

COMPRESSOR STAGING AND CAPACITY CONTROL

Large scale industrial refrigeration plants often comprise of multiple compressors. Typically, the controls logic which stages these compressors in order to maintain and control their capacity does not necessarily optimize the efficiency of the compressors, since the existing control logic typically aims to achieve the desired capacity without taking into account the efficient operating range of the compressor, or the amount of time each individual compressor operates.

The loading and unloading of compressors is also often achieved using slide valve control (in the case of screw compressors), which is aimed to be efficient at full load. Unfortunately this means that they act inefficiently at part load. Given that compressors often operate at part load for a significant portion of their operating life, this inefficiency presents a possible annual energy saving of around 25% per compressor. Optimising compressor operation requires efficient control of both the compressor staging and speed control at all system loads.

CAPACITY/SPEED CONTROL

Industrial screw compressors conventionally reduce in cooling capacity (unload) via their slide valve. Depending on the compressor, unloading may be continuous between 100% and 10% capacity, or incremental (i.e. in stages at 100%, 75%, 50%, 25% etc.). Slide position is approximately representative of the refrigeration capacity of the compressor.

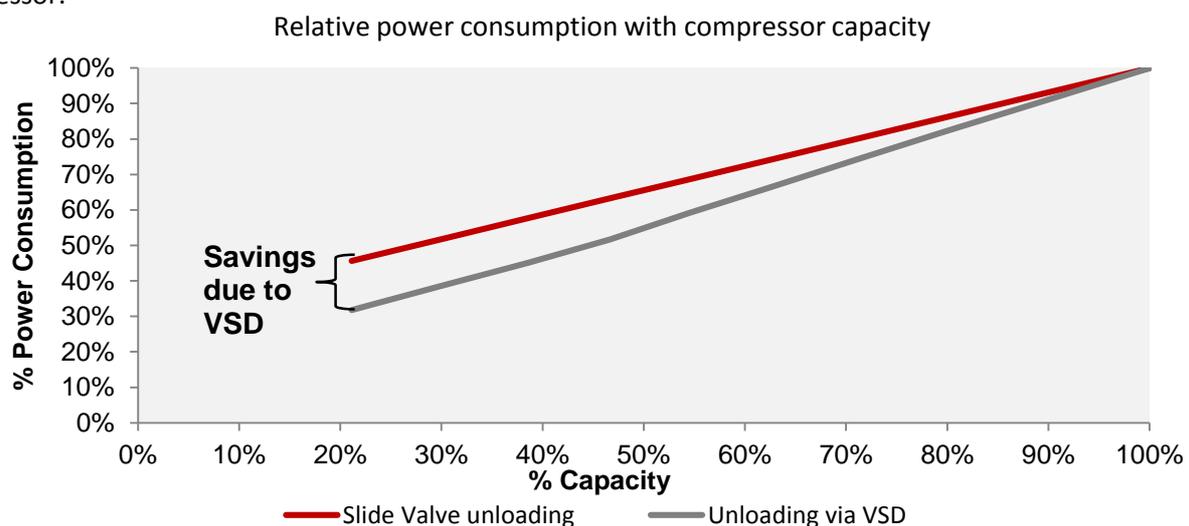


Figure 1: Slide valve and variable speed drive (VSD) control disparity.

When unloading a compressor using slide control, the power consumption does not reduce in proportion with the capacity, as can be seen in Figure 1. Slide positions between 75%-100% are efficient, however for required capacities that are lower, the installation of a variable speed drive (VSD) would be beneficial. The use of a VSD provides a more energy efficient alternative to slide control as shown in Figure 1.

Reciprocating compressors unload in a very different manner to screw compressors. The cylinders within the compressor can be made ineffective by switching off the suction valve and, depending on the compressor model, the compressor can then operate on a reduced number of cylinders (i.e. an 8 cylinder compressor may be able to operate with 8, 6, 4 or 2 cylinders). This method of unloading is very energy efficient, rendering the installation of a VSD onto a reciprocating compressor commercially unviable.

AUTOMATED COMPRESSOR STAGING & CAPACITY CONTROL

By using an appropriate automatic compressor staging logic, it is possible to not only improve the energy efficiency of the refrigeration plant, but also improve the operational effectiveness and lifespan of the compressors. The control logic determines which compressors run at any given moment and at what capacity. If for example one of the available compressors had an attached VSD, then this compressor would be selected as the base load machine, in which the lower 50% capacity range would be determined by the VSD speed control, and then the upper capacity range determined by slide control. When more capacity is required, and more compressors brought into operation, the control logic would stage these compressors so that they remain in their efficient operation range throughout the staging process. Figure 2 outlines such a process. During single compressor operation, the base load machine is carefully speed controlled, then slide controlled to reach the desired capacity, and then in dual compressor operation, the compressors are both carefully controlled so that neither is running in inefficient ranges unnecessarily.

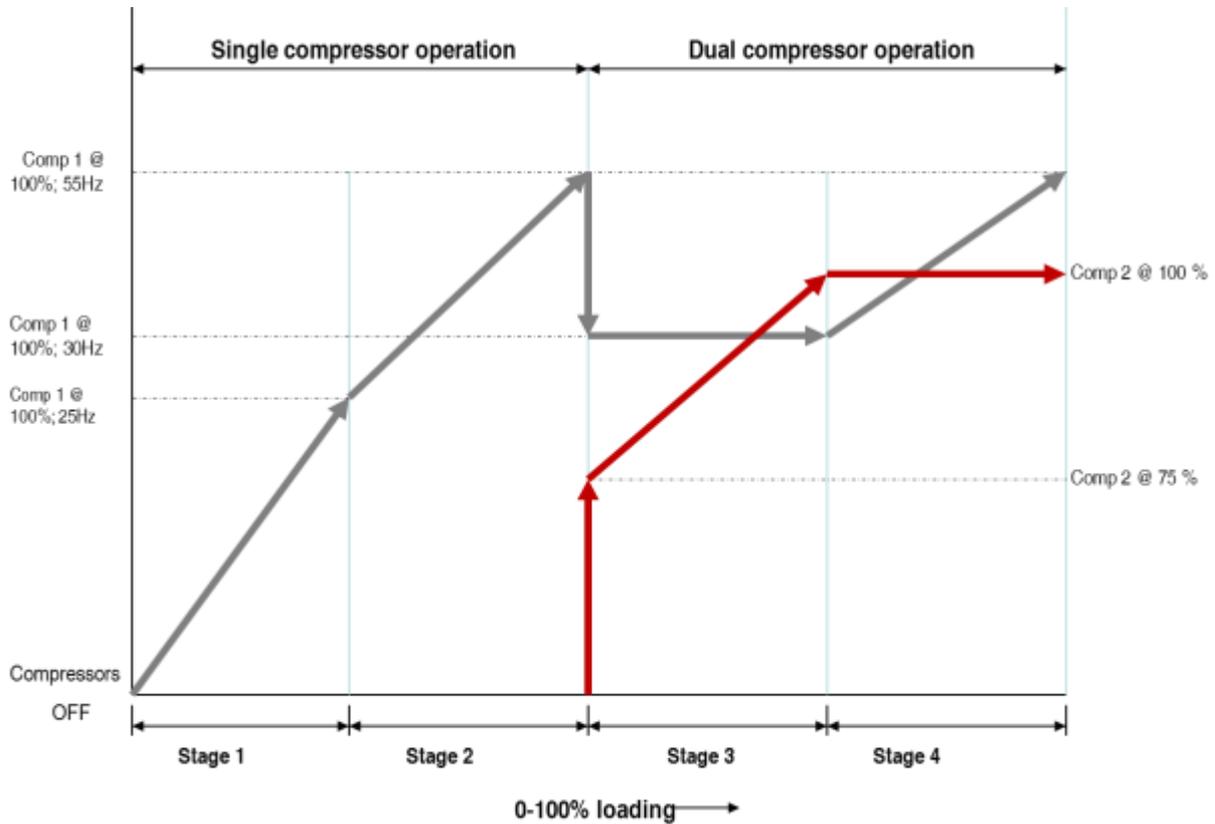


Figure 2: Example of efficient loading sequence on a two-compressor plant.

The control logic can also determine the rotation of compressor use. This will ensure that they run for the same amount of time and thereby receive the same amounts of wear, allowing the compressors to run efficiently for longer.

There are many benefits which can be gained through the implementation of capacity control logic and VSDs. Compressor loading is optimised relative to the cooling requirements; start-up power spikes are avoided by installing VSDs which prolongs the motor life; short-cycling of compressors (when a compressor is frequently switched on and off) is avoided; and the plant suction temperature is stabilized which enhances compressor life due to load sharing.

Average annual energy savings resulting from the implementation of capacity control and VSDs can be as high as 24%.

POTENTIAL SAVINGS

Table 1 shows the savings that can be achieved by installing capacity control and VSDs to a single stage refrigeration plant with two compressors operating under conventional compressor staging control.

Plant Load	Energy Saving
10%	40%
20%	33%
30%	24%
40%	41%
50%	32%
60%	14%
70%	6%
80%	5%
90%	3%
100%	0%
Total Annual Energy Saving	24%

Table 1 - Energy savings achievable based on plant load.

CONCLUSION

The energy savings achieved through the installation of capacity controls and VSDs depend on the load profile of the plant and the number and size of the compressors used. In order to ensure that the maximum efficiency is achieved even if conditions change slightly, remote control optimization can be successfully undergone – a process which observes the operation of the plant remotely and can identify those aspects of the control logic which need to be altered in order to maintain the achieved efficiency.