



# **New Energy Saving Air Compressors: Case studies from Indian Industries**

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*Padmanabh Nagarkar, XL Consultants*  
*Prosanto Pal, TERI*

# Outline

- ❑ Energy consumption in compressed air system.  
(oil injected screw)
- ❑ Factors influencing specific power consumption
- ❑ Single stage vs two stage compressors
- ❑ Guidelines for selection of two stage compressors

# Power cost :- Compressed air system

- ❑ Air compressor is a major expense for SMEs
  - 37 kW compressor costs US\$ 5,500 and causes electricity costs of US\$ 33,000 per year (24X7, 8760h.)
- ❑ Energy consumption of compressed air system
  - Generation
  - Treatment
  - Distribution
  - Consumption
- ❑ Compressor selection decision is difficult for SME, for selecting Oil Injected Screw compressor(OIS) due to power saving claim by some manufacturers for two stage

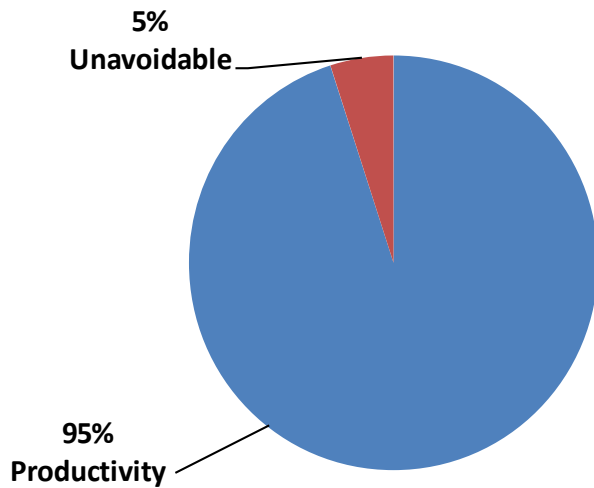
# Managing compressed air cost

Cost centre	Ideal values
Generation cost	SPC close to 15.5 kW/ 100 CFM (2.83m <sup>3</sup> /min) /100 PSIG(7kg/cm <sup>2</sup> g).
Treatment cost	Pressure drop not exceeding 3 psi(0.21kg/cm <sup>2</sup> ) with moisture -23 deg. C. dew point and oil to 0.1 PPM
Distribution cost	Pressure drop at 2 psi(0.14 psi) and variation of pressure throughout the plant +/- 1 psi(0.07kg/cm <sup>2</sup> )
Consumption cost	Varies from plant to plant

# Productivity

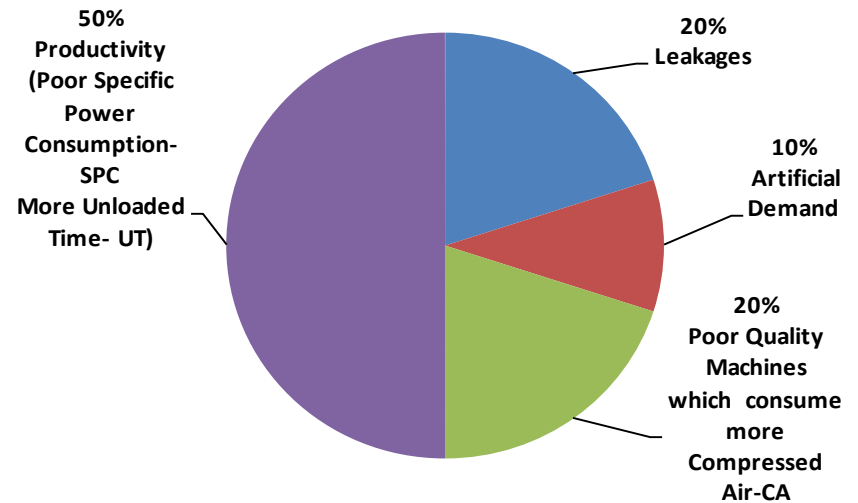
## Ideal Plant

Produce Ideally, Consume Correctly.



## Common Practices

Produce More, Leak More, Consume More.



# Factors influencing specific power consumption

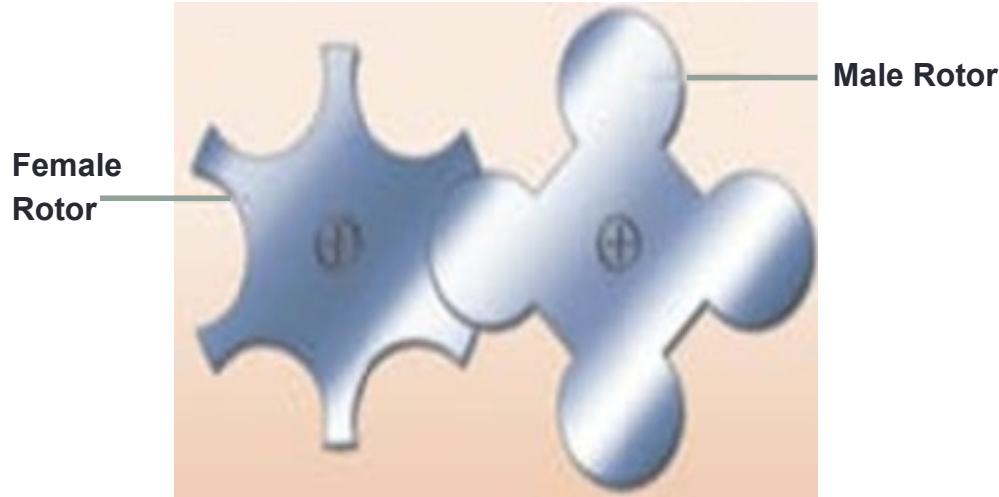
- ❑ Screw profile and allied parameters
- ❑ Transmission losses
- ❑ Oil separation efficiency
- ❑ Electricals – motor and drive
- ❑ Number of stages (one/two)

# Screw Profile and Allied Parameters

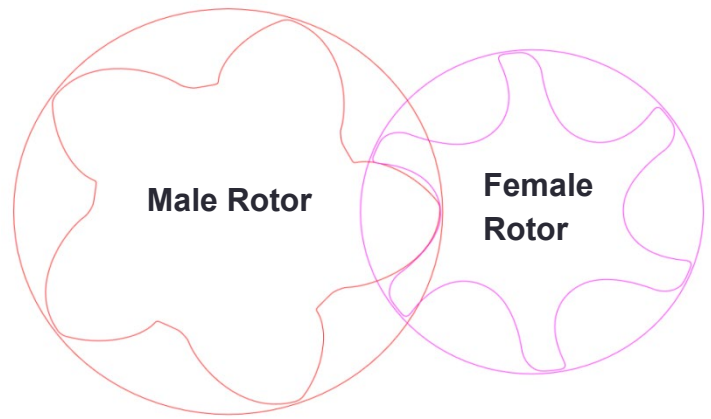
- ❑ Symmetrical profile was in use for almost 100 years, however it was very inefficient
- ❑ In the year 1960 asymmetrical profile was introduced
- ❑ Around 1980, with the help of “Computational Fluid Dynamics” (CFD), many efficient profiles have been developed.

# Screw profiles

**Symmetric Profile**



**Asymmetric Profile**



**Typical Screw Compressor Rotor Profiles**



# Oil separation efficiency

- ❑ Air oil separator element creates resistance while separating air from air oil mixture.
- ❑ Air oil separation process is called coalescence. In the last 30 years, the development of fibre glass and paper media have reduced pressure drop in oil separator element and also reduced oil content in compressed air.

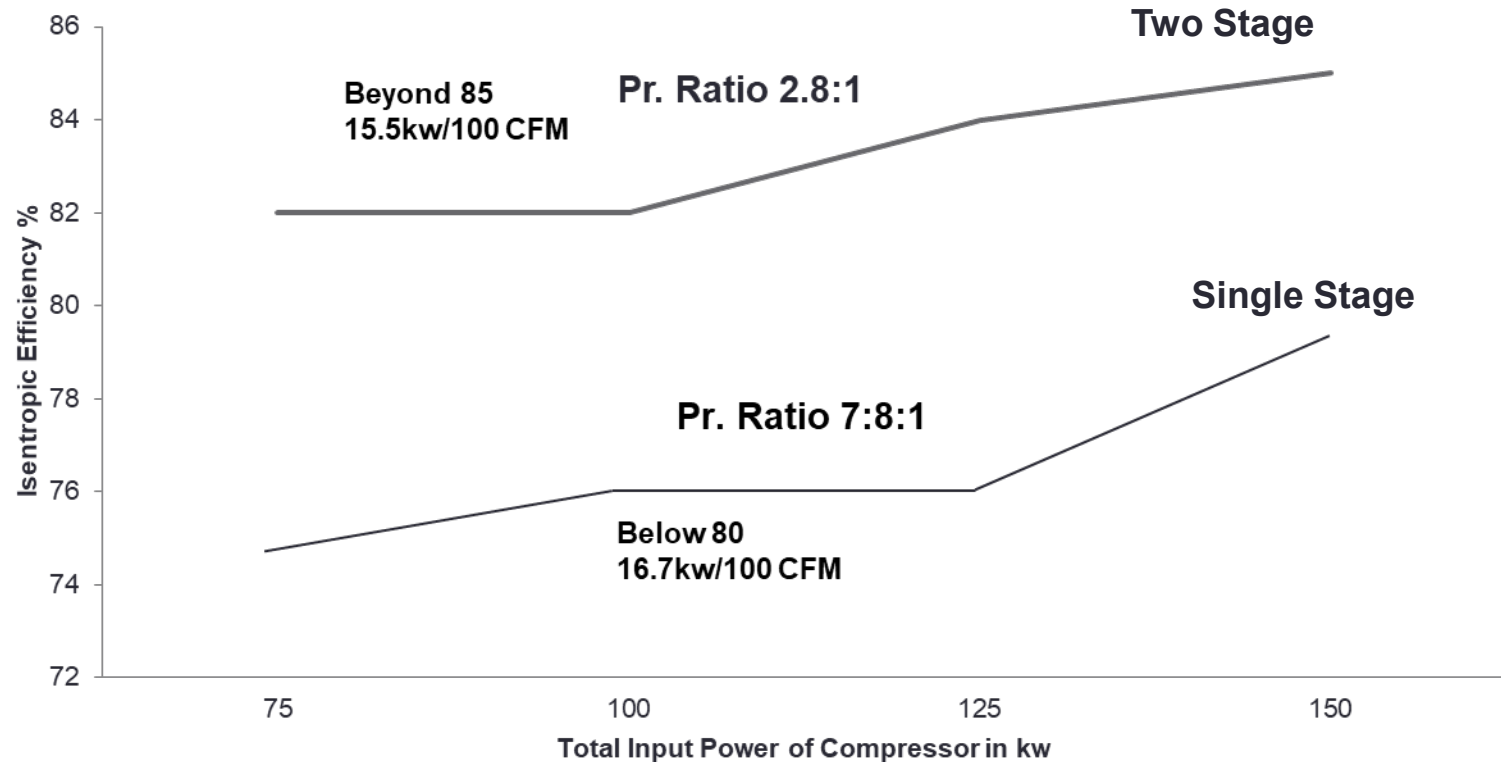
# Electricals – motor and drive

- ❑ Although efficient motors like IE4 were introduced, the power wasted in unloading condition was still a problem.
- ❑ Introduction of PM(Permanent Magnet)+VSD(Variable Speed Drive) has revolutionised the compressor selection process.
- ❑ PM + VSD is a great energy saver for SME.
- ❑ The quality of winding and permanent magnet decide full load as well as part load efficiency
- ❑ Combined motor and drive should have efficiency class defined in IEC 61800-9-2

# Two Staging (TS)

- ❑ “Specific Power Consumption” (SPC) of compressors, amongst other things, depends on “Two Staging”
- ❑ Some manufacturers claim “Two Stage Oil Injected Screw Compressors” save energy, only if the operating pressure is more than 14 bar
- ❑ Others have practical data showing a “Two Stage Compressors” saves 10-12% electric energy
- ❑ Decision of selecting energy efficient TS compressors poses difficulty for SME

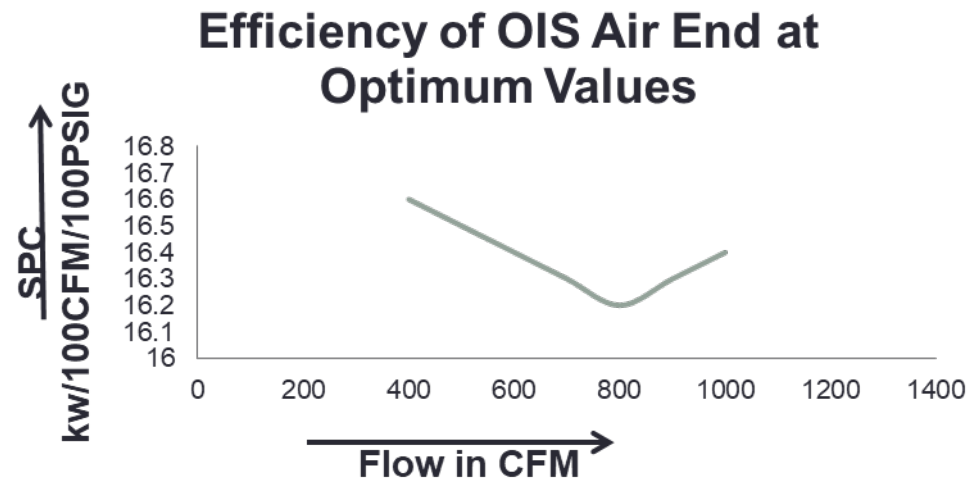
# Understanding Two Stage Compressor



For a 1000 cfm/100 psig(28.3m<sup>3</sup>/min at 7kg/cm<sup>2</sup> g) compressor running as a base load, the SPC difference of 1.2 kW/100 cfm (1.2kw/2.83 m<sup>3</sup>/min) is 12Kw per hour translated to US\$12,000 per year, which is 50% cost of a new compressor.

# Efficiency of an 'Air End'

- ❑ It depends upon profile, tip speed, diameter of rotors, pressure and rotor pairing (4X6 or 5X6)
- ❑ Every air end gives its best efficiency at certain values called as optimum values for that configuration.
- ❑ It is difficult to select two air ends with optimum values in smaller diameter of rotor with a flow up to 400 cfm.(11.33 m<sup>3</sup>/min)



# Understanding two stage compressor

- ❑ Conventionally two stage compressor means intercooling and achieving ideal inter stage pressure of Square root of  $(p_1 \times p_2)$
- ❑ 'Control air cooling' is used in TS by spraying slightly cooled oil between the stages
- ❑ Compression ratio in absolute terms for 7 bar compressor is approx. 7.8 to 1 while in two stage it will be about 2.8 to 1
- ❑ Single stage has leakage losses which are reduced in two stages

# Comparison of two stage and single stage OIS compressors

Two Stage	Single Stage
<b>300 Kw/(7Kg/cm2 g) – 6 months old</b>	160 Kw X 2/(7 Kg/cm2) – 2 years old
<b>Location – Automobile Factory in Mumbai</b>	Location – Automobile Factory in Mumbai
<b>FAD by flow meter – 63m3/min at 7 Kg/cm2 g</b>	FAD by flow meter – 61 m3/min at 7 Kg/cm2 g
<b>Compressor Package Power – 338 kw</b>	Compressor Package Power – 366 kw
<b>Service Factor = 1.15</b>	Service Factor = 1.15
<b>SPC – Average 15.5 kw/100 CFM(2.83 m3/min)</b>	SPC – Average 17.4 kw/100 CFM(2.83 m3/min)

Two Stage	Single Stage
<b>Compressor Motor Power – 132kw/(7Kg/cm2 g) - 2 years old</b>	Compressor Motor Power – 150kw/(7Kg/cm2 g).3.5 years old
<b>Location – Large Fabrication Shop in Mumbai</b>	Location – Large Fabrication Shop in Mumbai
<b>FAD by flow meter – 28 m3/min</b>	FAD by flow meter – 27.2 m3/min
<b>Compressor Package Power – 158 kw</b>	Compressor Package Power – 179 kw
<b>Service Factor = 1.15</b>	Service Factor = 1.15
<b>SPC – Average 15.4 kw/100 CFM(2.83 m3/min)</b>	SPC – Average 17.2 kw/100 CFM(2.83 m3/min)

Calculating SPC in a running plant, is difficult since it is not possible to maintain 7 bar constant pressure and figures may vary with test bed.

# Guide lines for selection of two stage compressors in SME's

- ❑ Recommendations for adoption of two-stage compressors
- ❑ If the compressed air requirement is for 8 hours a day and it can be met by small sized ( < 50 HP-37Kw) compressor, additional investment in a two stage may not be justified. The SME can go for reputed fixed speed compressor with start/stop for up to 20 HP-15Kw (with a bigger air receiver) and soft starter up to (50 HP-37Kw)
- ❑ If the compressed air requirement is for 24 hours a day and can be met by medium sized ( < 75 HP-55Kw) compressor , PM+VSD seems to be the best option especially if the demand is fluctuating (or is low in the second and third shift)
- ❑ For large compressors (> 100 HP-75Kw) and above, especially for compressed air requirement of 24 hours per day, two-stage compressor with IE3/IE4 fixed speed motor system from a Compressed Air and Gas Institute(CAGI) approved supplier is recommended



# Thank You

Padmanabh Nagarkar: [parth\\_2005@hotmail.com](mailto:parth_2005@hotmail.com)

Prosanto Pal: [prosanto@teri.res.in](mailto:prosanto@teri.res.in)