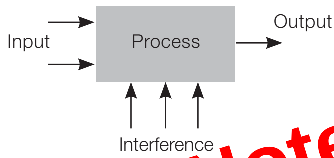
# Chapter 4 - Variable volumes require some form of control

In most processes there is at least one variable. This variable causes the need for process adjustment. Therefore variable processes and material volumes need some form of control.

In this chapter we will look at processes and their variables. We will also examine different control methods.




**Typical cases**

| | Application | Input | Interference | Output |
|---|---|---|---|---|
| 1 | Submersible pump | Water level | | |
| 2 | Pump application | Water level | | Water flow |
| 3 | FD fan | Heat demand | Atmospheric pressure | |
| 4 | Sawmill line | Log diameter | Hardness of wood | |
| 5 | Screw conveyor | | | Material volume |
| 6 | Feeder | | Hardness of material | Load |
| 7 | Grinder | | Wear of the grind | |

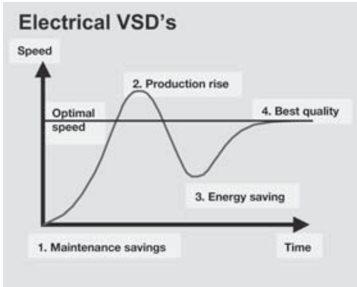


## Variable material flow and input/output requirements

There may be many different parameters involved in a process, the most common being input, output and interference. These parameters may need to be constant or they may need to be changed according to a preset pattern. As discussed in the first chapter, there are always inputs and outputs present in a process and, in almost every case, interference as well.

In some processes there is no interference and the input is constant. This kind of process works without any variable speed control. However, if the output parameters need to be changed, the input is variable or there is interference present, then variable speed control might be the solution to fulfilling the process requirements.

The above table lists some processes in which variable speed control is required. It also shows the reasons for the control; input, interference or output.




**VSD Market**
Year 2000: Europe (estimate)

| VSD | Market size (MUSD) | Market share (%) |
|---|---|---|
| AC Drives | 1310 | 63.7 |
| DC Drives | 364.2 | 17.7 |
| Mechanical | 189.0 | 9.2 |
| Hydraulic | 193.0 | 9.4 |
| *Total* | *2056.2* | *100.0* |

Source: Frost&Sullivan, 1996

## Electrical VSDs dominate the market

Here are the four most important arguments for using electrical VSDs, presented along with estimated VSD market shares in Europe in 2000. The four main benefits of using electrical VSDs are highlighted at the turning points of the speed curve.



### Maintenance costs

Direct on-line starting stresses the motor and also the electrical equipment. With electrical VSDs, smooth starting is possible and this has a direct effect on maintenance costs.

### Productivity

Process equipment is usually designed to cater for future productivity increases. Changing constant-speed equipment to provide higher production volumes requires money and time. With the AC drive, speed increases of 5 to 20 percent are not a problem, and the production increase can be achieved without any extra investment.

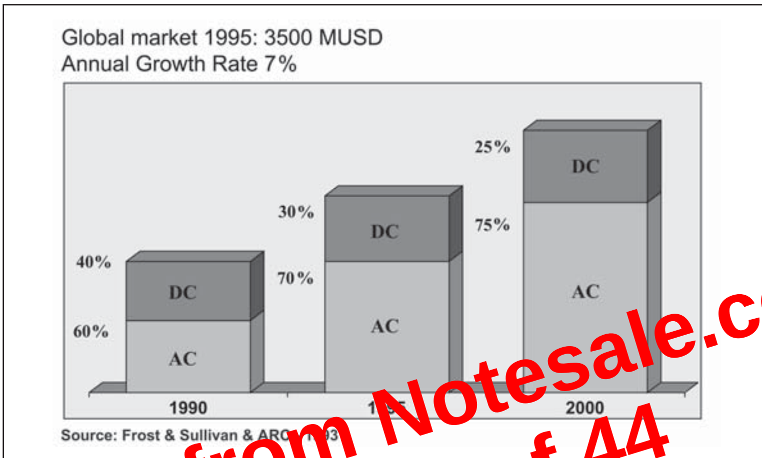
### Energy saving

In many processes, production volumes change. Changing production volumes by mechanical means is usually very inefficient. With electrical VSDs, changing the production volume can be achieved by changing the motor speed. This saves a lot of energy particularly in pump and fan applications, because the shaft power is proportional to the flow rate to the power of three.

### Higher quality

The accurate speed control obtainable with electrical VSDs results in process optimisation. The optimal process control leads to the best quality end product, which means the best profit for the customer.

Due to these benefits, electrical VSDs are dominating the market, as can be seen from the table above. AC and DC drives together account for over 75%, and AC drives for more than 50%, of the total VSD market in Europe in 2000.

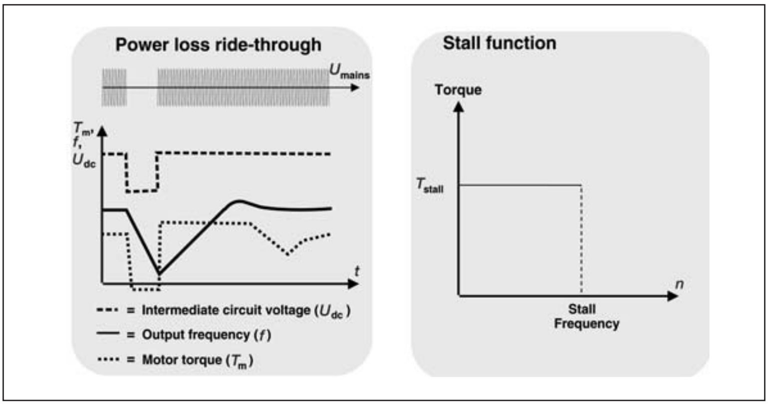





## The AC drives market is growing fast

This diagram shows the projected development of the electrical VSDs market to the year 2000. As can be seen, the AC drives market is growing at almost 10% per year, which accounts for the entire growth of the electrical and VSD market. The market share of DC drives is diminishing, and the total DC market size remains approximately constant. This progress is due to the development of AC drives technology.

As presented earlier in this guide, the AC drive has many benefits over other process control methods. The difference between the AC and the DC motor is that the DC motor has a mechanical commutator, utilising carbon brushes. These brushes need regular maintenance and the commutator itself complicates the motor structure and consumes energy. These are the main reasons why the AC drives market share is growing in comparison to DC drives.




## Power loss ride-through

The power loss ride-through function is used if the incoming supply voltage is cut off. In such a situation, the AC drive will continue to operate using the kinetic energy of the rotating motor. The drive will be fully operational as long as the motor rotates and generates energy for the drive.

## Stall function

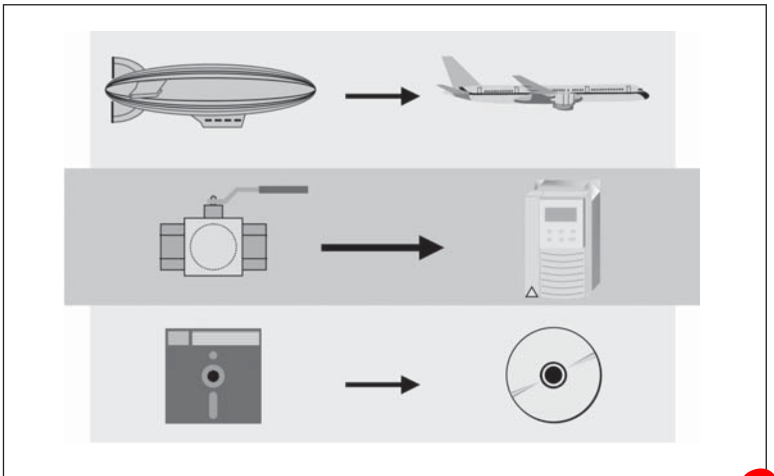


With an AC drive, the motor can be protected in a stall situation with the stall function. It is possible to adjust supervision limits and choose how the drive reacts to the motor stall condition. Protection is activated if three conditions are met at the same time.

1. The drive frequency has to be below the preset stall frequency.

2. The motor torque has to rise to a certain limit, calculated by the drive software.

3. The final condition is that the motor has been in the stall limit for longer than the time period set by the user.



## Technical differences between other systems and AC drives

AC drive technology is completely different from other, simpler control methods. It can be compared, for example, to the difference between a zeppelin and a modern airplane.

We could also compare AC drive technology to the development from a floppy disk to a CD-ROM. Although it is a simpler information storage method, a floppy disk can only handle a small fraction of the information that a CD-ROM can.

The benefits of both these innovations are generally well known. Similarly, AC drive technology is based on a totally different technology to earlier control methods. In this guide, we have presented the benefits of the AC drive compared to simpler control methods.

| | Throttling | AC drive |
|---|---|---|
| Installation material | 20 USD | 10 USD |
| Installation work | 5h x 65 USD = 325 USD | 1h x 65 USD = 65 USD |
| Commissioning work | 1h x 65 USD = 65 USD | 1h x 65 USD = 65 USD |
| Total | 410 USD | 140 USD |
| **Savings in installation: 270 USD!** | | |

## Installation costs: throttling compared to AC drive

Because throttling is the second lowest investment after the AC drive, we will compare its installation and operating costs to the cost of the AC drive. As mentioned earlier, in throttling there are both electrical and mechanical components. This means twice the amount of installation material is needed.



Installation work is also at least doubled in throttling compared to the AC drive. To install a mechanical valve into a pipe is not that simple and this increases installation time. To have a mechanical valve ready for use usually requires five hours compared to one hour for the AC drive. Multiply this by the hourly rate charged by a skilled installer to get the total installation cost.

The commissioning of a throttling-based system does not usually require more time than commissioning an AC drive based system. One hour is usually the time required in both cases. So now we can summarise the total installation costs.  As you can see, the AC drive saves up to USD 270 per installation. So even if the throttling investment costs were lower than the price of a single phase motor (approximately USD 200), the AC drive would pay for itself before it has even worked a second.

| | Throttling | AC drive saving 50% |
|---|---|---|
| Power required | 0.75 kW | 0.37 kW |
| Annual energy 4000 hours/year | 3000 kWh | 1500 kWh |
| Annual energy cost with 0.1 USD/kWh | 300 USD | 150 USD |
| Maintenance/year | 40 USD | 5 USD |
| Total cost/year | 340 USD | 155 USD |
| **Savings in one year: 185 USD!** | | |

## Operational costs: maintenance and drive energy



In many surveys and experiments it has been proved that a 50% energy saving is easily achieved with an AC drive. This means that where power requirements with throttling would be 0.75 kW, with the AC drive it would be 0.37 kW. If a pump is used 4000 hours per year, throttling would need 3000 kWh and the AC drive 1500 kWh of energy per year.

To calculate the savings, we need to multiply the energy consumption by the energy price, which varies depending on the country. Here USD 0.1 per kWh has been used.

As mentioned earlier, mechanical parts wear a lot and this is why they need regular maintenance. It has been estimated that whereas throttling requires USD 40 per year for service, maintenance costs for an AC drive would be USD 5. In many cases however, there is no maintenance required for a frequency converter.

Therefore, the total savings in operating costs would be USD 185, which is approximately half of the frequency converter's price for this power range. This means that the payback time of the frequency converter is two years. So it is worth considering that instead of yearly service for an old valve it might be more profitable to change the whole system to an AC drive based control. To retrofit an existing throttling system the pay-back time is two years.