ISSN No:-2456-2165

Performance, Enhancement and Analyses of Screw Air Compressor with Zero Purge Loss Dryer

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Abstract:- Comparative analysis of the performance in terms of reduced purge loss, operating cost and enhancement efficiency of the screw Air compressor has carried out Vista chemical Ltd Mandideep Raisen (MP), India. This system has been working under two different conditions, where being used one of the adsorption Air dryer install with screw compressor with minimal pressure dew point for save purge loss so that increased free air delivery for enhance the efficiency and the second alternative has been found over silica gel desiccant bed and FRL conventional equipment in the system for optimal working condition for removal moisture. The proposed replacement results in the improvement of overall thermal average efficiency and the yearly cost has saved also by means of zero purge loss. It is used in process industries where the super dry compressed Air is required, for the fulfill of various utility just like packaging, transporting of product. The screw compressor is positive displacement type rotary compressor which is working under screw action and emerged with desiccant adsorption dryer for removal of moisture of compressed humid Air. This combination of system is studies under the various published literature paper show that moisture is removal under using by means of chemical substance like activated alumina, silica gel and molecular sieves of compressed Air and may save the purge loss in dryer. The performance of compressed dry Air is utilizing the super dry Air in pharmacy utility sector and various industries.

Keywords:- *Zero Purge Loss, Desiccant Bed, Compression System, Regeneration, Adsorption Process.*

I. INTRODUCTION

➢ *Compressor-*

The compressor is a mechanical device which is used to increase the pressure from lower to higher level; it is used in process industries Influence of injection parameters on the performance of powered screw air compressor [1]. Rotary screw compressor has to define as Air compressed by means of screw action, in this rotary screw compressor has two rotors which rotate regularly. Each revolution of rotor that increases of pressure of working fluid via the chamber, the rotary compressor has to dependent on air dryer. The Screw compressor is a mechanical device which is used to increase the pressure from lower to higher level which depends on DOE with the study on mechanical wet compression single screw compressor [2]. It is used in process industries where the super dry compressed Air is required, for the fulfilling of various utility just like packaging, transporting of product. The screw compressor is positive displacement type rotary compressor which is working under screw action and emerged with desiccant adsorption dryer for removal of moisture of compressed humid Air throughout Saving Operation of Screw Air Compressor [3]. This combination of system is studies under the various published literature paper show that moisture is removal under using by means of chemical substance like activated alumina, silica gel and molecular sieves of compressed Air and may save the purge loss in dryer by using reusing compressed Air by heated blower to show that it can be enhancement of efficiency of screw compressor. In screw compressor has no fluctuation on deliver compressed Air with desiccant adsorption dryer by means of rotary action with male and female rotor. The investigation of published paper has to summarize the performance of compressed dry Air which is utilizing the super dry Air in dharma utility sector and various industries [4]. The dew point has the main parameter for acquiring the humid compressed Air to dry compressed Air by means of the at dew point lowest for easy condensation of compressed Air of the system [5].

➢ *Air dryer*

Air dryer system has to fully self automatic it is used to reduce the moisture of compressed air which is coming from air compressor at certain exit parameter on the basis of balancing on performance of a desiccant based humidification-dehumidification [6]. When compressed air has to go through a desiccant chemical bed, the desiccant adsorbs its humidity of compressed Air [7]. This desiccant bed did not dry to the maximum. Reactivation of desiccant has to absorb then necessary the adsorbed and up to original adsorptive capacity [8]. Heatless air drying unit has two towers, filled with silica gel desiccant for drying operation Air dryer using waste heat of HVAC systems [9]. One tower is used for drying of compressed air while the other tower is reactivated simultaneously. These are two towers desiccant to absorb moisture present in the coming compressed air. Reduced desiccant dust found in regenerative towers. Its element efficiency is up to 5 micron size. Adsorption type of Air dryer is Fully automatic for continuous operation. Desorption is happening in counter flow direction to the adsorption process with heated blower air [10]. Cooling is in co-current flow direction to the adsorption process with blower in a closed circuit. In the adsorption Air dryer no compressed air loss for regeneration, which is saved by means of purge loss. Flow beneficial butterfly valves for low pressure drop which is raise the performance of the dryer in Screw system [11].

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➢ *Nomenclature*

DP Dew point temperature (0C)
HPC High-pressure compressor
DOE Design of experiment
ZPL Zero purge loss
Ti Inlet temperature
To Outlet temperature
E Efficiency
OP Operating cost
PDP Pressure Dew Point

II. MATHEMATICAL FORMULAE

There are many formulae used in cooling tower as follows

➢ Range It is the temperature difference between cooling tower inlet temperature and cooling tower outlet temperature [5].

Range = (Ti - To)
Free air delivery = [(final pressure –initial pressure) x receiver capacity] / time in minutes.
Efficiency = Actual CFM / Desired CFM, where CFM is free air delivery.

The estimated loss of cost of existing air dryer by electricity used of total CFM in one year
= power required for per CFM per hour × total air delivery × hour in one year × rated cost of power per unit

Net saving by manner of operating and maintenance of other = cost of energy saving due to pressure drop + cost difference of oversized compressor + total saving of zero purge loss + cost of desiccant 800 Kg for 2.5 year + maintenance cost of heatless dryer for last 2.5 year.

Average efficiency = sum of all efficiency in 24 hour / number of all efficiency.

Average free Air delivery = All CFM in one day / number of taken data.

III. EQUIPMENT & INSTRUMENTATION

We are using four equipment in this procedure
a. Sling psychomotor
b. Mercury Thermometer
c. Ultra-sonic flow-meter
d. Digital Temperature Indicator
e. Pressure gauge

IV. EXPERIMENTAL INVESTIGATION & PROCEDURE

A. Site

The installation of this air compressor is in VISTA Organics PVT Ltd. Mandideep (M.P) India. In this plant the air screw compressor is used for compresses the working fluid of air. This compressed air is to be used for the purpose of packaging medicine in utility vista chemical company. The tube with butterfly valves has to low pressure drop and heat recovery. This system has to define to convert dry Air to super dry Air by the capacity of 850 CFM by means of using the Zero purge loss dryer in place of existing heatless dryer. It is recommended to provide a moisture separator air receiver before the air drying unit and an after filter after the drying unit. It is define as quantitative methodology.

B. Methodology

- Note down the rated capacity.
- Measure running Air dryer capacity and pressure of flow in pipe by pressure gauge.
- Measure wet bulb temperature and ambient temperature by siling psychomotor in every one hour.
- Note down cooling capacity of pre cooler in terms of temperature by temperature indicator in every one hour.
- Find out the pressure drop in Air dryer by pressure gauge.
- Find out the efficiency of compressor by
- Efficiency = Actual free Air delivery/Desired free Air delivery

Table 4.1. Measurement of Data from in screw compressor with adsorption dryer with zero purge loss

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FAD MEASUREMENT WITH ZERO PURGE LOSS DRYER										
Time	DESIGNED CFM	RECEIVER CAPACITY (M3)	RECEIVER CAPACITY (Ft3)	INITIAL PRESSURE (Kg/cm2)	FINAL PRESSURE (Kg/cm2)	TIME				% EFFICIENCY
						MINUTES	SECONDS	MINUTES	CFM	
9:00:00	800	5	176.55	0	6	1	30	1.50	706	88
11:00:00	800	5	176.55	0	6	1	32	1.53	691	86
13:00:00	800	5	176.55	0	6	1	29	1.48	714	89
15:00:00	800	5	176.55	0	6	1	28	1.47	722	90
17:00:00	800	5	176.55	0	6	1	29	1.48	714	89
19:00:00	800	5	176.55	0	6	1	28	1.47	722	90
21:00:00	800	5	176.55	0	6	1	29	1.48	714	89
23:00:00	800	5	176.55	0	6	1	26	1.43	739	92
1:00:00	800	5	176.55	0	6	1	28	1.47	722	90
3:00:00	800	5	176.55	0	6	1	27	1.45	731	91
5:00:00	800	5	176.55	0	6	1	26	1.43	739	92
7:00:00	800	5	176.55	0	6	1	28	1.47	722	90
9:00:00	800	5	176.55	0	6	1	26	1.43	739	92

V. SAMPLE CALCULATION OF OPERATING COST AND EFFICIENCY

The above data in the existing heat less Dryer in terms of PER HOUR given shows that the purge loss is about 10%, which will define that the raising the efficiency of air compressor through the air dryer by medium of operational cost.

The estimated loss of cost of existing air dryer by electricity used of total CFM in one year
= power required for per CFM per hour × total air delivery × hour in one year × rated cost of power per unit
= 0.2 kWh × 800 CFM × 8760 hour × 7 Rs per unit
= 1401600 × 7 Rs/unit
= 9811200 Rs per year

A. Zero purge loss adsorption dryer for 850 CFM data calculation:

Total power saving in terms of Rs. = the O.C of heatless dryer – the O.C of zero purge loss dryer = 981120 – 196224 = 784896.00 Rs per year

Net saving by manner of operating and maintenance of other = cost of energy saving due to pressure drop + cost difference of oversized compressor + total saving of zero purge loss + cost of desiccant 800 Kg for 2.5 year + maintenance cost of heatless dryer for last 2.5 year.
= 149375.56 + 0.00 + 784896.00 + 0.00 + 150000.00
= 1084271.56 Rs.

Since, cost of FRL dryer package is thirty lacks so that it is called as additional investment. So that RETURN ON INVESTMENT has to define as the ratio of additional total investment upon net saving of both the dryer and it is equal to 2.77.

Pressure drop saving calculation in terms of money: pressure drop is FRL Beko dryer = 0.328 BAR and pressure drop is heatless existing air dryer =0.5 BAR.
Difference =0.50-0.38=0.12 BAR, since in terms of energy require of 1% of motor power for 1 psi pressure drop. For 0.12 BAR, energy of motor required % = 0.12 Bar/1psi in Bar×100

=0.12/0.0689655×100=0.01740004%

So energy loss in KW =required % of motor power for pressure drop ×140

=0.017400004×140=2.436000609 kWh

Where for 850 CFM dryer motor power is =140 Kilo Watt
TOTAL UNIT SAVED = energy loss in KW per hour × total no. of hour in one year

=2.436000609×8760=21339.36533 KW
Total money saved in year= Rs 7× total unit saved =7 Rs/unit ×21339.36533
=149376 Rs
After the 10% of purge loss electricity energy require in terms of Rs = total cost of air dryer for 800 CFM × 90% = (1401600×90)/100= 1261440
LOSS = 1401600-1261440=140160 kWh.

B. Sample calculation of efficiency for zero purge loss dryer of screw Air compressor

Due to less pressure drop and more free air delivery enhance the efficiency of screw compressor with zero purge loss Air dryer in place of heatless Air dryer. Therefore thermal performance and analysis of Air dryer is the beneficial of efficiency up to 13% by the parameter. The formulas are as below with data from table 6.4.1 and table 6.4.2 by approx calculation.

Free air delivery of 800 CFM = ((final pressure-initial pressure) × receiver capacity) ÷ (1×time in minutes) (1).

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Efficiency of screw compressor with zero purge loss dryer = actual CFM ÷ Designed free air delivery in CFM (2).
AFTER ZERO PURGE LOSS

Free air delivery = [(final pressure –initial pressure) x receiver capacity] / time in minutes

CFM-1 = ((6-0) × (176.55)) ÷ (1× 1.50) = 706 similarly,

CFM-2 = ((6-0) × (176.55)) ÷ (1× 1.53) = 691

CFM-3 = ((6-0) × (176.55)) ÷ (1× 1.48) = 714

CFM-4 = ((6-0) × (176.55)) ÷ (1× 1.47) = 722

CFM-5 = ((6-0) × (176.55)) ÷ (1× 1.48) = 714

CFM-6 = ((6-0) × (176.55)) ÷ (1× 1.47) = 722

CFM-7 = ((6-0) × (176.55)) ÷ (1× 1.48) = 714

CFM-8 = ((6-0) × (176.55)) ÷ (1× 1.43) = 739

CFM-9 = ((6-0) × (176.55)) ÷ (1× 1.47) = 722

CFM-10 = ((6-0) × (176.55)) ÷ (1× 1.45) = 731

CFM-11 = ((6-0) × (176.55)) ÷ (1× 1.43) = 739

CFM-12 = ((6-0) × (176.55)) ÷ (1× 1.47) = 722

CFM-13= ((6-0) × (176.55)) ÷ (1× 1.43) = 739

E1=706÷800=88
E1=691÷800=86
E1=714÷800=89
E1=722÷800=90
E1=714÷800=90
E1=722÷800=89
E1=714÷800=90
E1=739÷800=89
E1=722÷800=92
E1=731÷800=90
E1=739÷800=91
E1=722÷800=92
E1=739÷800=90

SO THAT,

$CFM_{avg\ with}$ purge = 614

Efficiency average = 77%

$CFM_{avg\ without}$ purge = 721

Efficiency average= 90%

So the increased free Air delivery is by 107 CFM and efficiency is increased by 13%.

VI. RESULT & DISCUSSION

➢ *Zero purge loss dryer with screw compressor*

In zero purge loss dryer the performance has to define by means of operating cost saving on the basis of purge loss and the maintenance cost. At the starting of procedure the various parameter is considerable in the format of table and the after finding the result which is shown by graph. At the starting of the method on 9:00 am the reading of air, inlet temperature and Air and outlet temperature are as follows.. The operating cost is saved on the by means of pressure drop and also on the basis of maintenance cost. The efficiency parameter depends on the free air delivery.

Table 6.1: At 9:00 AM (starting procedure) reading

Free air delivery	Inlet pressure In BAR	Outlet compressor pressure	Cooling water inlet temperature	Dew point temperature
800 CFM	1 BAR	6 BAR	30^0C	-40^0C

Table 6.2 Parameter of zero purge loss dryer

DESCRIPTION	UNIT	Inlet Parameters	Remarks
Inlet flow to the air dryer	CFM	850	
Inlet pressure to the air dryer	BAR	7 BAR	
Inlet air temperature to the air dryer	°C	35^0C	Compressor outlet temperature of 50°C cool down to 35°C
Cooling water inlet temperature	°C	30^0C	
Pressure dew point (PDP)	°C	-50^0C	

➢ *Reduced cost*

Also we have seen that the maintenance cost has to reduce by using zero purge loss FRL series adsorption dryer as compared to heatless dryer that's why zero purge loss adsorption Air dryer is more efficient & beneficial as compared to existing heatless dryer. Zero purge loss desiccant adsorption Air dryer has reduced the moisture content from compressed air which helps from corrosion of pipe and equipment and life of equipment.

Results of efficiency when we are measuring by using Beko dryer by means of increasing CFM capacity in terms of power we find the increasing efficiency by means of input free air delivery. Zero purge loss dryer increases the life of adsorbent like silica gel while decreases the life by previous existing heatless Air dryer because of using oil with compressed air, which is also harm for bacterial growth.

We are saving approx 10 lakhs Rs per year while using zero purge loss dryer which very optimize also inlet parameter on the basis of one unit cost 7 Rs per unit which is also define as the power consumption per hour energy loss

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due to purge is 16 kWh that is total energy loss due to purge in one year is 140160 kWh.

Figure 6.1 shows that between efficiency and free air delivery, the increasing graph pattern obtained by using zero purge loss adsorption dryer in place of heatless dryer. This data investigated in 24 hour or one day.

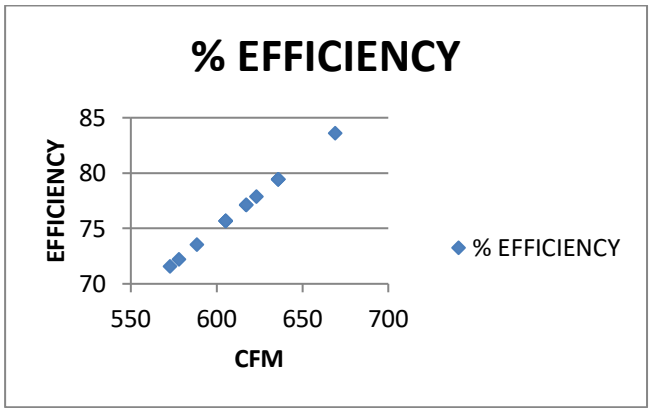

Fig 6.1 Efficiency with free air delivery

Figure 6.2 Shows that efficiency generally increases with ambient air temperature. Show the variation of the efficiency with the Air ambient temperature, the value of ambient temperature and temperature shown in figure. There are so many series in the figure for zero purge loss adsorption dryer.

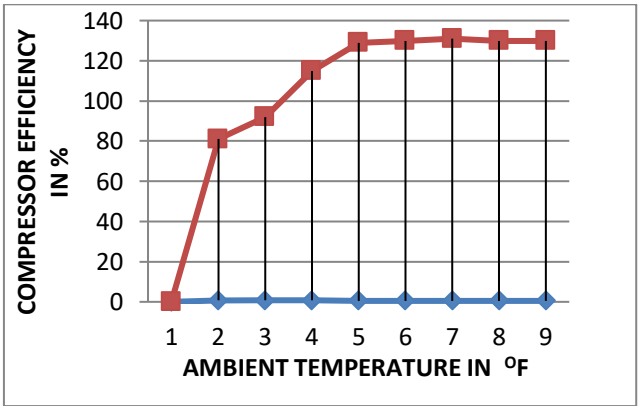

Fig 6.2 Efficiency vs. ambient temperature

In the graph 6.3 drawn is between Efficiency and time schedule drawn which is too simple once the power gone on higher side the current drawn will be also be higher which is evident as seen from the graph. For 60 kW where on the current drawn is 98 Amps in case of 110 kW it is taking 155 amps. Compressed air is required only for operating the pneumatic driven actuators (instrument air supply) and for analyzing the pressure dew point.

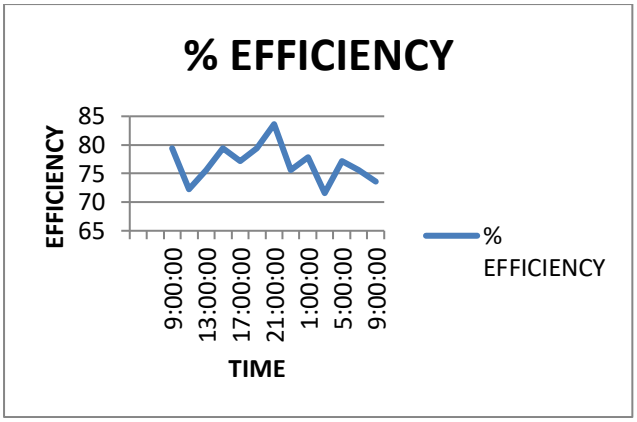

Fig 6.3 Efficiency and time schedule

This is the graph 6.4 drawn between free air delivery and time schedule, this graph depicts the picture of power as unit capacity with the actual power. Power analyzers accurately measure electrical power characteristics of devices that generate, transform, or consume electricity.

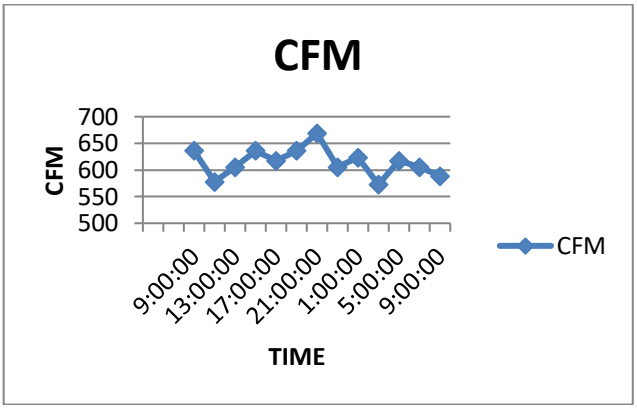

Fig 6.4 free air delivery and time schedule

On the similar lines as of Fig 6.5 in this case the graph has been plotted between the power consumed as different internal of time starting from 6 AM to few days 4 morning calculating the figure on every two hrs lines When the zero purge loss dryer involved.

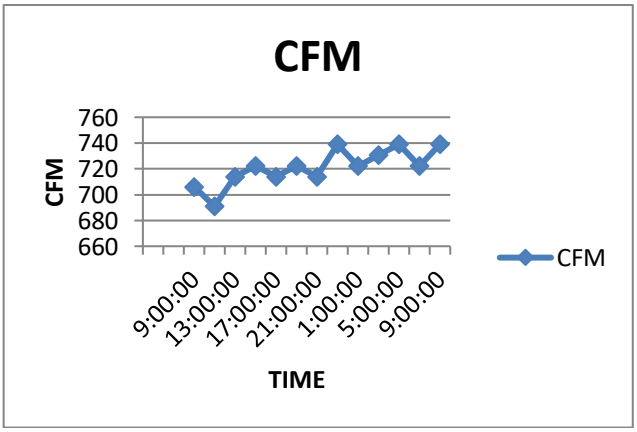

Fig 6.5 free air delivery and time schedule

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Fig 6.6 Graph between efficiency and time schedule for 24 hour of screw compressor and TIME Maintenance of reciprocating compressor is very high due to piston to cylinder line contact, high thermal heat, high vibration in between piston and cylinder due to reciprocating motion. As per company.

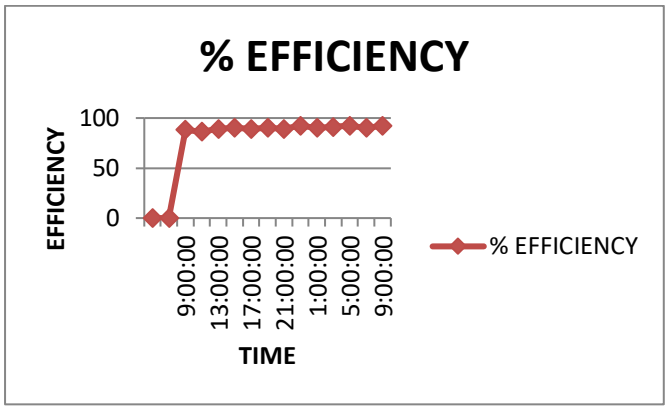

Fig 6.6 Efficiency and time

Figure 6.7 shows that instant variation response between Efficiency and free air delivery. Drive mechanism has to use for running in the compressor. The dynamic compressor are less expensive that why it use are commonly

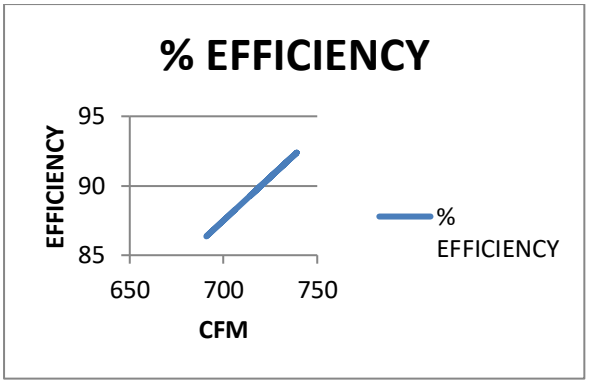

Fig 6.7 Efficiency and free air delivery

Figure 6.8 shows that the increasing graph making between efficiency verses free air delivery with zero purge loss dryer. It has to define in the manner of calculated and using methodological formulas.

➢ *Comparison*

Table 4.1 shows and Table 4.2 shows that a comparison of efficiency of efficiency of screw air compressor with zero purge loss adsorption desiccant Air dryer, free air delivery and purges air heatless dryer. This table shows a efficiency of 24 hour or one day in hour wise. Experimental started from 9:00 AM is done tomorrow 9:00 AM. Efficiency is calculated by free Air delivery of compressor.

6.1 Table comparisons between with purge and without purge in CFM and efficiency

TIME	CFM WITH PURGE LOSS	CFM WITOUT PURGE LOSS	EFFICIENCY IN HEATLESS DRYER	EFFICIENCY IN ZERO LOSS PURGE DRYER	RECEIVER FILL TIME
9:00	636	706	79	88	1.50
11:00	578	691	72	86	1.53
13:00	605	714	76	89	1.48
15:00	636	722	79	90	1.47
17:00	617	714	77	89	1.48
19:00	636	722	79	90	1.47
21:00	669	714	84	89	1.48
23:00	573	731	72	91	1.45
1:00	617	739	77	92	1.43
3:00	605	722	76	90	1.47
5:00	589	739	74	92	1.43
7:00	**614**	**721**	**77**	**90**	1.45
9:00	573	731	72	91	1.43
AVERAGE	617	739	77	92	

Figure 6.8 shows that between before and after efficiency with time greater in case of zero purge loss dryer used during 24 hours of operation. However, the difference in efficiency during night operation is comparatively slightly higher.

ISSN No:-2456-2165

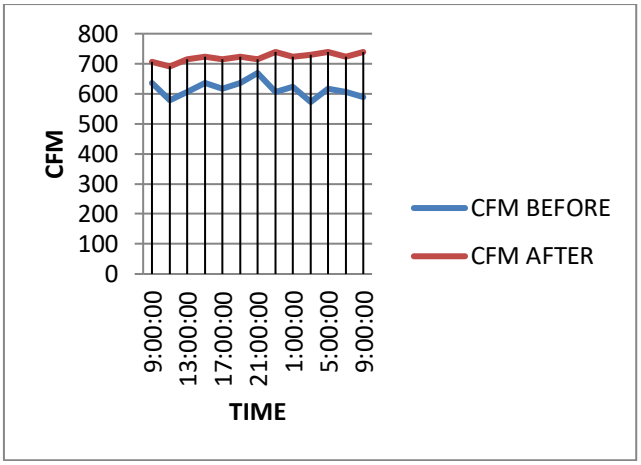

Fig 6.9 Comparison between free air delivery with heatless dryer and zero purge loss dryer

Fig 6.10 shows that power and current amp with zero purge loss adsorption dryer and also predict greater saving of electrical energy in terms of kWh. Both vessels are switched to parallel function by opening the inlet valve (here K2). For approximately 5 to 15 minutes (individually adjustable), the compressed air is flows through both adsorption vessel.

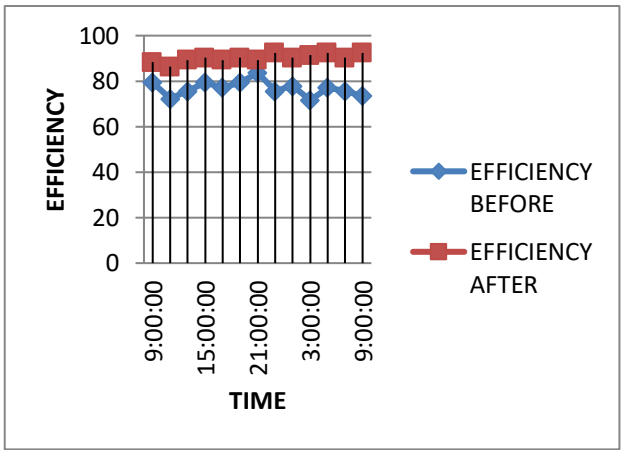

Fig 6.10 comparisons is b/w efficiency with heatless dryer and zero purge loss dryer

VII. CONCLUSION

The conclusion has to describe by the investigation and studies by means of collected data from the air compressor with dryer setup are as follow:

- Replacement of the existing air dryer with existing heatless Air dryer with the zero purge loss adsorption dryer in the system of screw air compressor by the dew point temperature results in efficiency represented by free air delivery.
- Improvement and increased in the life of silica gel adsorbent bed by using dry compressed Air.
- Tends to zero purge loss by using the FRL adsorption dryer by means of heater and blower.
- Reduction in specific power consumption in the motor by means of pressure drop.
- To reduce the operating cost and also reduction in maintenance cost.
- Moisture content reduces accordingly to the ambient condition by the zero purge loss dryer.

REFERENCES

[1]. Influence of oil injection parameters on the performance of diesel powered screw air compressor for water well application K.K. Dhayanandh, K. Rameshkumar, A. Sumesh, N. Lakshmanan S0263-2241(19)31187-X MEASUR, Volume in pi 19, 23 November 2019, Pages 107323.

[2]. Study on mechanical vapor recompression system with wet compression single screw compressor Junling Yang, Chong Zhang, Zhentao Zhang, Luwei Yang, Wenye Lin, Applied Thermal Engineering, Volume 8099, and Issue 11 April 2016, Pages 8099.

[3]. Research on Energy-Saving Operation of Screw Air Compressor Chong lie, Dewen Kong and Maolin Cai, Research Journal of Applied Sciences, Engineering and Technology 6(2), 2013December 28, Pages 325-333.

[4]. Combining effect of optimized axial compressor variable guide vanes and bleed air on the thermodynamic performance of aircraft engine system sangjo Kim Changmin Son b, Kuisoon Kim, Energy volume 119, Issue 19, December [2017] Pages 199-210.

[5]. Synthesis, characterization and tribological investigation of vegetable oil based pentaerythryl ester as biodegradable compressor oil S. Arumugam, P. Chengareddy, G. Sriram, industrial crops and product Volume123, Issue 16, July [2018] Pages 617-628.

[6]. The impact of thermodynamic balancing on performance of a desiccant based humidification-dehumidification system to harvest freshwater from atmospheric air Naef A.A. Qasem, M.A. Ahmed, Syed M. Zubair, Energy conversion and Management, Volume 199, Issue 28, August[2019] Pages 112011.

[7]. Energy efficiency analysis of wet compression systems through thermo-fluid dynamic considerations Abhay Mohan c , Palani Kumar Chidambaram b , Abhilash Suryan, Heuy Dong Kim, journal of cleaner production, Volume 214, Issue 28, December [2019] Pages 132-144.

[8]. Exergoeconomic analysis of staggered tube cross-flow heat recovery unit incorporated into industrial air-compressor for process water heating Richard Opokua,b, Charles K.K. Sekyerea,b, Solomon Ackumeyc, Obed Y.W. Abotsid, John P. Kizitod (Energy conservation and management, Volume X7, Issue 31, July [2020] Pages 100055.