NEW CONCEPT OF A HIGH EFFICIENT ROTARY PUMP

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P/M allows the economic production of components for high efficiency pumps. The planetary G-rotor produces at low speed very high efficiencies. This new pump has been tested at a range from 30 rpm to 7000? rpm and pressures up to 100 bars. This new planetary G-rotor is ideally suited to automotive engines and transmissions as well as in a variety of other applications, which demand high pressures or high efficiencies at low rpm. Due to its complex tooth shapes only a tooled forming like PM allows is possible.

INTRODUCTION

Volumetric acting pumps need good sealing mechanisms to achieve high pressures. This is particularly critical at low rpm. All current rotor based pumps need an axial clearance for a smooth function and to allow commercial mass production. Depending on the pump design, leakage will occur at the tooth tip clearance of G-rotors, between tooth tips and the crescent of crescent rotors, or at the vane tips of the cam contour in vane pumps.

LEAKAGES LIMIT IDELING RPM AND PRESSURE LEVELS

Traditional rotor pump clearances allow the pumped medium to flow back from high to low pressure depending on; the axial clearance, the pressure level, and the viscosity of the fluid. This back flow is constant for a defined pressure and independent on volume flow of the pump (rpm). Thus at low rpm this leads to low efficiencies and even may lead to no pressure and no volume flow. At higher rpm the pump volume flow increases while back flow stays constant and the pump shows an increase in net efficiency. This requirement for clearance limits the functionality of these type pumps.

The application of G-rotors is typically limited to pressures between 5 and 10 bar and idling speeds of 500 – 800 rpm (typical application in engines, fig. 3). Crescent pumps (typically used in automatic gearboxes) have similar rpm limits, and operate at higher pressures (15 – 30 bar).

SELF ADJUSTING SEALING ELEMENTS

To improve low speed performance it is therefore necessary to reduce back flow. Since axial clearance is necessary for operation a solution that provides variable sealing of the tooth tip areas will significantly improve low speed efficiency.

GKN has developed a self-adjusting sealing system for G-rotor pumps. A micro gear is superimposed on the typical G-rotor gear shape and is meshed with the addition of small pinion gears “planets”, which replace the circular teeth of the outer rotor. This is the GKN-PLANETARY-ROTOR (patents applied).
The rotor works similar to a conventional G-rotor. The planetary pinions roll over the micro teeth of the inner rotor. Thus there is no sliding movement in the sealing connection and therefore no friction. The micro teeth seal at the tooth flanks and as a result only transmit tangential forces for the sealing effect. Instead they transmit a radial force via the tooth tips and roots. This force running through the centres of the planets transmits the torque from the inner to the outer rotor.

The planetary pinions slide freely in the open bores of the outer rotor. The tips of the micro teeth build up a hydrodynamic cushion, which lifts them of the bore surface for sufficient lubrication.

**PERFORMANCE**

Test measurements show that the P-rotor covers the whole spectrum of rpm for automotive and industrial needs.

The P-ROTOR shows at very low rpm of 30 / min good volumetric efficiencies and high pressures up to 80 bar. Flow loss appears to be directly related to the axial clearance of the rotor and the housing.

The efficiency investigations for the P-rotor show a slightly higher loss by internal friction than G-rotors recognisable at low pump pressures. This friction loss is more than compensated by the improvement in volumetric efficiency at low pressures. This would allow the use of a smaller P-pump compared to a G-rotor, which would have lower friction.

The volumetric efficiency and pressure build up of the P-rotor are much better than of G-rotors, crescent rotors and vane rotors especially at low rpm. Fig. 3 details an automotive pump application comparison and shows the P-rotor advantage. The P-rotors volumetric pulsation is comparable to normal G-rotors of similar basic design.

**CONCLUSION**

GKN continues to optimise the P-rotor but initial investigations have shown that the P-rotor has a significant performance advantage over a wide range of rpm and at high pressures.

The high pressures and a volumetric output proportional to pump rpm offers improved hydraulic pump performance. Hydraulic motor applications (start moving a low flows) can also benefit from this technology.

It allows the development of a lubrication of lower idling engines and gearboxes. The better efficiency of this pump allows for a smaller geometric volume of the rotor and therefore save roughly half of the energy effort for lubrication. It is an aid by variable valve timing (VVT) applications. It is also applicable as a drive source for variable valve timing (VVT) for the development of proper combustion. Further the P-rotor allows the pressures necessary for the application in CVT gear boxes.

The P-pump shape is to complicated to be manufactured in typical machining processes however the powder metallurgy process is ideally suited to produce high volumes of the gear elements for the P-pump.
Fig. 1: The new GKN planetary-rotor with inner rotor, planet pinions, and outer rotor, the parts are shown at different levels to better show the combination gears.

- self sealing micro-gear
- clearance

P-Rotor

- self sealing tangential clearance by micro-gear
- $\eta_{vol}$ efficiency exclusively determined by axial clearance
- no internal leakage losses
- superimposed micro-/macro-gear

Fig. 2: Micro teeth of the planetary pinions perfectly avoid tooth tip leakage.
Fig. 3: The planetary rotor allows a high volumetric efficiency due to the fact that there is no tooth tip leakage but only the leakage through the axial clearance (in this case with 0.05 mm an upper extreme of typical clearances around 0.02 to 0.03).
Fig. 4: At low rpm the P-rotor produces high volumetric flows ($V_{geo} \sim 21 \text{ cm}^3$) at high pressures depending on axial clearance. In comparison a G-rotor falls with increasing pressure resulting in poor performance.
Fig. 5: The P-Rotor shows with rising pressure an increasingly good performance in relation to the internal gear rotor with crescent.

Fig. 6: The P-Rotor shows with rising pressure an increasingly good performance in relation to a G rotor.
Fig. 7: This principal design lay out for an engine shows that the GKN-PLANETARY-ROTOR for the same purpose is smaller in volume than a G-rotor and thus wastes also less energy at high rpm.