COMPRESSOR EFFICIENCY MONITORING

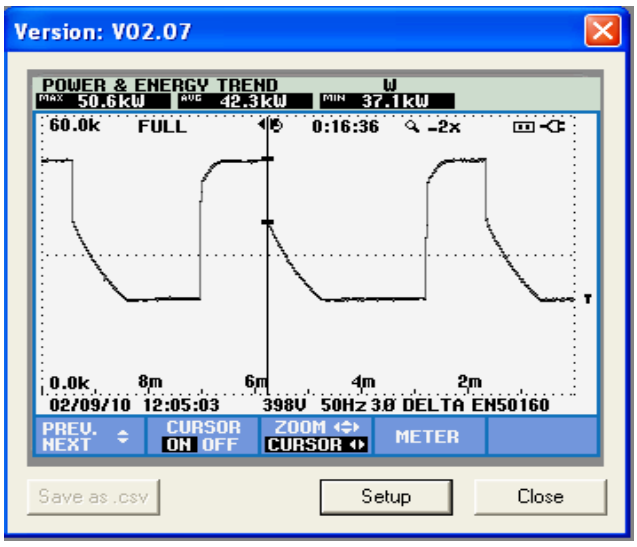
Electricity KWH can be used as tool to monitor daily health of compressor.

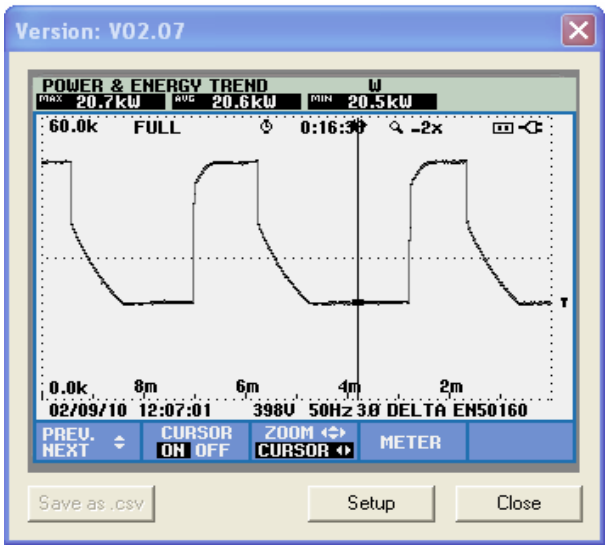
Existing Kwh meter on compressor panel shows the total compressor consumption of compressor during loaded and unloaded hours. Instead of that, we propose a Multi Function Energy Meter to monitor separately & trend load / unload Kwh of compressor.

Sharing with all, about the case study of our C.I.T.team's Energy Audit in an industry, we were monitoring the power waveforms of 45 KW screw compressor (without VFD). The following energy curves show the loading and unloading patterns of the compressor. You will find the cursor tracking the loaded consumption as 50.6 KW over a few minutes. Elaborating on the measurements:

This loading power curve, while starting takes a steep ramp due to ordinary startup (not soft startup) and the curve stays on the straight line and at this stage, the compressor fully loaded KW and the compressor discharge flow is matching the load and this is a straight line extending for few minutes to hours depending on the load demanding.

In the next energy curve, when the load demand falls, the compressor cuts out and slowly ramps down to the unloaded pressure consumption at 20.7 KW and as long as the demand is not there, then this is a straight line extending for few minutes and sometimes, switching off after unloaded time delay interval. If the demand starts to rise, then the compressor cycles from unload mode to load mode running for many minutes in both the modes. As demand fluctuates, the compressor always toggles from no load to full load. This is the practical cycling pattern seen in many of the industries now.





COMPRESSOR LOAD KW = 50.6 KW COMPRESSOR UNLOAD KW = 20.7 KW

For example, let us set the compressors A & B to operate equally, at 7 Kgsc cut-in and 8 Kgsc cut-out. For the given equal pressure settings, the relative readings of unloaded KWH of compressors A & B trended daily, will indicate the relative compressor No-load KWH at 7 Kgsc. This no load power Kwh shows the **Compressor Tare Efficiency.**

Above 7 Kgsc and say up to 8 Kgsc the relative readings of the loaded KWH of compressors A & B trended daily will indicate **Relative compressor loaded efficiency.**

Regular monitoring will indicate the deviation between the machines and we can analyze the reasons related to poor efficiency is due to the maintenance : as inlet air filter choke, inter / post cooler malfunction, element temp high, oil heat transfer poor etc.

The compressor daily working efficiency can be studied by this cumulative KWH, KVAH measurement over a period of day, week or month or year and assess the compressor performance over a period of years. Also the same Energy Multi Function Meter if fitted in two or more compressors in the plant, this can be used to study the relative health monitoring of the compressor as explained in the example above.

Though FAD, the Free Air Delivery measurement is the ideal tool to analyze the compressor efficiency, it is practically difficult to set up and measure regularly the compressor outputs. **Above meter can be used an Inferential tool to monitor compressor No load & Load Efficiency regularly.**

- **The proposed Compressor Efficiency Monitor (C.E.M.) to contain:-**

- First page of 3 window displays to show -
- Loaded KWH in top, unloaded KWH - middle, total KWH in bottom window.
- Second page of 3 window display to show -
- Loaded hours, unloaded hours, and total running hours of the compressor.
- Third page of 3 window display to show -
- Loaded units per hour UPH, Unloaded UPH, and Total run UPH
- Further pages to show instant values like KW, KVA, PF, V, A, Hz etc.
- 3 phase volts & currents as Vr, Vy, Vb and Ir, Iy, Ib.
- Also, meter to capture initial KW shoot up and latch display the max KW.

Now, is there any Energy Meter OEM who gives this meter type in 4"x 4" size?

The proposed embedded software in the meter to include an undercurrent setting and the same settable by the user during hook up of the above meter. After putting on the meter on trial, measure the loaded and unloaded kw and set threshold values of kw to enable cumulative KWH function to switch on & off.

Please find below, the compressor spec at two pressures say at 7 and 9.5 Kgsc from the compressor OEM. The table is interpreted now as 2 flow patterns and depending on the 2 set pressures; the flow is discharged from the compressor to the load. The last column is attached by us, to show that for every 1 Kg discharge pressure is UP, the power will go up by 6 to 10 % as per the BEE guidelines.

Model –	motor kw -	F.A.D.-	% Change -	Pressure-	% Change/	Power % change
45 kw - 7.5	45 kW	**267 cfm**	---	**7.0 Kgsc**	**--**	---
45 kw -10.0	45 kW	**223 cfm**	**16%down**	**9.5 Kgsc**	**35%**up	**20 % UP**

So for higher pressure cut-out set, we get less flow & at higher power consumption.
For Less pressure cut out setting, we get more flow and at less power consumption.
Please make use of these figures in industry “compress less & conserve more”!

Hence if we measure thro the above meter, the loaded and unloaded KWH and from the pressure gauge display, the corresponding pressures for any compressor, then **we can compare with the compressor name plate to know the deviation from the spec and analyze the ways to reduce the power consumption.**

If we have two or more compressors in the plant, we measure the above power and at the given same and for the given equal load & unload pressure settings, **we can compare the two compressors to know the relative efficiency of the same and the deviation with respect to the compressor name plate.**

Now industry saves on VFD up to 25 % on this type of screw compressor. When VFD is used, the CEM to have loaded KWH and hours only. But THD current & volt % to be displayed in the meter. Each VFD increases the THD i % during its part loading and we must know their values too since they are dumping harmonics into the grid.

When we study the macro Specific Energy Consumption of the industry, we look into the energy is spent towards on two heads of consumption, namely,

- Machine Off- load Energy Consumption that is the Tare Load Consumption
- Machine ON-load Energy Consumption that is the Product Load Consumption.

There are many similar applications in the industry involving big motors like:-

Material handling machine like conveyor where in tare load & material power KW

Lathe machine where in empty run power mostly and tooling power consumption

Fuel oil circulation pump in Bypass mode to process power consumption,

Batch process which involves intermittent material movement & consumption etc.

MACHINE EFFICIENCY MONITOR:-

Hence, this compressor efficiency monitor can be used as a **MACHINE EFFICIENCY MONITOR** for any machine with varying power consumption from no load to full load during its daily running hours in the batch & continuous process industry and even in the commercial segment where in motor idling is inevitable.

S. ASHOK, BEE certified ENERGY AUDITOR, COIMBATORE /

Pls. call 94437 20220 / Email id: ashok.anbesivam@gmail.com

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