 | 22 March 2007 | 1-6

Compressors without magnetic clutches

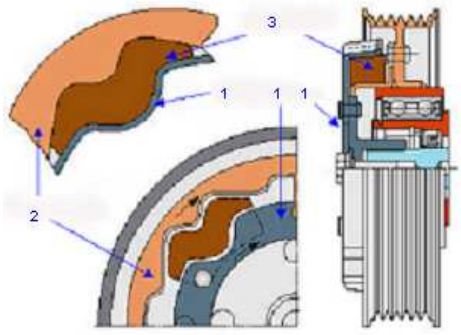
General

For some years, so-called "clutchless", externally triggered, variable compressors have been used (Fig. 1). All well-known compressor manufacturers use a great variety of different basic types. Here is a list of the most common types on the market: Denso, with the types 6SEU & 7SEU, Sanden, with the types PXE 13 & PXE 16. However, Delphi/Harrison is also represented via the CVC7 series, the design of which is very similar to the V5 compressor. This generation of compressors is used by almost all vehicle manufacturers (Audi, BMW, Citroen, Seat, VW, Opel). Externally triggered means that the stroke volume of the compressor is determined by a built-in control valve that is triggered by the air-conditioning control unit, depending on a wide variety of system parameters such as outside/desired temperature, high/low pressure, rotational speed, engine load. "Clutchless" means that the compressor no longer has an electromagnetic clutch. This means that the compressor is permanently driven via the pulley and works even if the air-conditioning system is switched off. However, in relation to this, the power is regulated down to a few percent.

Fig. 1

Operation

The pulley unit of the compressor consists, for example, of a drive plate and the actual pulley (drawing). The drive plate consists of a rubber element and forms the connection between the pulley and the compressor shaft. It acts as a vibration damper and also protects the compressor or the other driven units from overload or damage. If the compressor should lock up for example, the transmission forces between the pulley and the drive plate increase considerably in the area of the rubber element.



Example of operation

1. Drive plate, 2. Pulley, 3. Rubber element

Depending on compressor manufacturer or type, the connection is interrupted by the deformation of the rubber element or by the triggering of an "overload protection". The pulley then simply runs freely. This prevents damage to the belt or other units driven by the belt.
The control valve (Fig. 2) is located in the compressor and receives its pulse-width modulated signals (PWM) from the air-conditioning control unit. The current which is fed from the control unit to the control valve, and which ultimately determines the power of the compressor, can be displayed as a measured-value block with the aid of diagnosis equipment.
Clutchless compressors also have a safety valve (Fig. 3), which is intended to protect the compressor and the other components of the air-conditioning system from excessive pressure. The valve usually triggers at a pressure between 35 and 45 bar (depending on the compressor manufacturer). The valve opens only until the overpressure has reduced. Afterwards, it closes again, so as not to release the entire quantity of refrigerant into the atmosphere. If the film of the valve is damaged, it can be assumed that the valve has "triggered".

Fig. 2

Fig. 3

Diagnosis

The pulleys and their rubber elements that are designed as "overload protection" are, depending on the compressor type, designed differently. Depending on the type, it is possible in different ways to determine whether or not the "overload protection" has been triggered:

1. Rubber abrasion parts are visible on the inside of the pulley (Fig. 4). The compressor shaft is no longer driven. Provided that the compressor can be turned easily, the pulley and the rubber element can be replaced.
2. The overload protection has "triggered" the drive plate (Fig. 5). The drive plate and the rubber element can be replaced individually.
   Prerequisite: The compressor can be turned easily.

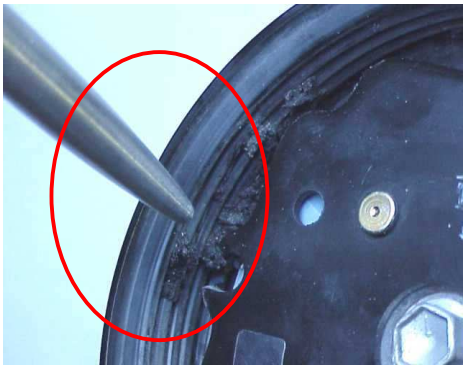


Fig. 4

3. A triggered torque limiter cannot necessarily be detected visually. In order to check whether the limiter has triggered, the compressor shaft must be held using a suitable tool (Fig. 6), and, at the same time, the pulley must be turned to the left. If the pulley can be turned to the left, the limiter has triggered and the compressor must be replaced. In the case of compressor types Sanden PXE 13 and PXE 16, replacement of the torque limiter is not possible.

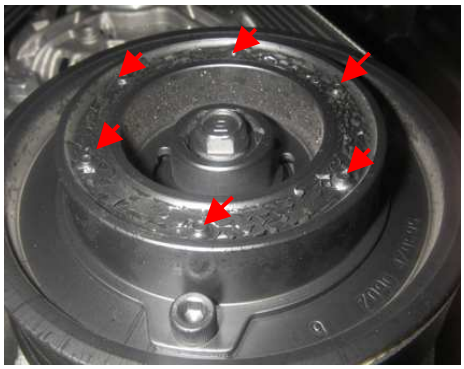


Fig. 5

In the case of the Audi A3 for example, at the lowest temperature setting, the maximum current that is fed from the control unit to the control valve is approximately 0.65 A. In relation to this, the compressor reaches its maximum power. In regulating operation, an average current of 0.3 A flows. In the case of newer vehicles, however, the problem is that diagnosis outside the engine-management area is not yet possible with many testers. Here, ideally, the use of an oscilloscope is helpful. With the aid of suitable test peaks, the PWM signal at the plug connection of the compressor can be recorded. In relation to this, the oscilloscope should be set to 5 V/div and 0.5 ms/div. With the engine running, the individual modes of operation can now be depicted on the screen of the oscilloscope. In the case of the lowest temperature setting (□Lo□) a square wave signal with a duty factor of approximately 75% (Fig. 7) is shown. The duty factor results from the ratio of pulse width -B- and the signal distance -C- (in this case 75% operating time, 25% switch-off time). At the same time, a readout of the level of the vehicle-electric-system voltage (approximately 13.5 V) can be taken on the basis of the volt divisions (A=5 V). The voltage value (9.8 V) displayed as a number is simply an average value. The pulse width depends on the desired cooling performance and the vehicle-electric-system voltage. Over the distance of the area -B-, the current to the control valve from the control unit is □regulated□. Depending on the setting of the control panel and ambient influences (e.g. outside temperature) the pulse width of the square wave signal is changed in such a

Fig. 6

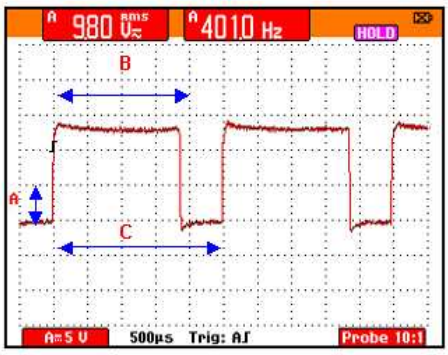


Fig. 7

way, or the control valve is triggered in such a way, that the compressor power necessary to reach the desired temperature is produced. Fig. 8 shows how, in the case of the temperature setting „High", the compressor is regulated downwards. Fig. 9 was recorded in „Econ"-operation (compressor off) and shows no signal. On the basis of these methods, it can be determined to what extent a signal change takes places through the control unit. If a plausible change of the signals takes place, but no change in the blow temperature or lowering of the interior temperature results, the compressor is probably faulty.
In addition, there is diagnosis equipment on the market with which it is possible to generate a PWM signal with a different pulse duration. Thus, it is possible to determine whether a triggering of the compressor leads to a change in the refrigerant pressure. This serves as the basis for being able to make a statement as to what extent the compressor still functions perfectly.
A functional check by means of a PWM signal can also be carried out using a function generator (Fig. 10). For this, it is however essential to connect a „load" which corresponds to that of an electronic control valve to the control-unit side of the air-conditioning system. Otherwise, the control unit will detect a fault in the system and will store this in the fault memory. This can lead to malfunctions or to failure of the system. In this case, a readout of the fault memory must be taken and deleted using diagnosis equipment.

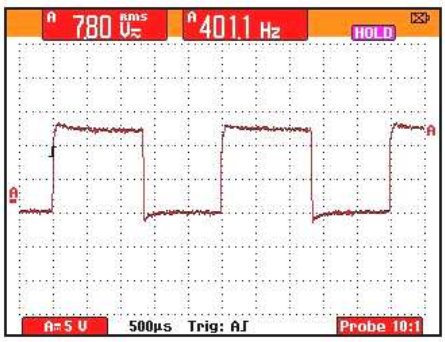


Fig. 8

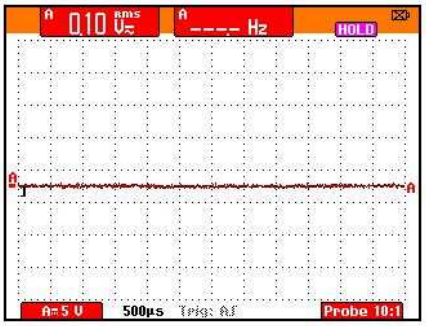


Fig. 9

Fig. 10

Again and again, complaints about compressors are hastily filed in connection with noises and other problems of air-conditioning systems. In very many cases, it turns out that the compressor is alright, or that the cause of the fault does not stem from the compressor itself. For this reason, all components of the system should always be included when troubleshooting. Noises are caused not only by the compressor, but also by its fastening, the drive, the expansion valve or the lines. An incorrect quantity of refrigerant can also be responsible for various noises. In

relation to this, there is the separate technical information "Noise development". The technical information "Compressor damage" provides information about different types of compressor damage and their causes.
In addition, the oil provides important information about possible damage:

- If the oil in the compressor has taken on a red colour, this may be attributable to much moisture.
- Oil with a black colour points to a defective compressor.
- Silver-grey oil should be checked for metal swarf. The greyish discoloration points to metal abrasion.

As the system oil quantities become ever lower (sometimes only 80 ml), the monitoring and observance of the oil quantity is of great importance (e.g. during air-conditioning servicing and when replacing components.
The repair of clutchless compressors is possible only to a limited extent. It is essential that suitable tools and repair information are used when carrying out such a repair.
Of course, assessment of the system pressures is very important when carrying out diagnosis work. In relation to this, the specified values of the vehicle manufacturer should be consulted.

This also applies to the blow temperature. Guidelines in relation to the assessment of system pressures can be taken from the table below:

High pressure	Low pressure	Symptoms	Possible causes	Possible solution
Normal	Normal	Air flowing out does not get cold	Too much oil in the air-conditioning system/ Air or moisture in the air-conditioning system	Recover the refrigerant from the air-conditioning system, flush, and refill will oil and refrigerant/ Recover the refrigerant form the air-conditioning system, replace the dryer and refill
High	High	Low-pressure line colder than the evaporator High pressure decreases when the condenser is cooled with water High and low pressure balance out as soon as the compressor switches off and pulsate as soon as it switches on	Expansion valve opened to wide Too much refrigerant in the system Condenser contaminated/blocked Fan problems Problem with the compressor (outlet valve/seal)	Replace the expansion valve Recover the refrigerant from the air-conditioning system and refill Check the condenser, clean/replace Check the fan Check the compressor, replace if necessary
Low	Low	Air flowing out does not get cold/ Suction line is colder than the evaporator	To little refrigerant in the system/ Blockage on the suction side	Recover the refrigerant from the air-conditioning system and refill the air-conditioning system/ Check the line and the connections, replace if necessary
High	Low	Ice formation on the fluid line/on the dryer	Line/Dryer blocked	Check dryer/line, replace if necessary