REPLACEMENT OF RECIPROCATING COMPRESSOR WITH VFD ENABLED PERMANENT MAGNET MOTOR BASED SCREW AIR COMPRESSOR

(*For Surat Textile Cluster*)

Cluster Brief:

Surat, known as the synthetic capital of India, is house to about 400 textile processing units, involved in processing of synthetic sarees and dress materials. The textile processing units can be broadly classified into 'Dyeing' units and 'Printing' units. Most of the units have the facilities of both dyeing and printing. The sarees and dress materials produced in Surat cluster are not only marketed in India but also exported to various countries. The textile processing units in Surat, are mainly micro, small and medium enterprises (MSMEs)and are spread over various location likePalsana, Sachin, Pandesaraand Surat city industrial areas. The main raw material for the cluster is polyester grey cloth which is sourced from local polyester producers in and around Surat. Majority of the industries located in Surat are wet processing units which requires high amounts of thermal energy in the form of steam and thermic-fluid, leading to a high share of energy cost. The sector is unorganized in nature, mostly using old and inefficient technologies. There is a significant potential to make these units energy efficient and cost competitive, through accelerated adoption of energy efficient technologies in the cluster.

Existing practice:

In the textile manufacturing process, there is a continuous demand of compressed air in order to cater various pneumatic operations throughout the manufacturing process. In the exiting manufacturing process the compressed air system is distributed in nature and most of the compressed air demand is catered by multiple reciprocating air compressor installed at various location of the plant. In most of the cases separate reciprocating air compressors are installed for individual processes. Generally, these single stage reciprocating compressors work with higher noise and have a relatively high cost of compression. The operational efficiency varies from 22 to 35 kW/100 cfm, based on the age of the equipment.

Proposed technology:

Based on the detailed analysis of the existing compressed air system, it is proposed to replace the low performing reciprocating compressor with VFD enabled permanent motor based screw air compressor. The key parameters to be included in the technology are:

- ✓ High efficient rotary screw compressor with VFD which can cater to fluctuating compressed air requirement.
- ✓ Equipped with high efficiency permanent magnet motor
- ✓ Motor is directly coupled to the screw arrangement of the compressor which actually nullifies the transmission loss of a belt driven system.
- ✓ Lubricating oil based cooling system

Justification of technology selection:

In a typical 24hour operating textile processing process where the compressed air demand is continuous and fluctuating in nature with an air pressure requirement of up to 7 bars, a screw air compressor with variable operation mode is more suitable as compared to the

reciprocating compressed system. Moreover a screw compressor is able to compress higher volume of compressed air as compared to a reciprocating compressed air system at same pressure.

A comparison is drawn between the two type of compressor air technologies on different aspects for having clear understanding. To start with, a screw air compressor uses two meshing helical screws, known as rotors for compressing the air whereas a reciprocating (Piston Type) air compressors use pistons driven by a crankshaft to compress the air. In the following aspects, the two technologies are differentiated from each other.

- ✓ **Number of Moving part:**
  There are a lot of moving parts like piston, piston ring, crankshaft, connecting rod, valves, etc. in reciprocating causing wear & tear. Hence lesser reliability & more chances of breakdown where as a screw compressor has only two moving parts which are not in contact with each other so no wear & tear, hence there is less possibility of breakdown.

- ✓ **Internal air temperature:**
  In case of reciprocating air compressor,the internal temperature at which the pistons operate is around 150 to 200 ^{o}C, it is due to the friction generated by the contact of piston rings against the cylinder walls. Whereas in case of screw air compressor the internal air-end (screw component) operating temperature is around 80 to 100^{o}C. This is possible because of no friction between the screws and oil / lubricant which forms a non-wearing seal between rotors and casing thereby removing heat through a thermostatically controlled fluid circuit.

- ✓ **Operational point**
  There are around 8 or more valves in total & hence will require frequent cleaning due to high carbonation thus highermaintenance in case of reciprocating compressor where as there is only one piston type inlet valve, so there is a less chance of carbonation hence minimum shutdown is not required for maintenance.

- ✓ **Space requirement**
  Reciprocating compressors require foundation as well as grouting because of high unbalanced forces & vibration. Here the pistons rise and fall (vertical machine) or move back and forth in the cylinder thereby causing too much vibration. Hence it involves additional foundation cost. Whereas in case of screw as it rotates in one direction thereby causing less noise, heat and vibration. Furthermore, Screw Compressor is skid mounted therefore foundation is not required. No additional cost of foundation. More over the space requirement is also less as compared to the reciprocating compressor of same capacity.

- ✓ **Noise generation**
  In case of reciprocating compressed air system the noise levels could go as high as 100 dB where in the noise levels are within 75 dB in case of screw air compressor. Also, most of the screw air compressor comes in a sound isolation box.

- ✓ **Transmission losses**
  In case of reciprocating compressed air system, v-belt is used for transmitting power from motor shaft to compressor which accounts for a loss of 5% whereas in case of the screw compressor either direct drive or poly cogged belt are used which decreases the transmission loss and increases the overall efficiency of the system.

Energy & monitoring saving:

For calculating the energy and monetary benefits, a typical case of compressor of 250 cfm requirement has been considered where in 8 number of reciprocating compressed air system were operating in order to cater the compressed air demand of the system.The benefits envisaged through replication of reciprocating compressor with screw compressor have been summarized in the table below:

Parameters	Unit	Values
Required CFM	CFM	250
Existing kW/CFM	kW/CFM	**0.29**
Proposed kW/CFM	kW/CFM	0.15
kWh per hour	kW	35
Annual Operating hours	Hours/annum	5304
Annual energy saved (kWh/year)	kWh/years	185640
Annual monetary saving (Rs/Year)	Rs/Years	1392300
Project cost Rs.	Rs	1652000
Simple pay back	Year	1.19

The benefits can be summarized as:

- ✓ 30-50 % reduction in specific power consumption of the compressor
- ✓ Noise free operation
- ✓ Longer compressor life

Replication Potential:

Based on the discussion with associations, units, sample survey and energy audits, it is estimated that the technology has a replication potential of 40% in the cluster. Based on 40% replication, the overall project benefits will be as follows:

Parameters	Units	Values
Annual electrical energy saving (one unit)	kWh/y	185640
Annual electrical energy saving (one unit)	MJ/y	668297
Annual electricity saving (considering 40% replication)	kWh/y	16633344
Annual CO_2 emission saving (one unit)	tCO_2/yr	167
Annual CO2 emission saving (considering 40% replication)	tCO_2/yr	14970
Estimated investment in technology (one unit)	Rs in Lakh	16.52
Estimated investment in technology considering 40% replication (assuming price down due to demand aggregation)	Rs in Lakh	1480

Parameters	Units	Values
Total Investment	Rs in Lakhs	2.11
Lifetime energy savings (in 10 years)	TJ	34222
Lifetime CO_2 emission saving (in 10 years)	tCO_2	149700

Availability of the technology

There are good many technology providers available in India and many of them have their base in Surat. The following are the technology providers available in the cluster.

1. Atlas Copco
2. Venus air compressors
3. Kaeser air compressor
4. Hitachi compressed air system

Effect on the process

This technology has no effect on the existing production process, it will only reduce the power consumption required for generating compressed air.

Reasons for unpopularity:

This technology has yet not penetrated the cluster because of the following reason:

- ✓ Less knowledge on use of VFD in compressed air system.
- ✓ Higher capital cost of the technology as compared with the existing.
- ✓ No one has yet demonstrated the results of the technology to all unit owners in the cluster.