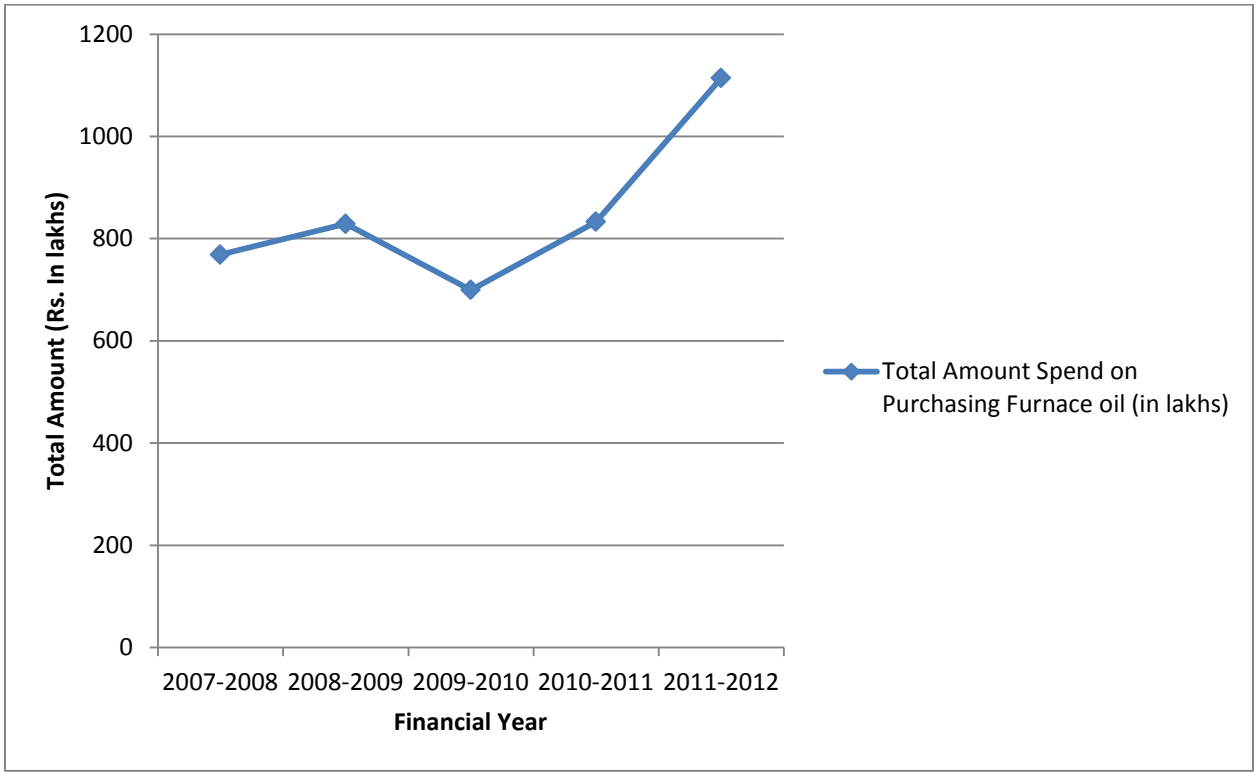

Fig 1: Total amount of money spend on purchasing furnace oil for last five years

III. WORK DONE

From the process study carried out in chemical industry it is found that hydrogen is produced during the electrolysis as a byproduct. A part of hydrogen is used for producing hydrochloric acid. But it is found that still an amount of hydrogen is getting wasted. This is can be utilized as an alternative fuel in boilers in place of furnace oil.

3.1 CALCULATION OF THE AMOUNT OF HYDROGEN WASTED

The main process is

$NaCl + H_2O \longrightarrow NaOH + H^+ + Cl^-$

Based on the data available from the company, 1.72 tons of raw salt is needed to produce 1 tons of caustic soda.

Production rate of caustic soda per day = 175TPD
Quantity of Raw salt required to produce 175 T caustic soda = 1.72*175
= 301 TPD

Molecular weight of NaCl = 58.5 g/mol
Molecular weight of H_2O = 18 g/mol
Molecular weight of NaOH = 40g/mol
Atomic weight of hydrogen = 1g/mol
Atomic weight of chlorine = 35.5g/mol

Then from the equation we know that 58.5 g NaCl produces 1 g hydrogen
Then, 1 g NaCl produces 1/58.5 g of hydrogen
301 T of NaCl produces 1/58.5 * 301 of hydrogen
Quantity of hydrogen produced = 1/58.5 * 301
= 5.14529 T

To find the total amount of chlorine produced per day,
From the equation we know that 58.5 g of NaCl produces 35.5 g of chlorine
Then, 1 g of Nacl produces 35.5/58.5 g of chlorine
301 T of NaCl produces 35.5/58.5 * 301 of chlorine
Total chlorine produced during electrolysis per day = 35.5/58.5 * 301
= 182.65 T

In this 72T of chlorine is liquefied for sale
Remaining Chlorine = 182.65 – 72
= 110.65 T
This chlorine is utilized for producing HCl
Hydrogen required for producing HCl

$H_2 + Cl_2 \longrightarrow 2HCl$

35.5 g of chlorine using 1 g of hydrogen produces 36.5 g of HCl
Therefore, 1 g chlorine requires 1/35.5 g of hydrogen
110.65 T chlorine requires 1/35.5 * 110.65 T of hydrogen

Amount of hydrogen required to produce HCl	= 1/35.5 * 110.65
	= 3.1169 TPD
Balance hydrogen	= Total hydrogen produced – Hydrogen required to produce HCl
	= 5.14529 – 3.11690
	= 2.02839 TPD
Amount of hydrogen getting wasted annually (approximately 330 woking days in a calander year)	= 2.02839 * 330
	= 669.3687 T

669.3687 T of hydrogen is getting wasted annually during the shutdown. This hydrogen can be utilized as an alternative fuel in boilers for producing steam.

3.2 HYDROGEN AS FUEL

Gross calorific value (GCV) of hydrogen	= 141790 KJ/Kg
Balance hydrogen (annual)	= 669.3687 T
Energy from hydrogen	= balance hydrogen * GCV of hydrogen
	= 669368.7*141790
	= 94909787970 KJ
Unavailability of energy (less in energy)	= 141957639800 – 94909787970
	= 47047851830KJ
Corresponding amount of furnace oil required	= less in energy/ calorific value of FO
	= 47047851830/41858
	=1123987.095 Kg
	=1123.987 T
Amount of furnace oil saved per year	= 3391.41 - 1123.987
	=2267.423 T
Total amount saved per year (money saving)	= 2267.423 * 32863.02
	= Rs. 74514367.4
Percentage oil saving	= (2267.423/3391.41) *100
	=66.86%

From the above calculation, we are able to determine that hydrogen alone cannot meet the need of steam production in boiler. Thus we need hydrogen and furnace oil as fuels at the same time. For this either existing boiler must be replaced or the burner system of the existing boiler must be replaced with a dual fuel burner. Replacing the entire boiler system is too costly. Replacement of burner system with a dual fuel burner system in which firing of furnace oil and hydrogen fuels are possible costs about approximately Rs8200000, which was far below when compared with profit achieved by this. But in coming years, based on the finance availability it is better to purchase a new boiler which can use multiple fuels in steam production. This work suggests the replacement of firing unit.

3.3 PAYBACK PERIOD

Approximate cost of new fire injection unit (including installation and other miscellaneous cost)	= Rs. 8200000 (82 lakh)
Amount saved annually by using hydrogen	= Rs.74514367.4
Payback Period (PBP)	= 8200000/74514367.4
	= 0.110 year
	= 0.110 * 365
	= 40.166
	= 41 days.

IV. RESULT

Annual consumption of furnace oil	= 3391.41 T
Amount of hydrogen getting wasted	= 669.3687 T
By using hydrogen as fuel, amount of furnace oil saved per year	= 2267.423 T
Total amount saved per year	= Rs. 74514367.4
Percentage oil saving	= 66.86%
Payback Period (PBP) for new fire injection unit	= 41 days

V. CONCLUSION

The study shows that, using hydrogen as fuel in place of furnace oil in boiler is very economical to the company. By this change in fuel there will be a saving of 7.45 crore rupees per year. This work founds that in this chemical industry the amount of hydrogen wasted alone cannot replace the entire furnace oil usage. There will be an oil saving of 66.86% .So existing burner system is to be replaced for using multiple fuels. The payback period for this burner system replacement is calculated as 41 days.

APPENDIX

T – Metric ton
FO – Furnace oil

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