TOTAL OWNING COST OF SCREW AIR COMPRESSOR SYSTEMS UTILITY

S.ASHOK, BEE Accredited ENERGY AUDITOR / Coimbatore. ashok@energymeasuretosave.com

The case study of Total Owning Cost of compressors is derived from the techno-commercial offers of the three compressor-OEMs given to a North Indian textile spinning mill's compressors requirement project in 2016; the same is shared here in this article. The mill was planning to replace & upgrade their existing BOP type reciprocating compressors with energy efficient Screw compressors system for their 750 CFM compressed air requirement. This article concludes technically the running cost criteria is the only priority to arrive at the purchase of compressors systems, to sustain thro life cycle.

TOTAL OWNING COST OF COMPRESSOR SYSTEM:-

This consists of compressor house-keeping, compressor daily condition-monitoring and running cost of the compressor as a package including its utilities like dryer, Wet & Dry Air Receivers etc. This includes the air intake and pipeline filters along with their Delta P indictors, before & after the dryer. But the industry needs to insist the energy of the compressor & compressed air treatment, in terms of pressure, temperature and flow parameters monitoring of the above sub systems to be the part of TOC.

Total Owning Cost of Compressed Air system provided by 3 compressor OEM & its comparison								
Description	**Proposal 1**		**Proposal 2**			**Proposal 3**		
Plant Requirement 750 CFM, 6.5 Bar	**Compr. OEM A**		**compressor OEM B**			**compressor OEM C**		
Installed Main Motor (In KW)	75.0	75.0	55 (VFD)	37.0	37.0	37.0	45.0	37(VFD)
Working Pressure(in BAR)	7.0	8.0	7.0	7.0	7.0	7.5	7.5	7.5
Maximum Pressure(in BAR)	8.0	9.0	8.5	8.5	8.5	8.0	8.0	13.0
Total No Of Equipment	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
Total Package Input Power	**85.8**	**85.8**	**62.9**	**44.0**	**44.0**	**44.3**	**53.4**	**44.3**
FAD in CFM	**522**	**485**	**358**	**247**	**247**	**250**	**303**	**256**
Total package UNITS / DAY	2058	967	1087	1056	1056	1063	1282	819
Total CFM - FAD	522	228	258	247	247	250	303	197
SEC Sp. Energy Consumption	**6.09**	**2.66**	**4.10**	**5.61**	**5.61**	**5.64**	**5.67**	**4.45**
Total Watts / CFM Averaged per day	**168**		**178**			**176**		
Total CFM /KWH / averaged per day	**5.95**		**5.63**			**5.69**		
Total Units per day	3026		3199			3163		
Unit Rate (INR/KW)	6.5		6.5			6.5		
Total power cost / day Rs.	**19669**		**20793**			**20563**		
Life Time Cycle in Hrs	40000		40000			40000		
Maintenance cost / LTC Rs,	1341760		1563447			1581330		
Maintenance cost / day Rs.	805		938			949		
TOTAL O & M COST / DAY Rs.	**20474**		**21731**			**21511**		

COMPARITIVE ANALYSIS OF WORKINGS FROM THE OEMS:-

WHY NOT TWO COMPRESSORS ONLY INSTEAD OF THREE NOW?

The plant requirement is 750 CFM at current header working pressure of 6.5 Bar and so the OEMs have given their compressors at 7, 7.5 and 8 Bar ratings. The plant can decide to go for 2 no compressors, instead of 3 no. to meet the demand. Compressor of higher KW ratings consumes less input Watt per CFM output compared to the compressor of lower KW ratings. So the user has to study his load pattern & cycle and decide on two compressors only are needed and what is the need to go for the third compressor now, he has to decide priorly, before getting the offers. See the SEC offered by the three OEMs in the comparison table, lower KW compressors give marginally higher 5 % SEC and the user industry to thrust on improving the overall SEC of whole system. Whatever the OEMs give the SEC here in their offer, the same SEC must be proved by the same OEMs during the commissioning and to be recorded in their commissioning report to the user.

WHY THEY NEED THREE COMPRESSORS FOR TROUBLE-FREE WORKINGS?

User Industry with a distant vision and looking for trouble free maintenance can think of one more compressor as active spare and rotate the duty workings of the three compressors as main and standby. The user must always keep in mind that,

what will happen if one of the compressors breaks down for few hours / days, the industry has to stop because of this breakdown. Maintenance crew will be in tension to keep the two active compressors always healthy and they can't' afford to have a breakdown of existing compressor even for few hours.

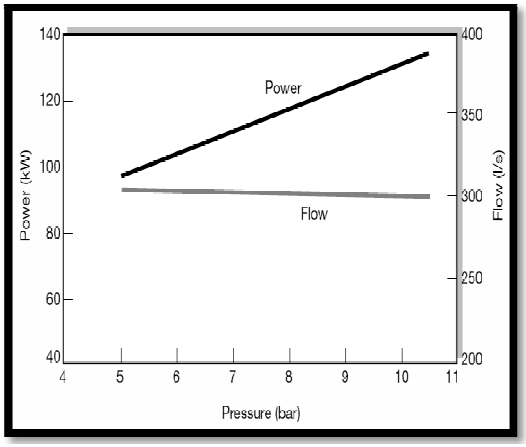
ANALYSIS OF COMPRESSOR OEM A WORKINGS:-

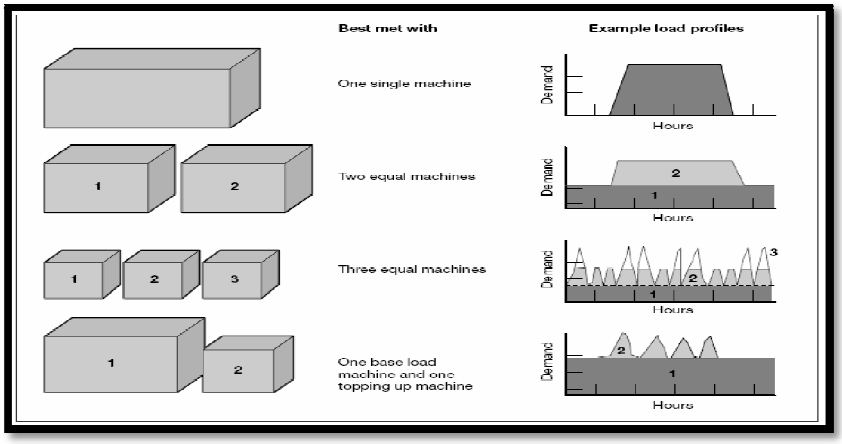
This 750 CFM demand can achieve with 1 no 75 KW & 1 no 55 KW (instead of 2 no x 75 KW as offered by OEM) rated compressors is suggested to OEM A. But here, OEM to recommend to use one 75 KW machine as base load and operate the same to its 80 % of rated motor KW capacity and modulate the other 75 KW compressor at around 50 % loading.

VFD OPTION RETROFITTING:-

The other 55 KW machine proposed now, can be modulated by cut-in & cut-out pressure settings to achieve the better SEC And by fine tuning its settings, the user can reduce the unloaded hours to less than 20 % of the cycle as well and can manage without VFD option. Only if the load-unload cycle is below the 70 :30 ratio, the OEM needs to recommend to put on VFD so that the VFD operated savings are achieved to save the unloaded 40 % power of the compressor. 2 no x 75 KW definitely need one VFD as additional cost to reduce the power during unload and the SEC of 2nd machine is offered by the OEM as 2.66 is very low as 2.66 CFM only per KW, when the Ist machine's SEC is offered by OEM at 6.09. This wide variation in SEC as offered in the comparison table cant' be tolerated.

LOAD PROFILE versus COMPRESSOR CAPACITY:-





POWER VS PRESSURE GRAPH FOR GIVEN FLOW. / LOAD PROFILES DECIDE COMPRESSOR SELECTION.

ANALYSIS OF COMPRESSOR OEM B WORKINGS:-

Out of the three compressors, offered, the VFD can be fixed to lower KW rated compressor only and not to higher KW machine as offered by OEM. The industry must keep in mind to use the VFD effectively in the mid-loading region, here in compressors usage in the " load: unload cycle" is around 50 % Loading + / - 20 % band. If the same VFD is used at 80:20 load / unload cycle, then VFD becomes ineffective and added to it, its self consumption reduces the scope of energy savings in that region. So VFD has its limitation to use thro entire load cycle. Here the user has to improvise the pressure settings of base load and modulating compressor to achieve energy savings.

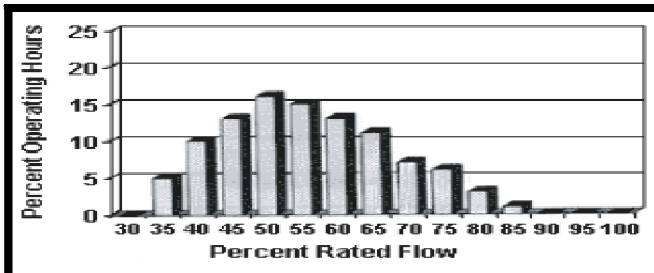


Figure 5.3 Example of an excellent variable speed drive candidate

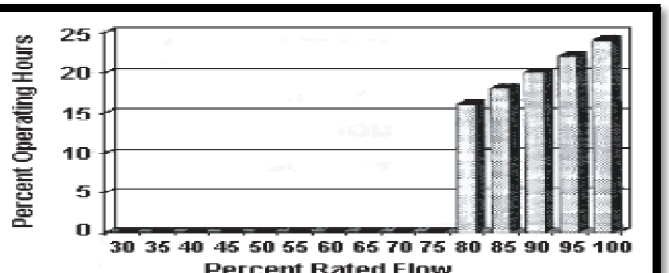


Figure 5.4 Example of a poor variable speed drive candidate

ANALYSIS OF COMPRESSOR OEM C WORKINGS:-

The VFD machine is rated at 13 Bar. This is ok for a stand-alone machine but for multiple compressors system, this 13 Bar rating is a mismatch; to say VFD compatibility can be achieved on 13 Bar rated machine. On the contrary, focus on the industry's requirement of 6.5 Bar pressure and what is the point in giving a 13 Bar machine and forcing the user to necessarily

make use of the VFD working on the machine? VFD to a screw compressor will be mismatched and the user has to tune the VFD compressor to use in its efficient loading zone. Here instead of energy saving, the user has to take care to efficiently use the VFD. So, first monitor to target reduce loading related energy losses. The user industry, if at all they have oversized compressors, then to fine-tune the pressure and reduce energy losses first, and later they have to utilize the VFD to function in closed loop control.

HOME WORK BY USER INDUSTRY BEFORE BUYING COMPRESSOR SYSTEMS:-

COMPRESSED AIR FLOW METERING PRIORLY:-

The existing industry needs to follow the BEE Manthra of Monitor Energy to Target its Reduction. They have to first buy and install compressed air header flow meter to measure the existing or proposed compressed air flow is at 750 cfm. After installing and studying the existing compressed air generation parameters and confirm they can match to the load. If it is new project, this flow meter needs to part of part of project package. User is paying Electricity charges of Rs.1 Crore PA, for the compressed air per year, and that the compressed air parameter is a fast acting variable, need to be measured fastly to monitor the generation, distribution and usage efficiency and the losses happening in between.

INDIVIDUAL COMPRESSOR ENERGY MONITORING MUST:-

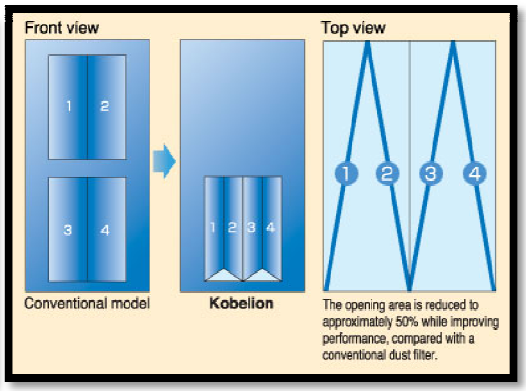
Each screw compressor panel must have Multi Function energy meter to show instant power and energy parameters and cumulative kwh for load hours and unload hours. This will show relative energy efficiency of each compressor compared to others. And overall compressor house KWH / KVAH parameters to be compared with Totalized CFM to study the WATT PER CFM at 6.5 Bar daily, weekly, monthly and yearly.

COMPRESSED AIR LEAKAGE ARRESTING BEFORE:-

First, the OEM in their offer has to include FAD study at site as part of their Commissioning Report. Then compressed air leakage needs to be measured by pump-up capacity procedure, or by the above compressed air flow metering method, routinely. First, let the industry arrest and confirm that the compressed air leakages are minimum and within the norms of industry segment. Compressed air leakages are different, as per the industry segment wise. Say the air leakage in spinning mill normally is around 20 % + Band. But in textile air jet looms, normally is around 5 % Plus only as per that segment norms. So know your leakages first and arresting them is immediate need of the hour now.

AIR INTAKE POINT IN COMPRESSOR HOOD TO HAVE PRIMARY PRE-FILTER:-

The compressor's input is only this Ambient Air at the intake, this must Freely deliver at inlet. If the filters are choked, then this air has to force itself thro choked air intake filter to deliver to compressor inlet. The air compressor vendors have given instructions to the user to change the air intake filter after few thousand hours and accordingly the industry is implementing this replacement. Why should allow your air intake filter to choke till 3000 hours and take action later. Every day and every shift, clean your pre-filter online. Instead of allowing the choke upto 500 mmWC across filter after 3000 hours, routine cleaning of pre-filters will allow you to maintain & sustain at say 100 mmWC pressure drop across your filter. This will improve and sustain your compressor FAD. If the same industry condition monitors the air intake daily, then keep swapping the cleaned filter weekly, the industry will see to it that the air intake pressure drop is very minimal.



We need Three stage Filtration of Air intake air, daily cleanable V type filter, weekly cleanable one inch depth thick mesh filter embedded on the hood, and next is the real air intake paper filter fitted on compressor mouth suction. The Magnehelic Delta P gauge to measure Air intake filter Delta P to fix on hood, to be monitored daily and keep Pascals minimum.

COMPRESSOR LOAD /UNLOAD PRESSURE CONTROL SENSOR TO RELOCATE TO AIR RECEIVER:-

It is suggested to the OEMs to recommend to the user to relocate the compressor's discharge pressure sensor from the hood to the Air receiver. This will reduce the pulsations of the compressor load & unload pattern, give steady compressed air header pressure & improves safety of compressor working thus leading to ENERGY SAVINGS. The industry which runs on

single or multiple air compressors in the compressor utility house can implement this sensor relocation to main receiver to maintain a narrower band, but constant air header pressure.

CHECK WITH EQUIPMENT OEMS FOR MINIMUM AIR PRESSURE DEMAND:-

First the industry, when floating an enquiry to the compressor OEMs, must say the flow and pressure criteria that it needs 750 CFM at 6.5 Bar as operating pressure**.** To check with the relevant equipment OEM what is the compressed air demanded in CFM and Bar minimum, average and maximum values. Here, the user has to reverse-educate the machine OEM that they have to reduce their minimum CA pressure demanded from header. During Audit, I came across 1000 CFM header air flow at 7.5 Bar. Here, the user industry maintained 7.5 Bar to cater to few machines of 100 CFM requirement only which required 7 Bar. And, 900 CFM out of 1000 CFM air flow is needed at 6 Bar loads only. So for 100 CFM @ 7 Bar, I had suggested the user to go for Pressure Booster and after that, user industry saved 1 Lakh units per annum. Also, I suggested to that industry to discuss with their machine OEM to reduce his demand for CA pressure from 7 Bar to 6 Bar by upgrading of pneumatic components inside his machine, to bring to 6 Bar as minimum requirement, instead of 7 Bar now.

OUTSOURCE ROUTINE AIR LEAKAGE MONITORING:- .

Every industry utility department will vouch that their compressed air leakage is only minimum. And that routinely they are attacking the leakages. But unfortunately the man, who maintains the machine, has to say this always. But periodically, you plan to outsource the compressed air leakage monitoring and arresting procedure to the locally available air leakage service providers. Monitor thro your air flow meter cum totalizer, how much leakage in % before and after the corrections. This monitoring will help you, to take control of your air leakage. Random air energy audit on your industry will show you, whether your air leakage is under your control, or yours is under air leakage surveillance or your air leakage is out of control. And that, if you could not control your air leakage as your other 0peratioal & Maintenance priorities demand more of your team than attending to this trivially-viewed your air leakage; then contract out Air Leakage Detection & Correction routinely, at least now.

WET and DRY AIR RECEIVER, A MUST PART OF PACKAGE:-

Wet & Dry air receivers are mandatory need in compressor & its compressed air treatment system. The compressed air generation cost goes up to 5 % due to poor performance of water separators, excess pressure drops across the filters, added to this is the artificial pressure cyclic load unload fluctuations. Allow each of the compressed air treatment sub system to stand alone, breathe well and with a buffer in between in them thro the two receivers. For which, after the compressor, the WS + AO filter in the pipeline at location, between the compressor & air receiver can be shifted at location, between Air receiver & Dryer. In a multiple compressor systems, even when only compressor is running, user to make parallel running of all individual receiver and dryers and filters so as to bring down pressure drops inside compressor house and allow more receiver volume to cool air.

DIGITALIZE AIR RECEIVER TEMPERATURE & PRESSURE WITH ALARM SETTINGS:-

Digitalize the compressor house final air receiver air pressure and temperature along with High / Low alarm settings. If there is generation air flow down or process demand high or heavy leakage somewhere inside, this will show with LOW pressure alarm. Instead of allowing the machines to shut down due to low air pressure, we can step in priorly to correct the low air pressure. The air receiver temperature with High alarm will show the compressor and its post air cooler heat exchanger healthiness. The above alarms are intended to improve the compressor house-keeping and not to trip system. If the user thinks compressed air is precious, he must talk in terms of two decimals like 6.54 Bar as Pressure and not with one decimal alone.

CONCLUSION:-

After studying the total owning cost of the three OEMs, we understand that the offers can still be, more practical on the TOC, i.e. the running cost. The OEMs have to standardize on the Add-ons to their offered systems as like two air receivers, VFD, Delta Pressure gauges across the Line filters, Refrigeration dryer of 50 % more capacity, one more Active Spare compressor system (optionally, so as to smooth & timely preventive maintenance on the rested compressor) etc. It is suggested here to the compressor OEM to give a matched set of compressor & its air treatment devices to the user, and not to compromise on those device parameters, by retaining the compressor cost and reducing the cost of peripherals to clinch the order.

Here, the user also needs to pro-actively discuss with the compressor OEM during the offer stage, to allow him to give his professional supply & services, as a complete system. Trying to cut down the initial budget, the user & OEM compromise there on the compressed air treatment. This leads to sustainable energy loss of more than 10 % over the compressor's life. This is typically explained in the above comparison statement of the three compressor OEMs. So this is to insist on TOC of compressor system, for which the user and the OEM have to be collectively responsible & pro-actively work towards sustainability.

S.ASHOK, BEE Accredited ENERGY AUDITOR , Coimbatore. ashok@energymeasuretosave.com

Pls Visit *www:energymeasuretosave.com*, " Sharing knowledge to Save OUR Energy"
- for more Practical Energy Saving Tips in Home & Industry.