9.Motor Controls - Applications

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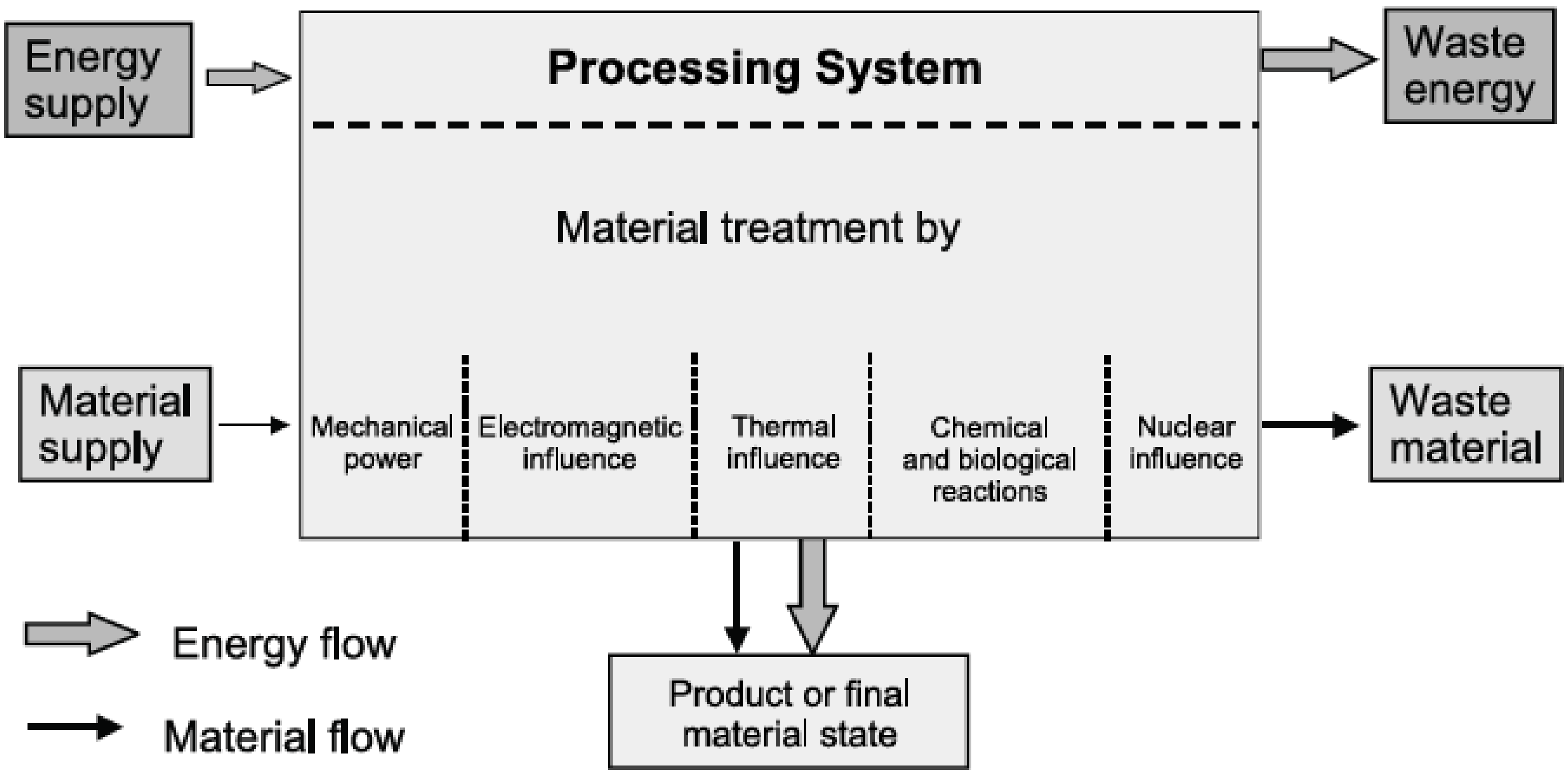
Discussed topics

- Fluid control
- Motion control
- Material handling
- Machine tools

Variables in Processing Systems



Energy Saving Strategies

Motor Controls

1. Use Variable Speed Drives

   In variable load applications VSDs can save

1. Use controls to turn off idling motors

Energy Saving VSD Applications

1. Centrifugal pumps, fans and compressors in which torque increases with the square of the rotating speed of the motor.
   The electric power sharply increases with the speed (up to the cube) and a smooth adaptation to the real need can lead to large savings.
2. Conveyors, escalators, hoists, cranes and similar types of equipment where the torque is more or less independent from speed.
   The cost and energy efficiency benefits are smaller compared to the first group of applications because the change of input power is only linear with the speed. Regenerative braking can lead to additional savings.

Affinity Laws

$$Q \propto N$$

$$H \propto N^2$$

$$P \propto N^3$$

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$

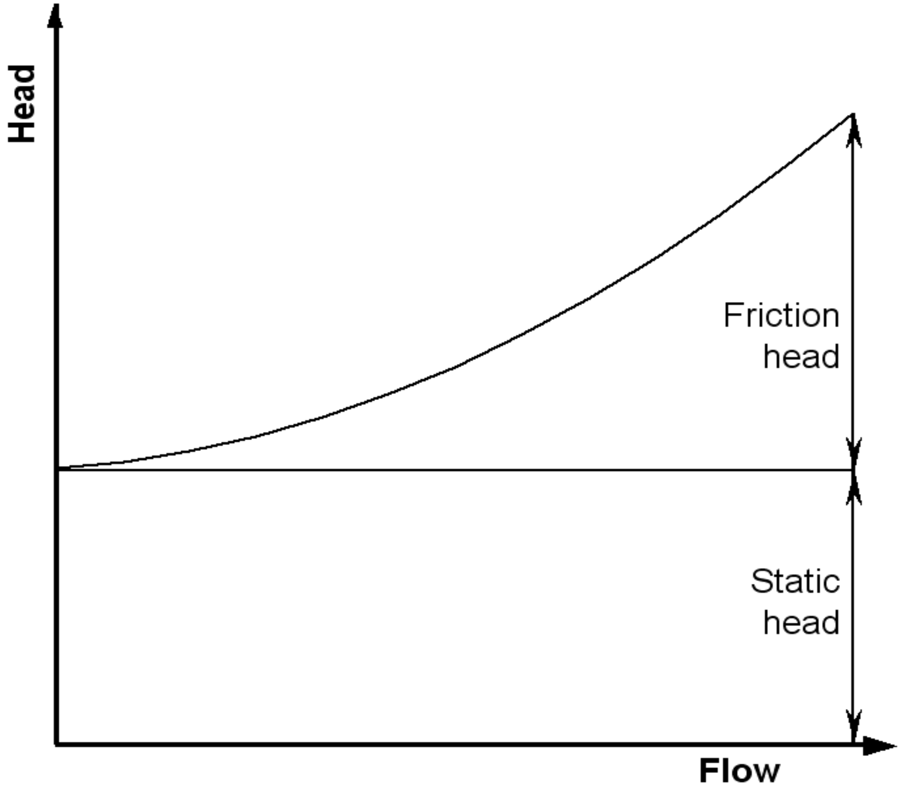
$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3$$

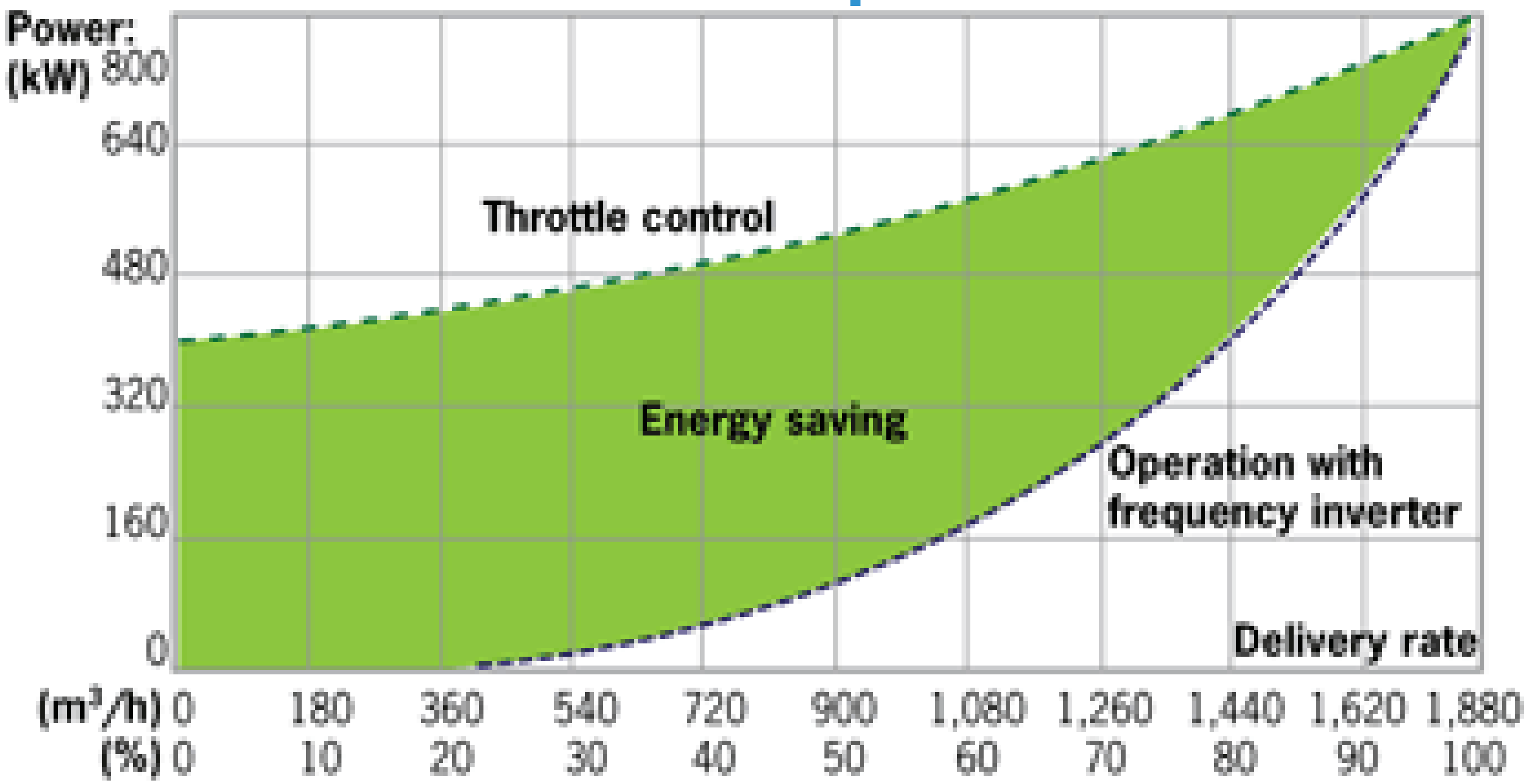
Where,
N = rotational shaft speed
Q = Flow
H = Head
P = Power

Centrifugal Pumps

Total system resistance from frictional losses (vary as function of the cube of speed) plus static head losses to provide lift.

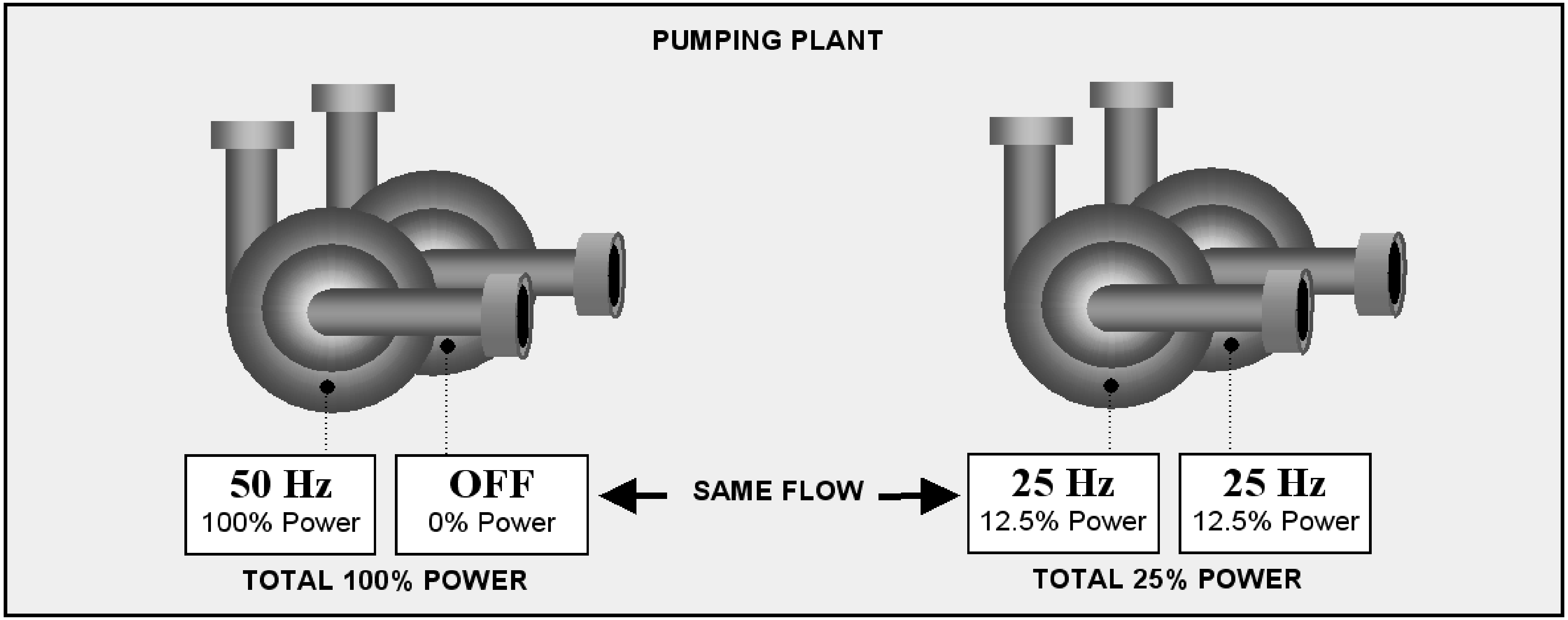


Example



The energy saved by replacing a throttle control with a VFD is given by the area bounded by the two power curves.

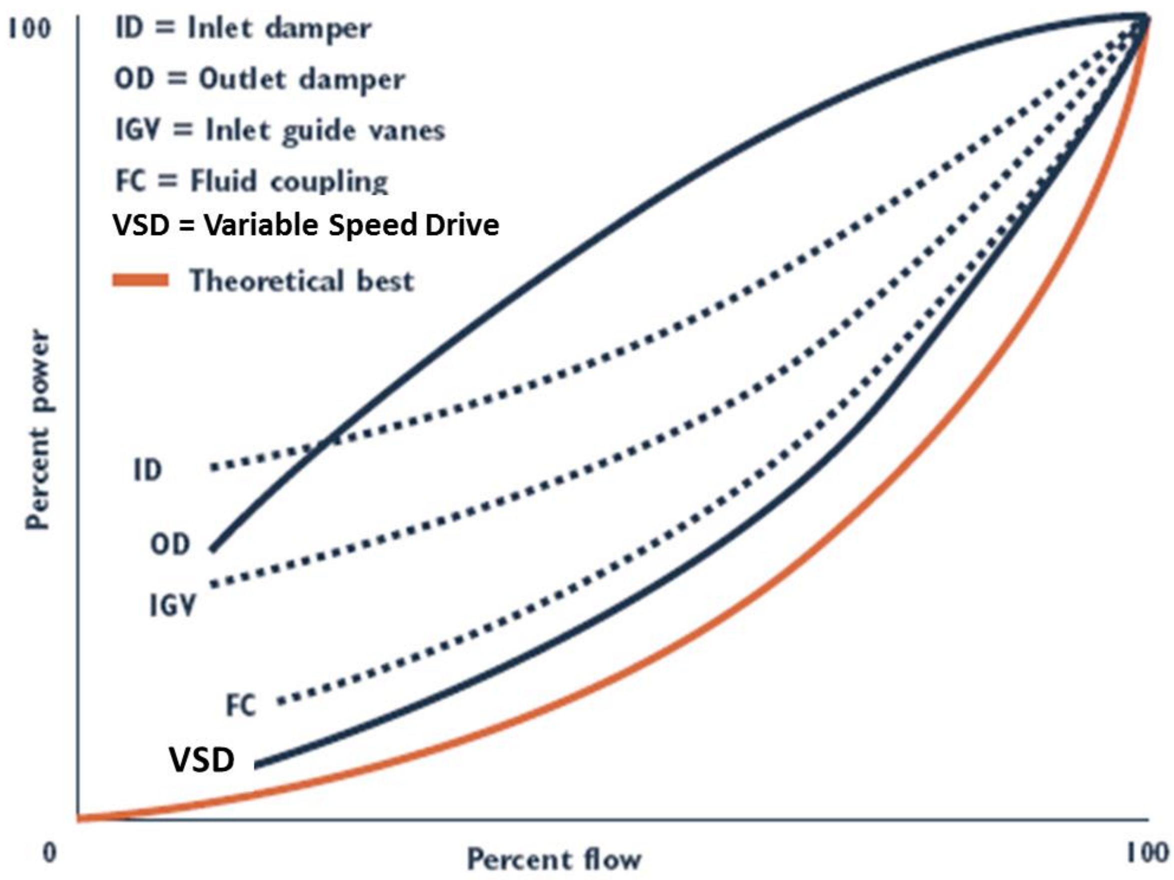
Pumping plant: Useful relationship to consider with closed loop circulating independent systems (two hydraulic circuits) where “static head" is not a major factor.



Pump Systems

- Pumps purchased based on cheapest initial price can be upgraded or replaced with higher efficiency models.
- Erosion by abrasive particles can affect clearances and efficiency.
- Special coatings can be applied to repair cavities and smooth internal surfaces to reduce friction losses.
- The suction inlet design should ensure that flow approaching the inlet is uniform and steady.
- A straight run of suction pipe of at least eight diameters in length immediately prior to the pump suction flange is recommended.

Fan systems


100
ID = Inlet damper
OD = Outlet damper
IGV = Inlet guide vanes
FC = Fluid coupling
VSD = Variable Speed Drive
Theoretical best
Percent power
ID
OD
IGV
FC
VSD
0
Percent flow
100

Fan Systems

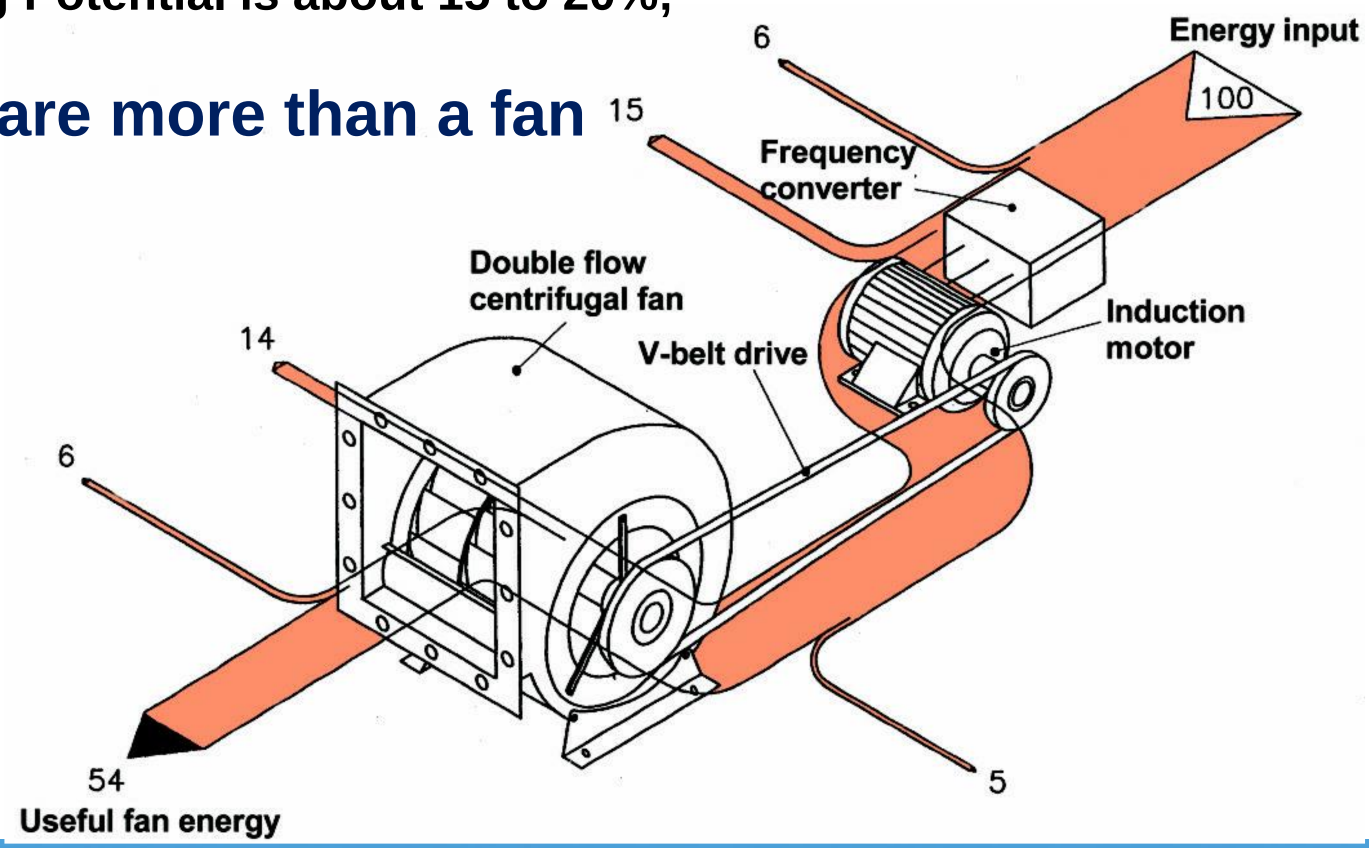
- Fans originally purchased based on cheapest initial price can be upgraded or replaced with higher efficiency models.
- Variable speed drive (VSD) control provides superior savings over the full range of flow.
- Causes of high system resistance include dirty screens, filters and coils.
- Flow that is lost due to leakage is a waste of energy.
- Fan systems are susceptible to developing leaks in flexible connections, at loose or distorted flanges and due to deteriorated gaskets.

Fan Systems

-Fan Saving Potential is about 5 to 10 %;

-Fan System Saving Potential is about 15 to 20%;

Fans systems are more than a fan

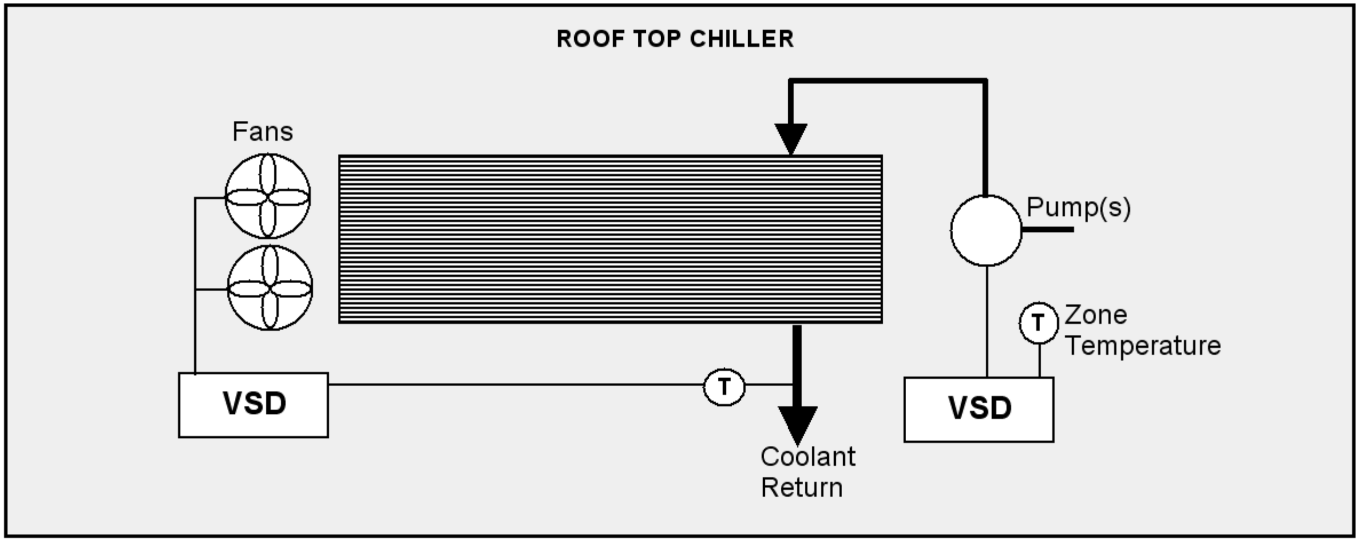


Fan Systems

- The most efficient flow of air into a fan is a non-restricted, uniform path.
- Elbows located directly on fan inlets increase losses and are to be avoided.
- Obstructions at fan inlets and outlets disrupt the flow, causing turbulence.
- Flex connections often cause poor transitions that disrupt flow.

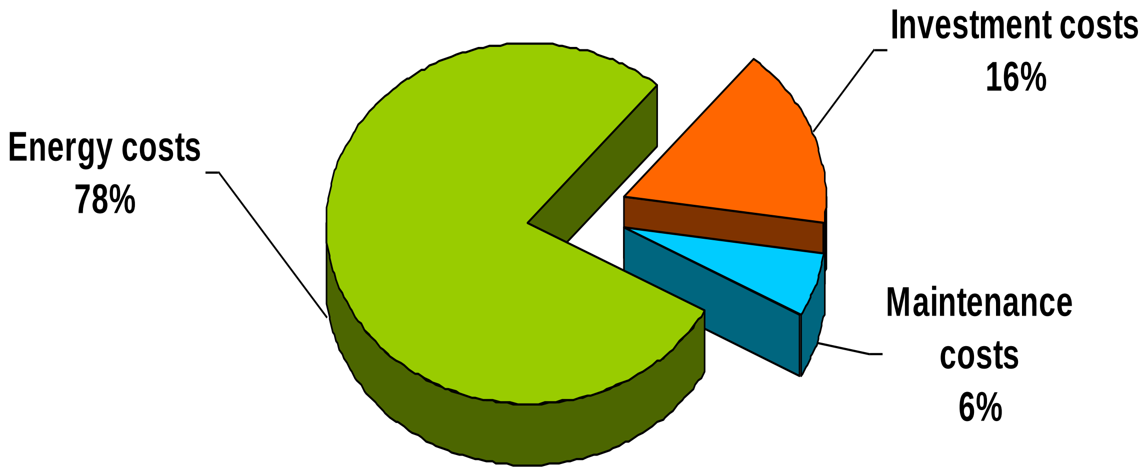
VSD Application

Application of VSDs on a roof top chiller.



Compressor Systems

- Compressed air accounts for 10% of industrial consumption of electricity
- Compressed air systems often have poor energy efficiency: possible energy savings are in the range from 5% to 50%…

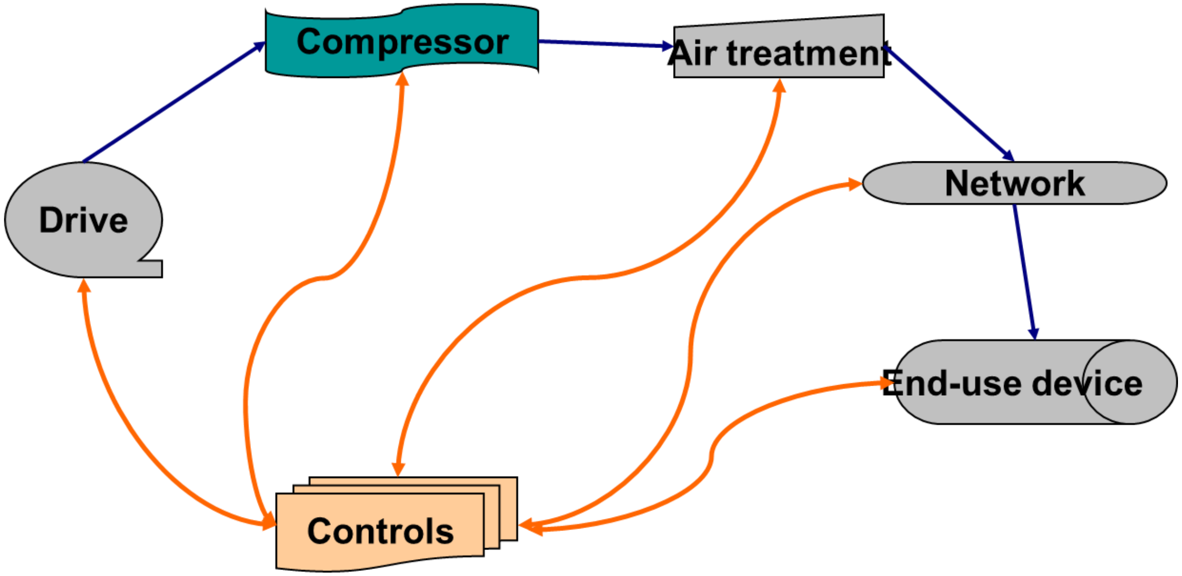


Assumptions

Power 110 kW
Equipment life 15 years
Operating hours 4000 h/year
Electricity price 5 c€/kWh

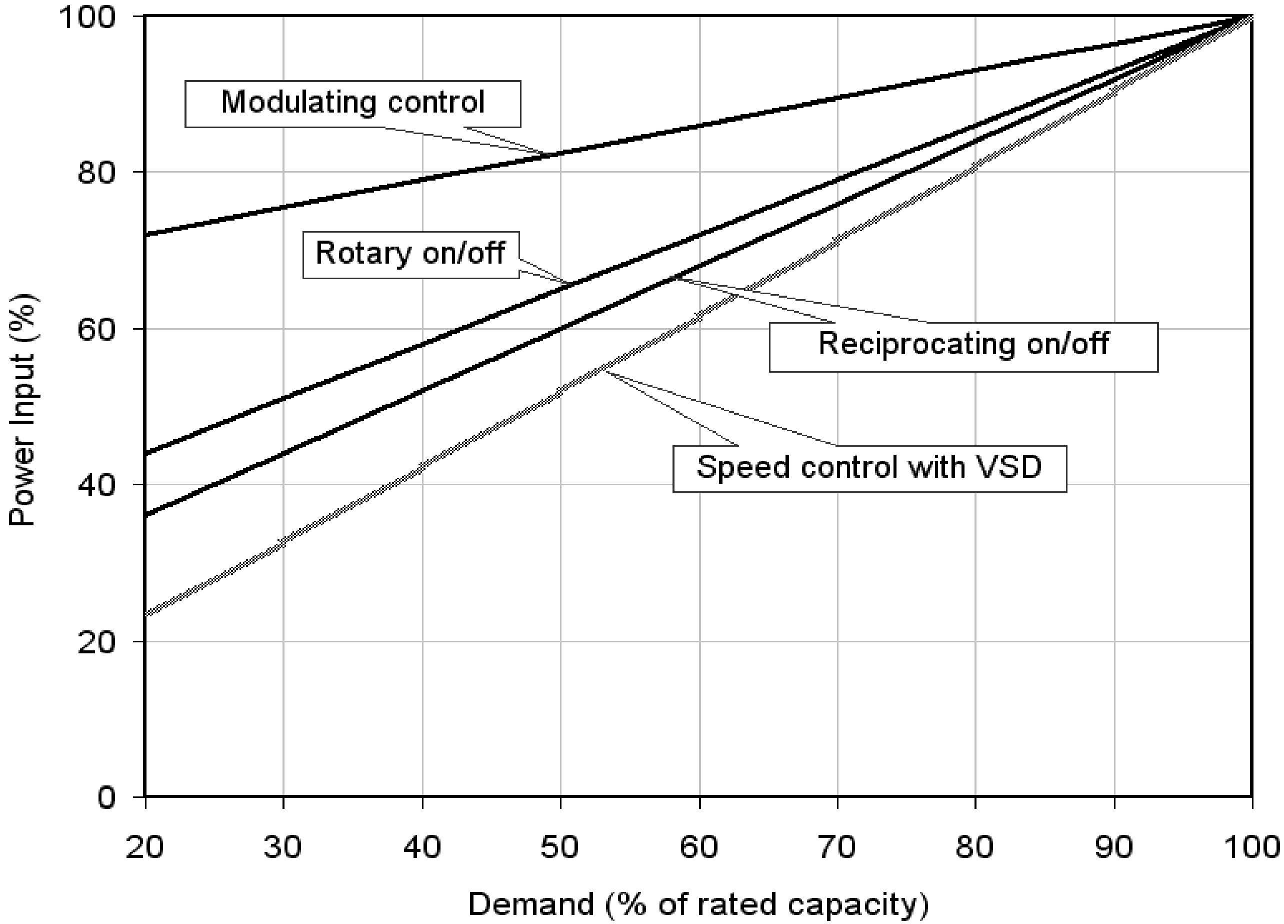
Compressor Systems

- The maximum overall system energy efficiency is limited by the component with the lowest efficiency in the system.
- The compressor itself is only one element of the system.



Energy savings measure	**Applicability** % applicable and cost effective	**Gains** reduction in annual energy consumption	**Potential contribution** Applicability x Gains
Reducing air leaks (develop a proper maintenance with a regular air leak detection program)	80%	20%	16.0%
Overall system design, to match air pressure, volume and quality to the needs, including multi-pressure systems	50%	9%	4.5%
Recovering waste heat for use in other functions	20%	20%	4.0%
Drives improvement - integration of adjustable speed drive, which is very cost effective when load shows variable conditions and in multi-machine installation	25%	15%	3.8%
Upgrading of compressor	30%	7%	2.1%
Use of sophisticated control systems, to match compressor output to system air demand, by optimizing transitions between the different states of the compressor (sequencers, control…)	20%	12%	2.4%
Optimizing certain end use devices, when buying the end uses, by choosing electrical or hydraulic equipment rather than compressed air end use devices	5%	40%	2.0%
Reducing frictional pressure losses (for instance increasing pipe diameter)	50%	3%	1.5%
More frequent filter replacement	40%	2%	0.8%
Drives improvement - use of high efficiency motors, especially for new systems and small machines	25%	2%	0.5%
Improved cooling, drying and filtering	10%	5%	0.5%

Compressor Systems



Energy saved by using a VSD on a rotary screw air compressor.

Compressor Systems

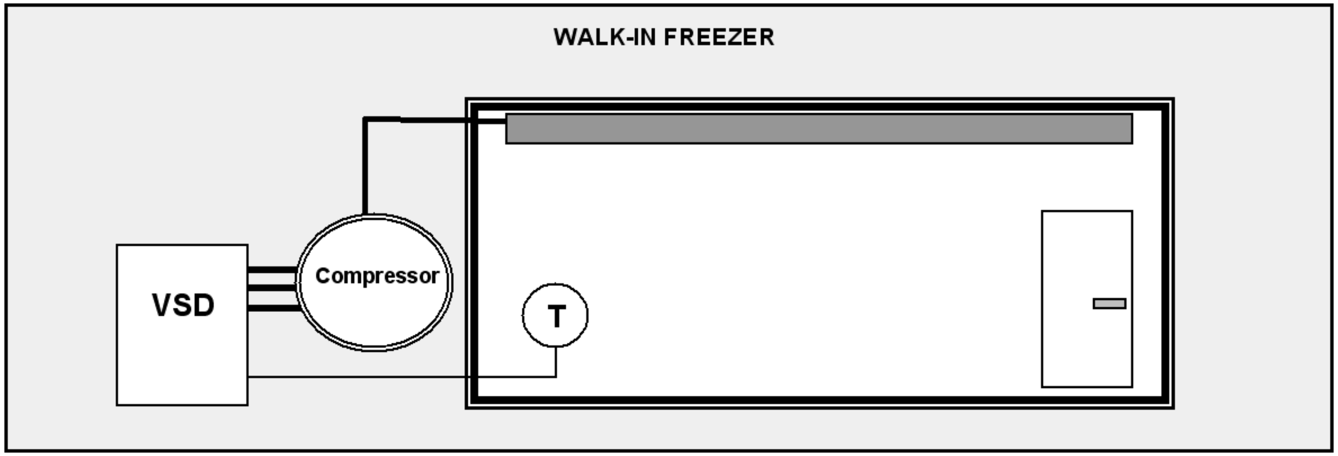
- Install intakes in locations providing the cleanest, driest and coolest air possible – outdoors if possible.
- Compressors charge the system to the preset pressure and maintain it by various methods including recirculation, venting, stop/start and speed control with variable speed drives.
- Choose filter systems with the lowest pressure drop.
- It is estimated that compressor cooling is approximately 5% to 7% of overall costs. Compressor systems give off high volumes of low-grade waste heat, which can be used efficiently by some industrial processes, boiler feed water, heating or ventilation systems.

Compressor Systems

- Leakage is the Largest Single Waste of Energy Associated with Compressed Air Usage
- Consider Alternate, More Efficient Methods. Low-pressure applications such as agitation, part ejection, cleaning, cooling and fume removal can be effectively done at greatly reduced cost by blowers or air amplifiers.
- Use Lowest Pressure Possible
- Pipe pressure loss is proportional to pipe length; the square of the compressed air velocity in the pipe is inversely proportional to the pipe diameter. Every 2 psi increase in pressure drop uses 1% additional power. Keep air velocities below 9 m/s.

VSD Application

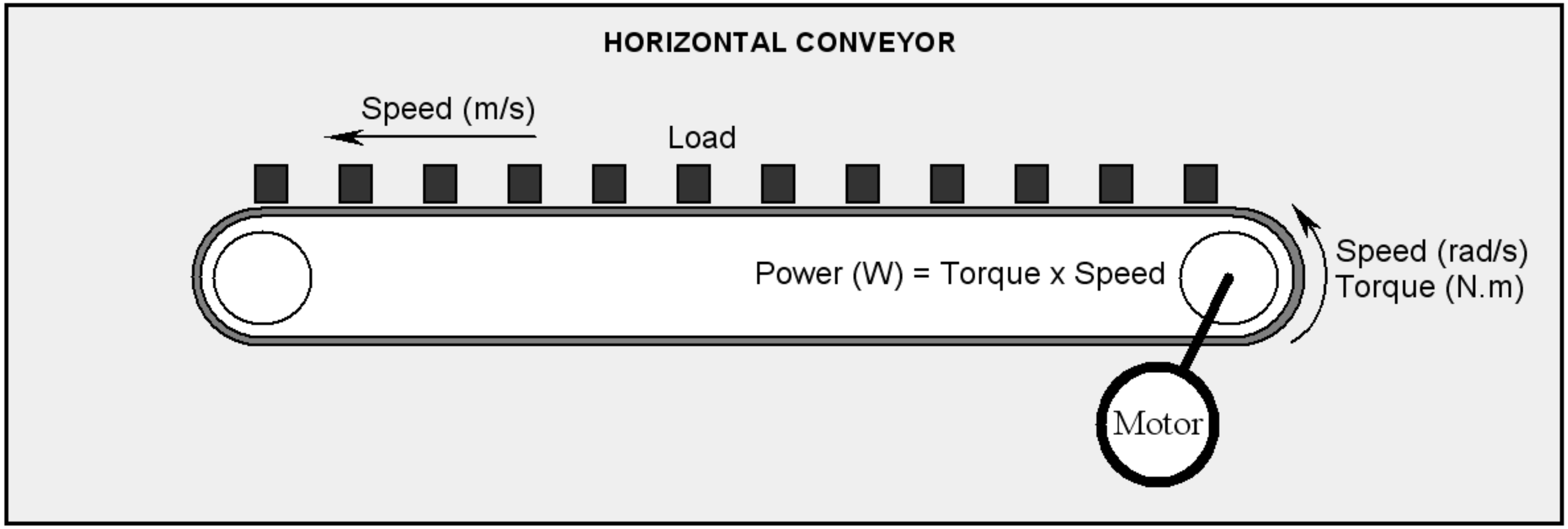
Application of VSDs on a variable speed refrigeration compressor (ESTIMATED SAVINGS: 25%).

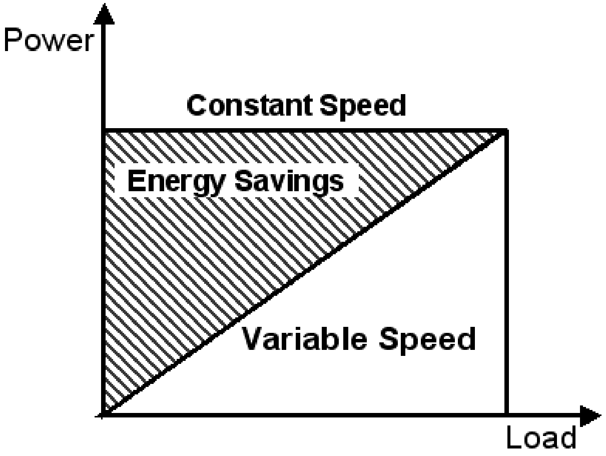


Other Energy Saving VSD Applications

3. Changes in load and speed but can benefit from a VSD in other ways like process control, soft starting and stopping, as well as the requirement of an especially high starting torque or of regenerative braking.
   The cost and energy efficiency benefits are small compared to the first two groups. VSDs allow for voltage optimization to improve motor efficiency if the torque changes.
4. Motion Control – AC drives can now provide high performance torque/speed control, similar to motor servo drives.

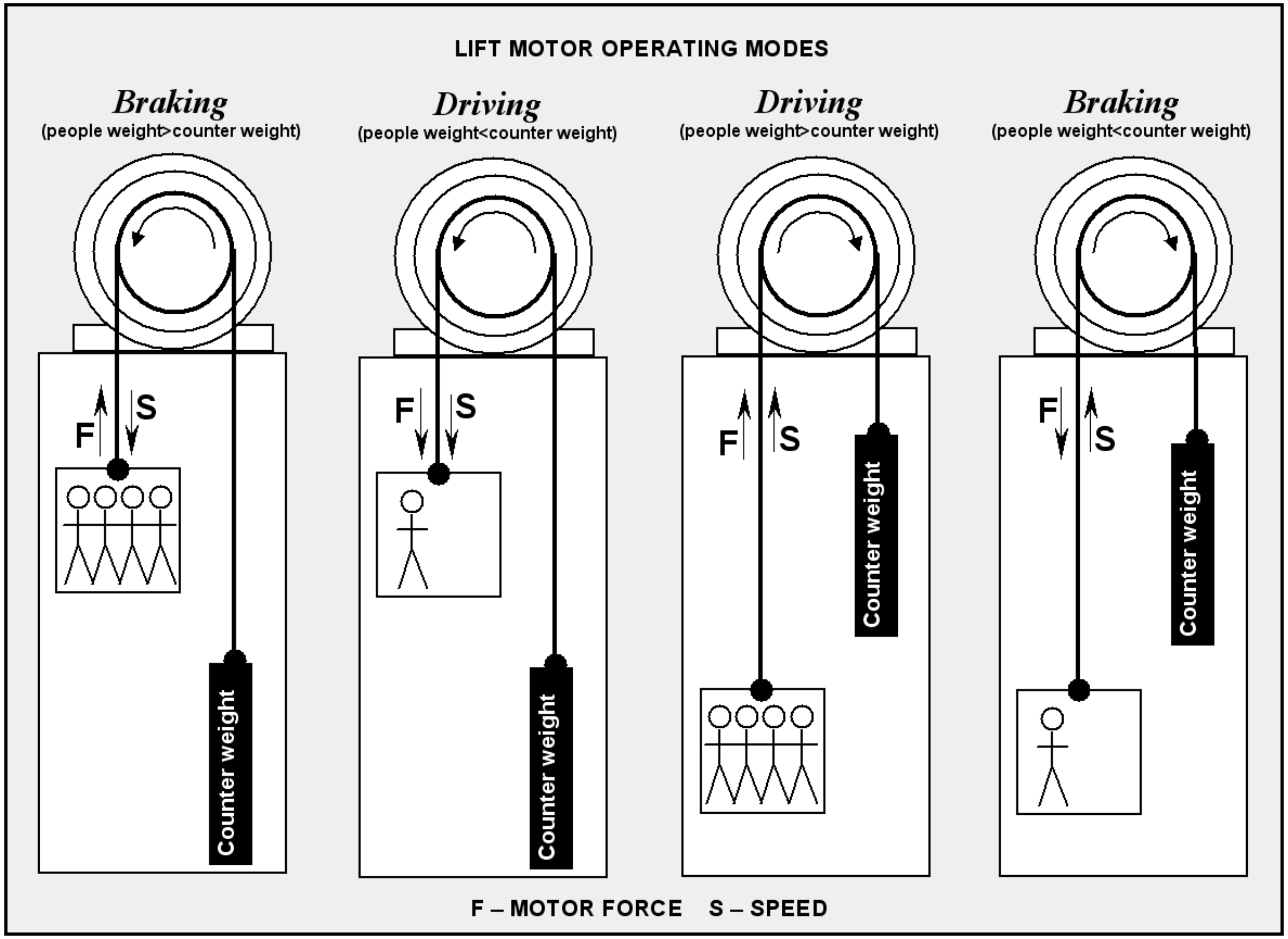
VSDs in conveyors





Energy savings in a conveyor using speed control, in relation to the typical constant speed.

VSDs in Lifts



Benefits of VSDs

- Large energy & cost savings (20% – 70% possible)
- Better match of machine to process requirements
  - Increased flexibility
  - Better process control
  - Better throughput
- Better start & stop control
- Reduced starting currents
- Reduced stresses on the system = reduced maintenance & longer life

Practical considerations for VSDs

- Do not use when:
  - Little variation in process demand
  - Little opportunity to reduce speed
  - When associated equipment does not allow speed changes
  - When cost savings not viable
- Installation
  - Adequate cooling, no dust, humidity
  - Ensure suitable cabling & electrical filtering
  - Ensure adequate electrical insulation in the motor
  - Correct commissioning

Will variable speed work?

- Variable demand
- No static head issue
- No lubrication or cooling issues
- Motor insulation adequate
- Is it really a fixed speed, variable load application?
- Are there worries about harmonic currents?

VSDs

- If you can reduce the flow by 20% for much of the time, the energy saving will almost halve.
- Its then just a question of operating hours in order to sort the economics.

Where VSDs can be wrongly applied– or why Static head can be a problem

- Understand the system curve!
- Fans rarely have any significant static head
- Learn to spot pump static head