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A New Design Rotary Compressor for Mobile AC&R Applications

energy efficient • anti-friction • eco-friendly • lighter • smaller • economical

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Vatanu-Cool Rotaryvanes Ltd. in collaboration with Dr. Edward's company, Dyneco International Corporation Inc. of USA has developed prototypes of "Orbital Vane Rotary" (OVR) compressors. Almost a hundred sample compressors have been produced in Pune and sold to different customers in USA, Europe, Australia, South Korea, Singapore and India for extensive field testing on vehicles and calorimeters. Two foreign companies have ordered bulk supplies. A new factory in Pune has been constructed to meet these requirements and this will be the first plant in the world to manufacture and sell and patented and globally new OVR mobile air conditioning compressors, starting 2001.

Compressors for mobile applications in air conditioning and refrigeration must meet the stringent requirement of constantly changing speed and very high speeds upto 6000 or 7000 rpm and also withstand much higher dynamic stress and strain than their stationary cousins. Also they must be lighter, smaller and highly efficient. Reliability of operation is, of course, of paramount importance. Conventional rotary vane compressors have been around for a long time but since 1970, Dr. T. C. Edwards from USA has toiled with a unique concept of designing a more efficient rotary compressor, which made me think and work towards the same goal. By the mid 80s, I was convinced that such a machine could be developed and in close association with Dr. Edwards and financial assistance from ICICI

Venture Funds Management Co. Ltd., developed prototypes that could be commercially manufactured.

Initially, in 1992, we developed an energy efficient, anti-friction, low pressure CFC refrigerant based, Constrained Vane Rotary (CVR) machine, but I was advised by some authorities in the hvacr field not to manufacture such compressors, but instead to develop a similar highpressure, eco-friendly refrigerant based compressor. Thus, in collaboration with Dr. Edwards company, Dyneco Corporation, we developed the prototype of the OVR or Orbital Vane Rotary compressor suitable for high pressure refrigerants like HFC 134a and Hydrocarbons (Propane and Butane mixtures).



Figure 1 : An Orbital Vane Rotary Compressor manufactured by Vatanu-Cool

In mobile air conditioning applications, we talk in terms of displacement per revolution and volumetric efficiency, to enable the selection of the right compressor for a particular vehicle, depending upon the engine capacity and cooling capacity required at idle and optimum engine speeds. Thus the right capacity of compressor can be determined for a particular vehicle. If this selection process is not carried out properly then either the vehicle's engine is overloaded (meaning fuel inefficiency and starvation of the vehicle driving power) or the required cooling capacity is not achieved.

In all conventional sliding vane rotary compressors, the vane tips rub with the inner wall of the stator housing or stator diameter with intensive friction between them. Manufacturers must therefore depend upon lubricating these friction generating surfaces or selecting the right materials for such parts in order to reduce friction through tribology or the science of friction. See **Figure 1**.

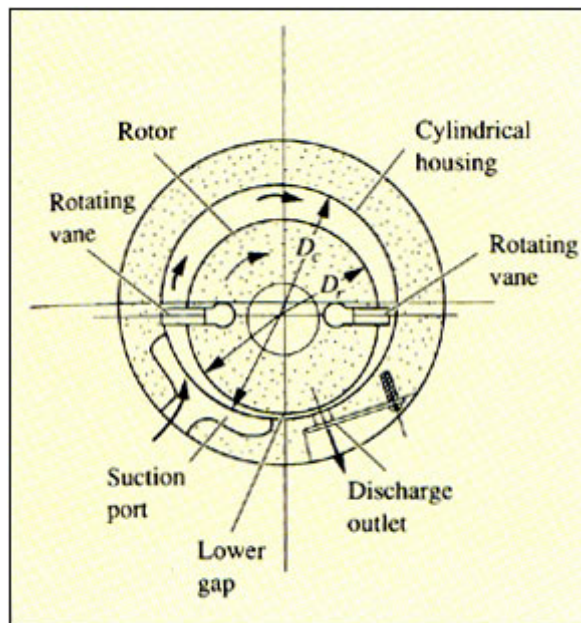


Figure 1 : Conventional sliding vane rotary compressor

"Constrained Vane Rotary" (CVR) compressors are such in their design that the vanes are constrained radially outwards to a definite position. Therefore, while the CVR compressor is compressing or revolving, the vane-tips describe a defined orbit determined by the gliding path. However, when the revolving / c o m p r e s s i n g stops, the vanes can move radially inwards. This concept of design is meant for low-pressure refrigerants. Only after a certain minimum speed of revolution such CVR compressors become a positive displacement machine, like conventional sliding vane rotary compressors. However, the vanetips do not touch the inner wall of the stator housing and do not have intensive friction between vanetips and the inner wall of the housing.

Whereas, in the case of "Orbital Vane Rotary" (OVR) compressors these are designed to constrain the vanes in both radial directions – radially inwards and outwards. Thus, the vane-tips remain or move in their defined orbit only. Therefore, such "OVR" compressors can accept highpressure refrigerants - like CFC - R12, HFC 134a, Hydrocarbon (Propane and Butane mixture). Therefore, OVR compressors are fully positive displacement machines at all speeds of revolution. However, like CVR compressors the vane-tips do not touch the inner wall of the stator housing and do not have any friction between them.

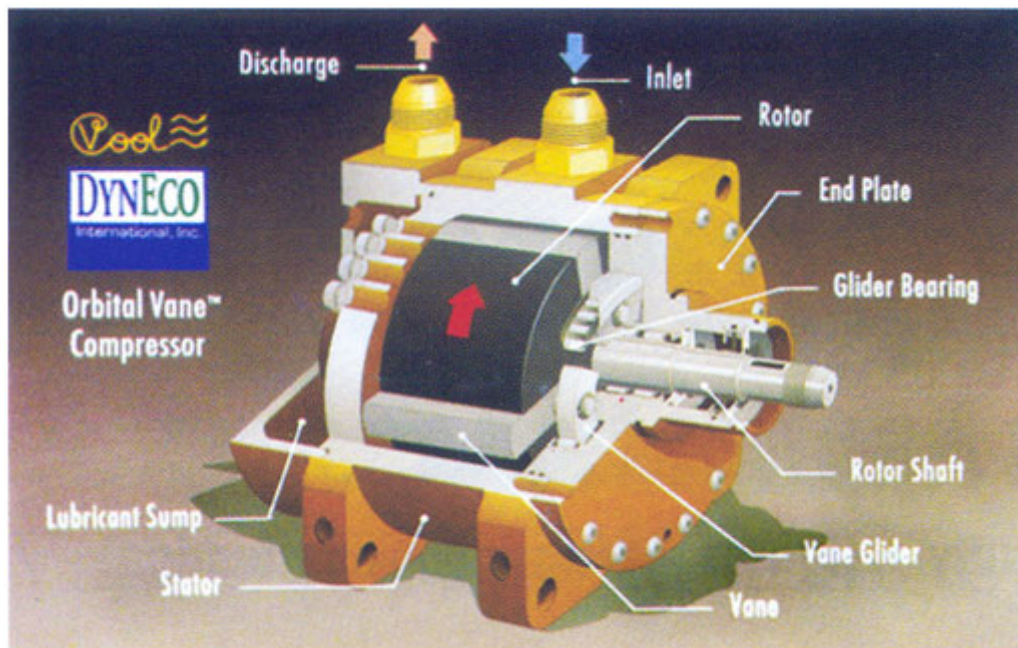


Figure 2 : Isometric sectional view of the OVR compressor

The Orbital Vane Rotary (OVR) Compressor inside view, is shown in **Figure 2**. **Figure 3** shows a direct frontal view of the compressor. As illustrated, the stationary portions of the OVR compressor consist of a Stator housing with an integral Rear Endplate and a matching Front Endplate.

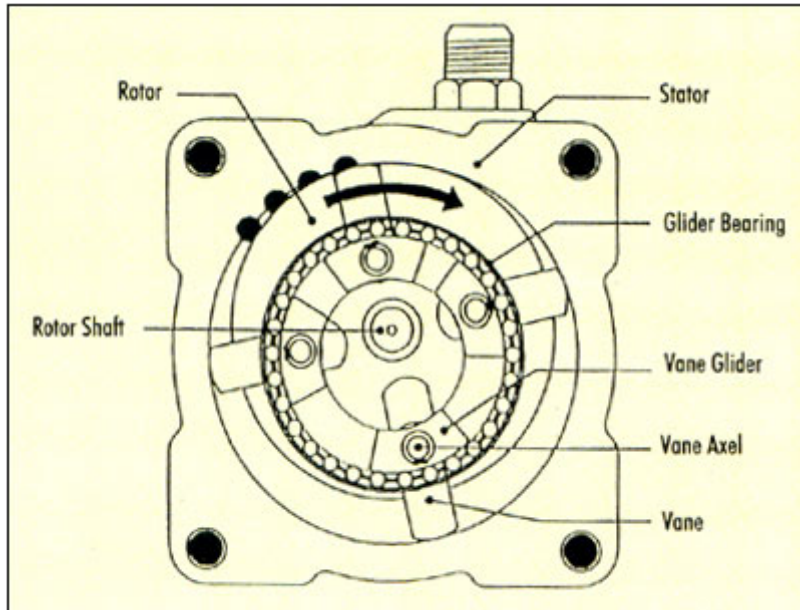


Figure 3 : Frontal phantom view of the OVR compressor

Specially developed drawn-cup anti-friction roller Glider Bearings are pressed into the Front and Rear internal ends of the compressor. The rotating components consist of a slotted Rotor equipped with four radial slots into which fit four identical Vanes. The Vane Gliders are pinned to the ends of these vanes and are free to rock back and forth on the pins. In turn, these vane gliders fit inside the special roller bearings and are thus confined

to move in the precise circular path defined and provided by the antifriction roller elements of the radial vane glider bearings.

The slots carrying the vanes impart a circumferential motion to each Vane when the Rotor is caused to rotate by the Rotor-Shaft. Because the vanes are mechanically coupled to the gliders, the vanes are confined to travel in direct conjunction with the precision enveloping circle of the Glider Bearing. The Vane-Tips execute an Orbit within the Stator Bore that is precisely prescribed by the Glider Bearing. Therefore, the clearance distance between the tips of the vanes and cylinder bore of the stator housing can be held to an accuracy limited only by the tolerances met by highly accurate circular manufacturing processes required to produce the parts. Also, the lubricant contained within the Lubrication Sump circulates in the machine and provides for additional gas sealing.

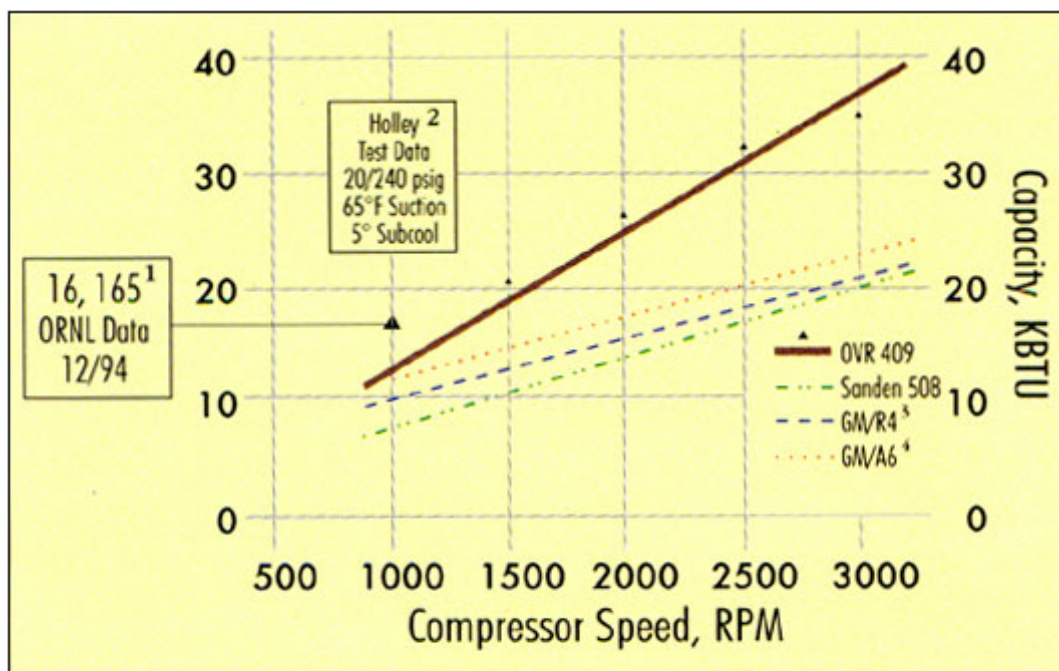


Figure 4 : Comparative Data OVR 209 and other compressors.

Notes 1 to 4 refer to superscripts in this Figure.

1. Data Number 16,165 Oak Ridge National Laboratory, USA
2. A Standard Test condition laid down by Holly and General Motor, manufacturers of mobile AC compressors
3. General Motor's radial four piston mobile AC compressor
4. General motor's axial six piston Swash Plate mobile AC compressor

Because the rotor-center is offset from the center of the stator housing bore, the rotation of the rotor - vane assembly causes requisite cyclic volumetric changes to occur within the machine – Inlet, Compression and Discharge.

The achievement of positive-location, non-contact vane-tip sealing results in high-efficiency, inherent machine reliability and longevity. Also, the development yields other significant advantages. For example, the absence of rubbing contact enables the use of

lightweight, rapidly machine-able materials such as aluminum. Furthermore, only minimal surface finish is needed to build Orbital Vane Rotary compressors. Additionally, this design enables the use of numerous and efficient fluid ports because the bore of the stator housing is not required to support the load of the vane-tips as in the case of the conventional sliding vane rotary compressors.

Comparative thirdparty data for the 142 cc / revolution (or 8.4 cubic inch) displacement model OVR 409 automotive AC Orbital Vane Rotary compressor is shown in Figures 4 and 5. This test of OVR compressor was carried out with HFC 134a while the conventional compressor was operated with R-12.

Vatanu-Cool manufactures two models of OVR - mobile air-conditioning (MAC) compressors - OVR- 406 and OVR-409. The Company is negotiating to give away the design and manufacturing technology rights of Hermetically Sealed "Orbital Vane Rotary" (for stationary air-conditioning and refrigeration applications) to some large multi-national manufacturing companies.

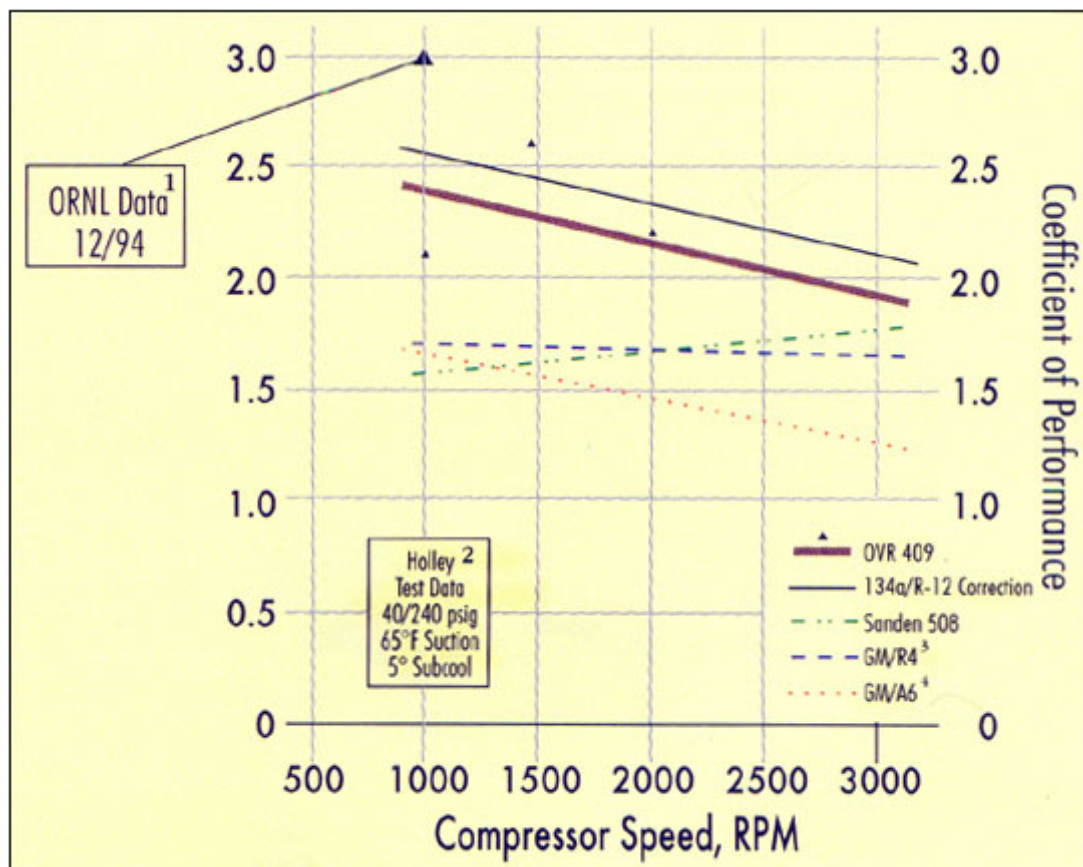


Figure 5 : Comparative Data OVR 409 and other compressors.
Notes 1,2,3 and 4 shown in Figure 4 refer to Figure 5 as well.

Orbital Vane Rotary compressors show similar efficiency and performance that can be observed in Scroll compressors. However, it is well known that the machining of the

complex geometry scrolls of any Scroll compressor make them expensive. Therefore, Scroll compressors are not yet very popular for mobile application although they have very high volumetric efficiency and are energy efficient. OVR compressor parts are of either round or rectangular geometry, therefore they are very cost effective to manufacture and have fewer parts compared to all types of piston compressors. Conclusively, it can be said here that although the OVR compressors are simple, with fewer parts, antifriction in design and highly balanced, they are highly energy efficient, with high volumetric efficiency and are less prone to wear - therefore very reliable and cost effective. A compressor for the 21st Century.

COMPRESSORS FOR AUTOMOTIVE APPLICATION A Brief Overview

By Ramesh Paranjpey

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There are various makes and types of compressors used in automotive air conditioning systems operating on R134a. The designs normally are axial piston reciprocating type wobble plate or swash plate, scroll, and rotary.

The wobble plate type compressors have pistons on one side of the plate and during rotation of the crankshaft, due to the angle of the wobble plate, the pistons move in the cylinder, compressing / expanding gas. See diagram showing inside view of a Sanden reciprocating compressor.

The swash plate design has pistons on the either side of the plate, giving more uniform flow and is a more balanced design.

Automobile compressors are directly mounted on the engine block and are driven through a belt drive from the engine pulley. The speed of the compressor is constantly changing as per engine speed, from idle speed to full speed, depending upon traffic density and vehicle speed.

The compressor declutches when the car cabin temperature is reached and when the temperature rises it gets engaged. When the compressor is declutched, the pulley rotates freely and there is no compression.

The rotary, scroll, or reciprocating compressors are all positive displacement compressors, however the rotary or scroll designs are more efficient, because they do not

suffer from the inherent disadvantage of volumetric efficiency drop associated with reciprocating compressors. The rotary or scroll compressor expels the entire volume sucked by the compressor and there is no reexpansion of gas. The rotary design is therefore more compact, efficient, having less starting torque, less vibration and noise. Since there are no suction and discharge valves, the valve plate noise is absent. On the discharge side there is a non-return valve.

The leading manufacturers of automotive compressors are Sanden, Zexel, Seiko-Seiki, Denso all from Japan, Subros from India, Hala from Korea and Delphi from USA.

What type of compressors do cars in India use?

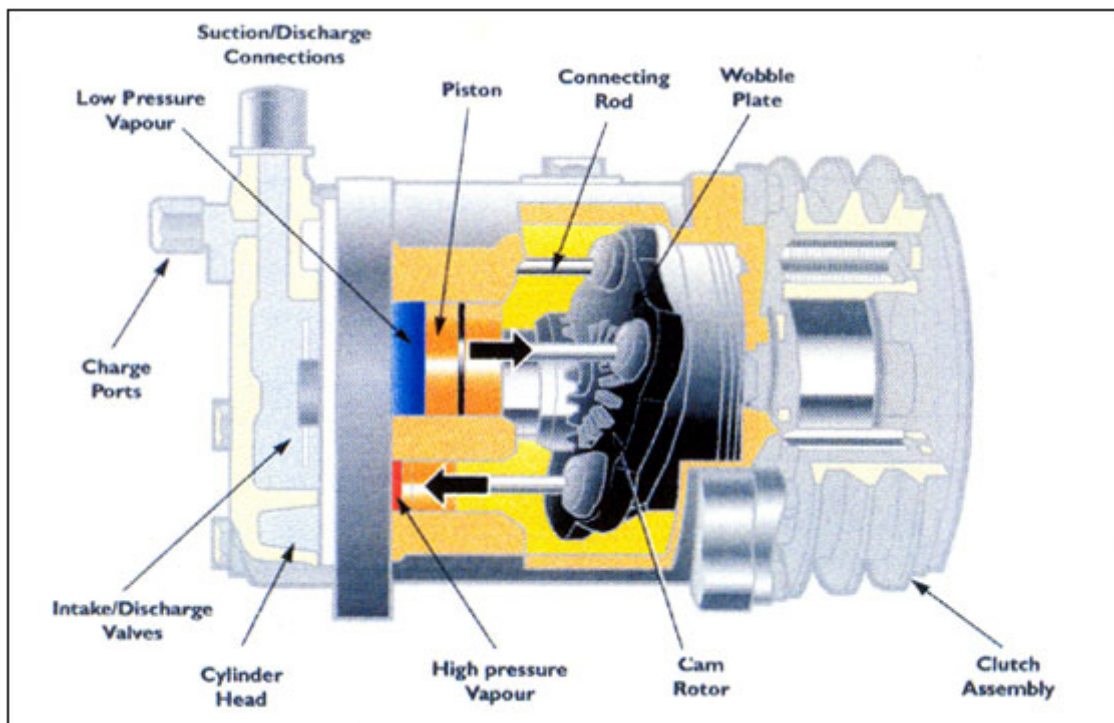


Figure 6 : Inside view of a Sanden reciprocating compressor

Practically all cars in India use reciprocating compressors which are preferred over rotaries because of the high ambient temperatures prevailing over most parts of the country with the following exceptions: It is understood that WagonR (Maruti) uses an imported Rotary, while Lancer (Mitsubishi) and Citi (Honda) both use Scrolls, from Japan.

Sanden Vikas (with Sanden, Japan collaboration) and Subros (with Denso Japan collaboration) manufacture Plate reciprocating compressors in the Delhi region. Denso of Japan is establishing an independent plant near Bangalore to manufacture reciprocating compressors for the Toyota Qualis. Visteon, a Ford Motor company is establishing a plant to make recip compressors in collaboration with Halla of South Korea to cater to the Ford vehicles, produced in Chennai and Delphi (a GM company) will also set up a facility to

manufacture automotive compressors. Compressors from these new plants will be of similar design to the recip compressors made by Sanden Vikas and Subros.