ENERGY SAVING OPPORTUNITIES IN OXYGEN PLANT–A CASE STUDY

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Abstract

Energy saving is the one of the step of the energy management. The energy management is play vital role in the industrial as well as domestic sector. The energy management concept was developed in USA and US since 1973, while in India and most Asian countries this concept was adopted in 1990 and later. The wastage reduction should include energy efficiency drives using improved designs and devices. The modification in components of the plant to increasing efficiency which is improved cycle performance. This Paper presented survey of energy end use in cryogenic-industries, such as OXYGEN MANUFACTURING INDUSTRIES. The energy required for the production of liquid and gaseous phase of oxygen. We had carried out energy saving opportunity in oxygen plant and find the energy saving opportunities in various components of oxygen plant. This paper discussed the various parameters for the energy saving in the plant components. We find opportunities of energy saving in plant with some modification and calculate the actual power required in plant equipments.

Keywords : *Energy saving , oxygen plant*

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1. INTRODUCTION

Industrial gases perform varied and essential function in our economy. Some are raw materials for the manufacturing of other chemicals. This is particularly true of O_2, N_2 & H_2, N_2 which preserves the flavor of packaged food by reducing chemical action leading to vancidity of conned fats. Some gases are essential medicaments such as O_2 & He. Oxygen is used in Metal processing, Space application, Welding, Cutting and Brazing processes, Oil and Gas sector, Oxidizer in chemical industries Chemical and petrochemical industries, Glass industry Fish farming and Waste management'. Generally 8 tones oxygen is required for 100 tones of steel production. **Figure.1** Represent the demand of steel production in future, the large amount of oxygen is required for this production.

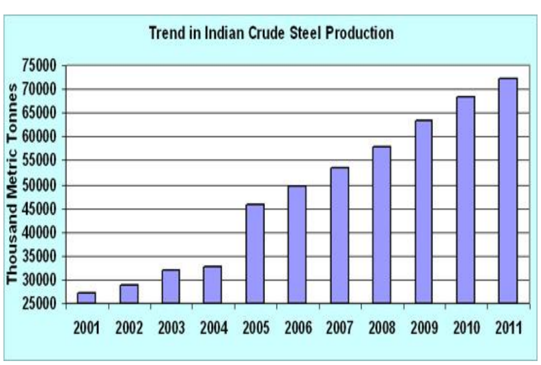

Figure.1: Demand of steel production

On the other hand, the expansion of Engineering branch in industry. Has arisen called cryogenics. This widely embracing term pertains to the production and use of extreme cold at the temp. below - 100°C. This cryogenic or super cold temperature cause fundamental changes in properties of materials. Oxygen is produced by the liquefaction and rectification of air in highly efficient, well insulated, compact plants or by the pressure swing adsorption (PSA) system.

SCOPE AND OBJECTIVE OF PRESENT STUDY

Energy management has two major operational aspects in which conservation is only one of them. The other and more important one in the longer term is that of developing new, especially renewable, sources of energy have such long term vision and macro economic perspective that they would work on developing new sources of energy. Perhaps more importantly, most of them would be struck with existing processes that constrain them to think only in terms of the fuel required for that process. In fact many are apprehensive of the arrival of new terms of energy which might require them to do process modifications. Hence it is no wonder that the development of new sources of energy is not a priority for enterprises. Against this back ground energy management would mean almost exclusively the conservation measures under taken by companies to this extent, the scope of the present study is limited to the identification and conceptualization of the conservation strategies in Indian industry. Energy conservation is one of the tool of energy saving in industries. Energy saving is the best than produce with optimization of the equipment performance. The performance of the plant depends on various factors which are effect the yield', Work and figure of merit (FOM) .

1.1 OXYGEN REQUIRED FOR STEEL CUTTING INDUSTRIES

This survey report is to study the oxygen manufacturing for the steel cutting industries at ALANG SHIP BREAKING YARD to cut the disposal ship. The requirements of oxygen gas for the steel cutting industries shows in Table-1.

Table –1 Oxygen demand for gas cutting

SR.NO.	1	2	3	4	5
YEAR	1990-1992	1992-1994	1995-1996	1997-1998	1999-2000
SCRAP IN METRIC TONS	3493	2196	3425	5087	3990
Oxygen Demand IN M^3 (10000)	8400	5300	9600	14130	9400

1.2 PRODUCTION CAPACITY: -

The plant is very versatile and can be set for cycle to be produced any one of the following alternatives in Table 2.

Table 2: oxygen plant alternative option

Oxygen Production				
SN	Alternative	Gas Qty.	Gas Purity	Product
1	1	80 M^3/hr.	99.6 %	150 atm.
2	2	72 M^3/hr.	99.6 %	150 atm.

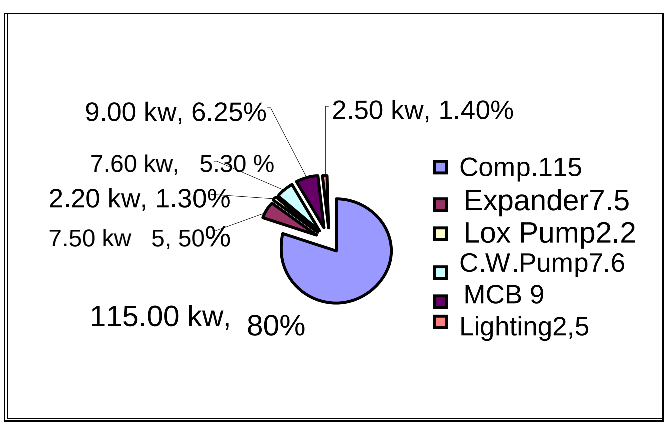

Figure 2: Load (KW) For 80 M3 Plant

1.3 LAYOUT AND MAIN COMPONENTS OF OXYGEN PLANT

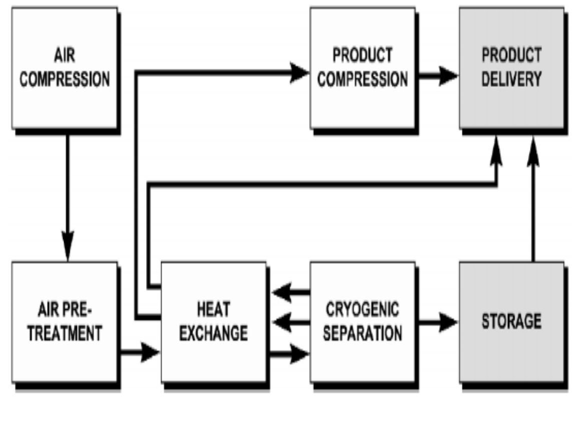

Figure.3: Plant layout with component

1.4 ENERGY END USE FOR OXYGEN PLANT:

For our 80 M3/Hr. oxygen manufacturing plant, the energy audit is implemented and to find out the end uses of energy and identify the energy conservation opportunities. For the process industries there are two types of energy audits. (1) Short Term Energy Audit, (2) Long Term Energy Audit. The energy used for 80 M3/Hr. oxygen manufacturing plant are as electrical energy, water energy, etc. (shown inFigure. – 2)

1. Compressor (4 Stage reciprocating type)
2. Expansion engine (reciprocating)
3. Heat exchangers
4. Molecular sieves
5. Liquid oxygen pump
6. Rectification column
7. Expansion valve (J-T Valve)
8. Piping and valves
9. Liquid level indicators
10. Temp. Indicators
11. Insulation
12. Motors
13. Drier, filter and Oil separator

2.0 PERFORMANCE PARAMETERS

2.1 Main Parameters Of The Plant Are As WORK, YIELD, FOM

It is dependent on efficiency of compressor and expander as shown in Table-3. If we consider compressor and expander efficiency is 85%, It is Shows from table the YIELD is decreasing up to 15% and WORK is increased up to 36% and FOM is decreasing up to 27%.

TABLE-3: performance of plant parameters

Sr. No.	η_{comp}	η_{exp}	yield	W_{ideal}	W_{actual}	FOM
1	100 %	100 %	0.2720	740.00	740.00	1.0000
2	90 %	90 %	0.2466	740.00	1003.35	0.7375
3	85 %	85 %	0.2340	740.00	1012.50	0.7306
4	80 %	80 %	0.2211	740.00	1367.80	0.5410
5	75 %	75 %	0.1913	740.00	1747.40	0.4635
6	70 %	70 %	0.1780	740.00	2307.24	0.3707

2.2 ENERGY SAVING AND ECONOMICS ANALYSIS FOR OXYGEN PLANT:

General

Compressor is a major energy consuming component in oxygen manufacturing plant. Electricity used to compress air is converted into heat. Efficient operation of compressed air systems therefore requires the recovery of excess heat where possible, as well as the maximum recovery of the stored potential energy. I find the energy saving scope is in the following areas.

1. Compressor and drives
2. Expander
3. Heat exchangers
4. Insulation
5. Rectification column
6. Molecular sieves, valves and piping
7. Inlet temperature of air

2.3 ENERGY SAVING OPPORTUNITIES IN COMPRESSOR

The compressor is the main component of the Oxygen manufacturing plant. The end use of electricity for the compressor is about the 80% of the total energy. The compressor performance is depends on the following criteria.

1. Stages of compressor
2. Pressure ratio
3. Cooling system
4. Volumetric efficiency
5. Polytrophic exponent (n)
6. Speed of the compressor

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3.0 RESULT AND DISCUSSION

PROBLEMS IDENTIFIED IN OXYGEN PLANT AND THEIR SOLUTIONS:

3.1 COMPRESSOR

Problem:-
In oxygen plant having four stages compressor, outlet pressure of compressor should be maintained at 36 atm. instead 42 atm. is obtained. I calculate the efficiency of the plant is only 75% in plant.

Solution:
1. To maintain the efficiency of compressor.
The efficiency of compressor is high, the work required for the plant is less shown in figure 4.

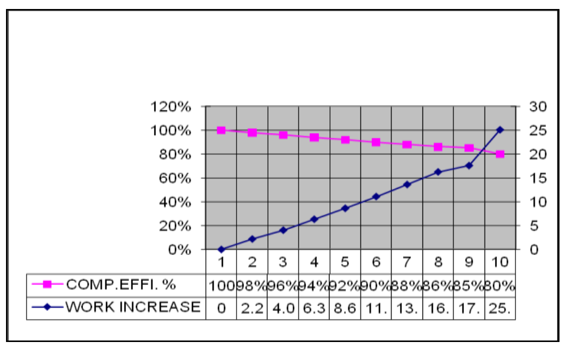
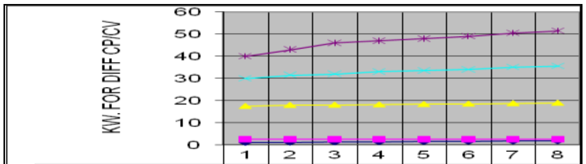


Figure 4: Efficiency v/s Work done

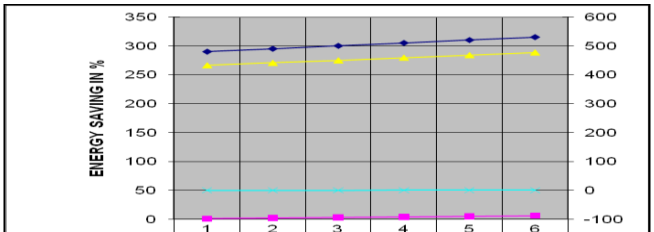
2. To maintain pressure ratio up to 2.5
In plant the pressure ratio is About 3.5, effect of pressure ratio on performance shows in figure.5.



	1	2	3	4	5	6	7	8
CP/CV	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
CP/CVWIT H PR.1.05	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.6
CP/CVWIT H PR.1.5	17.	18	18.	18.	18.	18.	18.	19
CP/CVWIT H PR.2.0	30	31.	32	33	33.	34	35	35.
CP/CVWIT H PR.2.5	40	43	46	47	48	49	50.	51.

Figure 5: Pressure Ratio v/s Work

3. To maintain inlet temperature and intercooler temperature in every stage



	1	2	3	4	5	6
SR.NO.	1	2	3	4	5	6
TEMP.	290	295	300	305	310	315
VOLUME	432.9	441.4	450	459.1	468	477
SAVING %	-2.65%	-1.32%	0%	1.32%	2.65%	4.00%

4. To decreasing clearance volume

3.2 EXPANDER:-

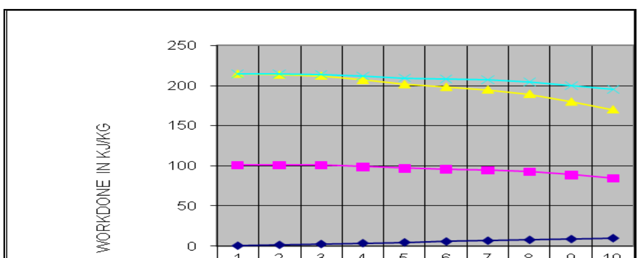
Problems:-

For the ideal oxygen plant the temperature drop is about 60k, but the actual temperature drop due to expander is only 50 to 51k.

Solution: for better efficiency of expander is

1. To maintain the expansion angle, redesigning of crankshaft.

2. Re-designing of valve to maintain constant velocity of air.



	1	2	3	4	5	6	7	8	9	10
MORE WORKKJ/KG	0	1	1.8	5	8	10	12	15	20	25
WORK DONE KJ/KG	113.	112.	111.	107.	104.	102.	99.8	96.4	90.7	85
EFFI.OF EXPANDER	100	99	98	95	92	90	88	85	80	75
SR.NO.	1	2	3	4	5	6	7	8	9	10

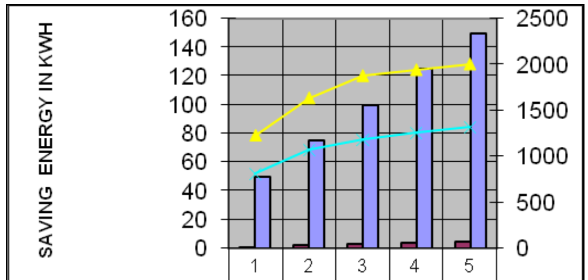
Figure 6: Expander Efficiency v/s WorK

3.3 COLD BOX:-

Problem:-Heat losses in cold box

Solution:

Optimization of insulation thickness, find out critical thickness to minimize heat loss. i calculate the critical thickness is 92 mm for perlite powder in plant is 100 mm. the effect of insulation in figure 7.



	1	2	3	4	5
SR.NO	1	2	3	4	5
Insolation rhick	50	75	100	125	150
Saving kwh for perlite	1227	1638	1882	1946	2009
Saving kwh for cal.silicate	810	1067	1184	1259	1317

Figure 7: Effect of Insulation Thickness

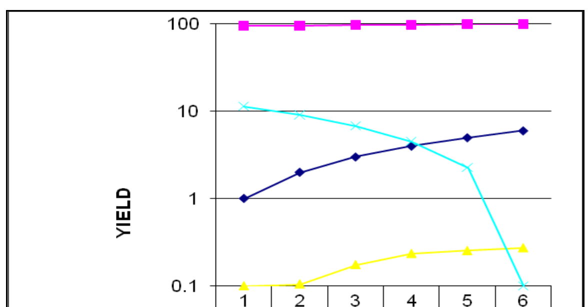
3.4 HEAT EXCHANGERS:-

Problem:- The effectiveness of heat exchangers is low

Solution:

Optimization of heat exchange area and heat transfer co-efficient factor for cryogenic application.

To maintain higher effectiveness and UA for better performance of heat exchanger shows in figure-8.



	1	2	3	4	5	6
SR.NO.	1	2	3	4	5	6
EFFECTIVENESS	95	96	97	98	99	100
YIELD, Y	0	0.105	0.175	0.235	0.253	0.2725
WORK DIFF.KJ/KG	11.34	9.1	6.8	4.53	2.27	0

Figure 8: Effectiveness v/s Yield

3.5 MOLECULAR SIEVE:

Problem:- The Capacity of molecular sieve is more

Solution:
Optimization area and heat transfer co-efficient factor
Remove moisture particles from material save energy
Use cyclone separator for moisture removes.

4. FINDINGS: -

During my work I found various lack of proper operation in working of plant. I collect findings and its solution for energy saving in plant

1. First collect Energy use in plant equipments

2. Calculate unit price of oxygen in plant and compare with ideal cycle I found that the ideal cost is 0.9 Kwh/ M3 while in plant is shows in figure 9.

3. I found during my work most of plant operation are not carried out properly. semi skill operator is operate the plant for saving of money, but for Planned maintenance and modification of equipments can saving large amount of money and life of equipment shows in table -4

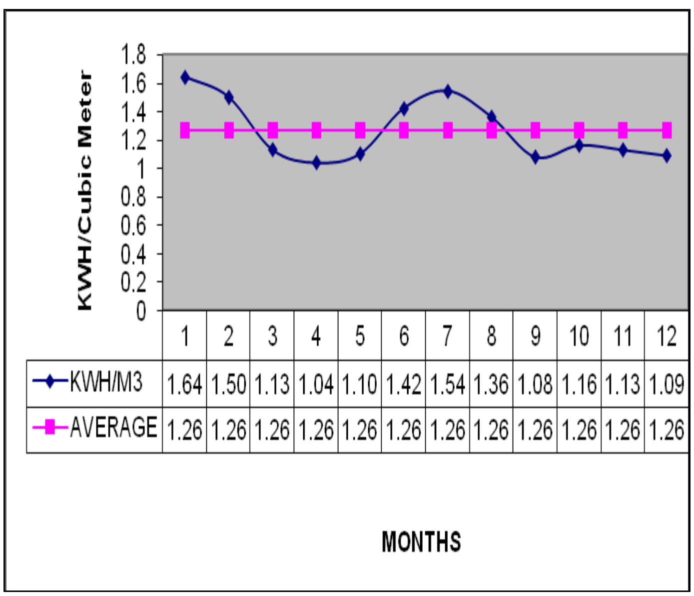


Figure 9: cost of per cubic meter oxygen

5. ENERGY SAVING OPPURTUNITIES IN OXYGEN PLANT

Energy saving oopurtunities in oxygen plants are shows in Table -4 and Figure.9

TABLE-4 Alternation OF PLANT RUN

SR..	EQUIPMENTs	PARAMETERs	PRESENT CONDITION	OPTION-1	OPTION-2
1	AIR COMPRESSOR		42 atm ,550 RPM	40 atm .,540 RPM	38 atm ,540 RPM
		POWER KW	96.51	90.25	85.72
		SAVE KWH	0	6.26	10.79
		% SAVE	0	6.48%	11.18%
		P.R	2.55	3.42	2.10
2	STAGES	1	3	4	5
		ENERGY SAVE	48%	35%	20%
		POWER KW	139	106	84
3	EXPANDER		48 K,37 ATM	55K ,31 ATM	51K,31 ATM
		POWER KW	7.06	9.0	7.8
		SAVE KWH	0	1.94	0.72
4	INTERCOOLERS	TEMP.DROP	4 C	5 C	6 C
		HEAT KW	5.15	6.8	7.72
		SAVE KWH		1.65	2.57
5	MCB		29 C 70% RH	28 C 60% RH	28 C 65% RH
		SAVE KWH		0.75	0.625

CALCULATION OF SAVING COST

1. COMPRESSOR : 10.80 KWh

2. INTERCOOLERS : 02.57 KWh

3. EXPANDER : 01.65 KWh

4. MCB : 0.75 KWh
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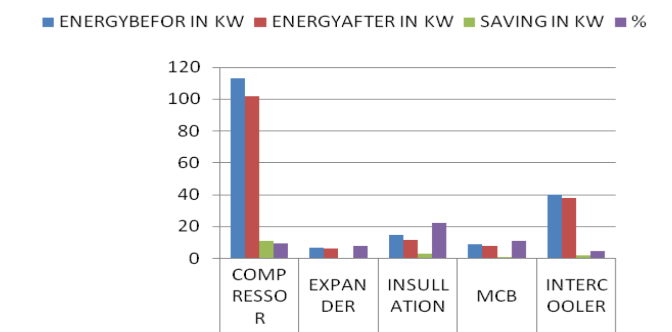
5. TOTAL 15.77 KWh

RS.SAVING PER YEAR : 15.77 KWh*5

Saving per year =RS/KWH *24 HRS*300 DAYS

Saving /year **= RS. 5,67,720/- PER YEAR**



	COMPRESSOR	EXPANDER	INSULLATION	MCB	INTERCOOLER
ENERGYBEFOR IN KW	113	7	15	9	40
ENERGYAFTER IN KW	102	6.44	11.6	8	38
SAVING IN KW	11	0.56	3.4	1	2
%	9.7	8	22.6	11.1	5

Figure.10: ENERGY SAVING IN OXYGEN PLANT WITH IMPROVEMENT OF THE EQUIPEMENTS

CONCLUSIONS

With increasing of oxygen demand in industries , everybody want to reduce cost of production applying with energy conservation concept. The maximum energy required for compressor and expander , so it is required to minimized the energy consumption per meter cube of oxygen. When I was started the case study on 80 cubic meter plant run on **1.30 to 1.40 kwh/m^3** , but theories said to required the energy for production of oxygen is **0.90 kwh/m^3** . I was stared the various readings and find out the problems in various components try to solve the problems. The possibilities for the energy saving is **5 lacs per year**. Finally I was attaining the production cost of oxygen at **1.1-1.2** kWh/ m$^{3..}$ **Overall saving 14-15% of energy.**

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