Report on talk on Digital Scroll Technology

By : Engr. Ng Yong Kong, M.I.E.M., P.Eng.

The talk was presented by Arup Majumdar, Director of Marketing from Emerson Climate Technologies Asia Pacific, based in Hong Kong. Digital Scroll technology is the latest capacity modulation compressor available in the air conditioning industry. The beauty of this technology is its inherent simplicity. The standard scroll compressor has a unique feature called axial compliance. This allows the fixed scroll to move in the axial direction, by very small amounts, to ensure that the fixed and orbiting scrolls are always loaded together with the optimal force. This optimal force holding the 2 scrolls together at all operating conditions ensure the high efficiency of the scrolls. The Digital Scroll operation builds on this principle. The physical hardware of the Digital Scroll is explained with the help of Figure 1.

A piston is fixed to the top scroll to ensure that when the piston moves up, the top scroll also moves up. There is a modulation chamber at the top of the piston that is connected to the discharge pressure through a bleed hole of diameter 0.6 mm. An external solenoid valve connects the modulation chamber with the suction side pressure. When the solenoid valve is in the normally closed position, the pressure on either side of the piston is discharge pressure and a spring force ensures that the two scrolls are loaded together. When the solenoid valve is energised, the discharge gas in the modulation chamber is relieved to the low pressure. This causes the piston to move up and consequently the top scroll also moves up. This action separates the scrolls and results in no mass flow through the scrolls. De-energising the external solenoid valve again loads the compressor fully and the compression is resumed. It should be noted that the movement of the top scroll is very small – 1.0 mm and consequently the amount of high-pressure gas that is bled from the high side to the low side is very little.

The Digital Scroll operates in two stages – the "loaded state", when the solenoid valve is normally closed and "unloaded state", when the solenoid valve is open. During the loaded state the compressor operates like a standard scroll and delivers full capacity and mass flow. However, during the unloaded state, there is no capacity and no mass flow through the compressor.

At this stage, the concept of a cycle time was introduced. A cycle time consists of a "Loaded State" time and "Unloaded State" time. The duration of these 2-time segments determine the capacity modulation of the compressor. Example: In a 20 seconds cycle time, if the loaded state time is 10 seconds and the unloaded state time is 10 seconds,
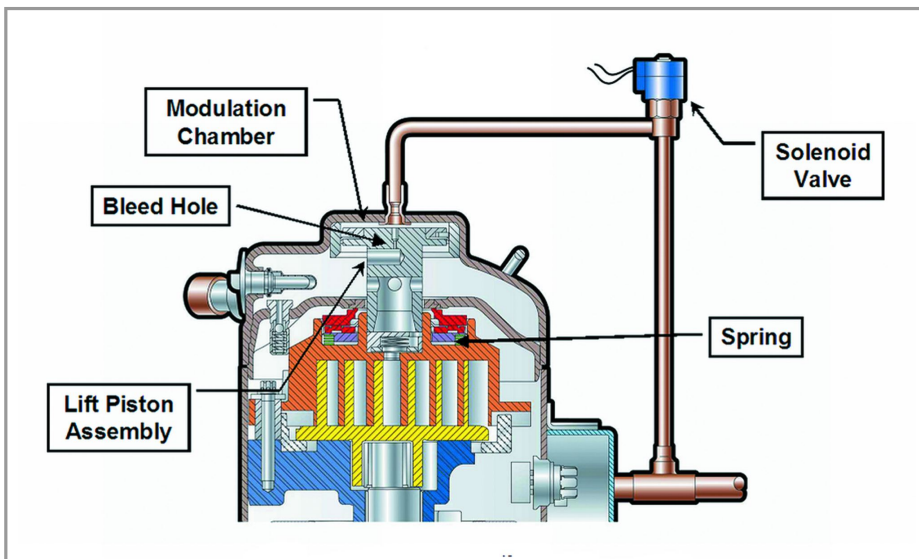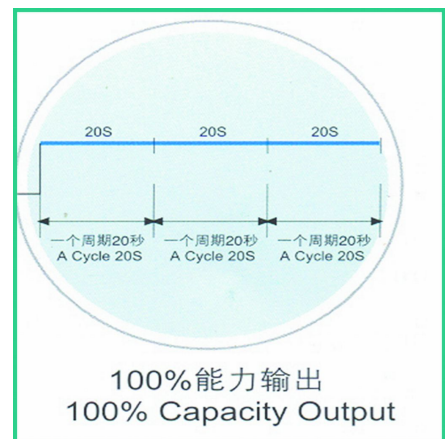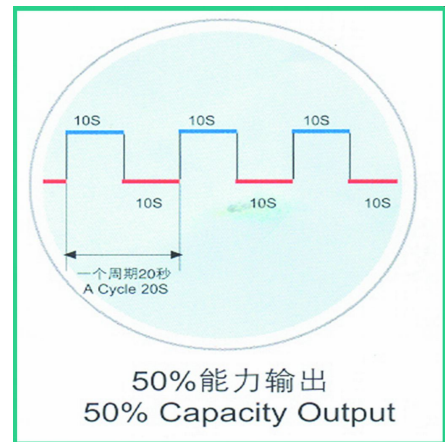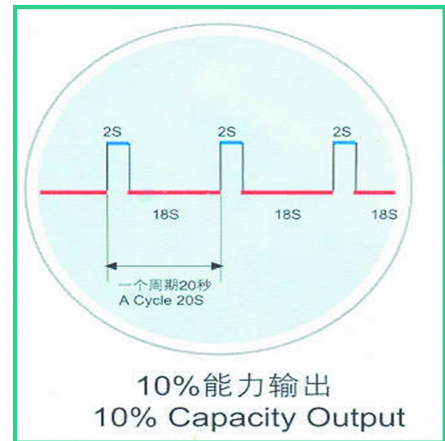

Figure 1: Digital Scroll Compressor

10%能力输出
10% Capacity Output

50%能力输出
50% Capacity Output

100%能力输出
100% Capacity Output

Figure 2: Time cycle

the compressor modulation is (10 seconds x 100% + 10 seconds x 0%) / 20 = 50% (Figure 2). If for the same cycle time, the loaded state time is 15 seconds and the unloaded state time is 5 seconds, the compressor modulation is 75%. The capacity is a time averaged summation of the loaded state and unloaded state. By varying the loaded state time and unloaded state time, any capacity (10%-100%) can be delivered by the compressor.

Oil return is a major issue in variable capacity multiple evaporator systems. Current technologies use an oil separator and/or complicated oil return cycle to ensure oil return after some period of operation. The Digital Scroll is an unique compressor – it does not require an oil separator or an oil return cycle. There are 2 factors that make the oil return easy. Firstly, the oil leaves the compressor only during the loaded cycle. So at low capacities, very little oil leaves the compressor. Secondly, as explained before, the compressor operates at full capacity during the loaded cycle. The gas velocity in the loaded cycle is sufficient to return oil back to the compressor. Testing has shown that oil is able to return back to the compressor in the worst operating condition – low modulation, 100 meter pipe length and 30 meter elevation (with standard oil traps), both straight and reverse elevation.

Dehumidification is necessary to ensure customer comfort and this becomes more important during low modulation operation. In the inverter system, at low modulation, the compressor operates at a lower frequency. This reduces the mass flow of refrigerant and results in a higher suction pressure. This results in a higher Sensible Heat Factor (SHF). The Digital Scroll compressor provides very good dehumidification because it operates at a lower suction pressure than the inverter. As mentioned before, during any modulation output, the compressor operates at full capacity during the loaded part of the cycle. This full capacity operation results in a lower average suction pressure that leads to a lower SHF.

Electromagnetic interference is a major issue in inverter driven systems. In many countries, particularly Europe, there are strict regulations on the amount of electromagnetic interference that any device can emit. The Digital Scroll system generates negligible electromagnetic interference because the loading and unloading of the scrolls is a mechanical operation. This unique feature not only eliminates the need for expensive electromagnetic suppression electronics, it also adds to the reliability and simplicity of a Digital system.

Controls simplicity is another main key to reliability for digital scroll. Typical inverter has 5 or more microprocessor board and 3 circuit boards. Digital scroll only has one microprocessor board to control the loaded and unloaded stage.

Mr. Dennis Lim from Acson Malaysia Sales & Service Sdn Bhd shared about the application digital scroll is able to offer. Since digital scroll is to be coupled to multiple evaporators, it is able to work with various indoor units like wall mount, ceiling exposed, ceiling concealed ducted and ceiling cassette. Its piping can go to 150 meter total length with 50 meter of vertical elevation between indoor and outdoor. ▪