could be designed as an integrated part of the piston. The circumferential slot allows the piston skirt to adjust elastically to the liner surface. The rising pressure in the slot during compression and thermal expansion would give rise to the sealing effect. The main advantage is that the gas leakage is almost totally suppressed. Since the sliding surface will be continuously in Gas spring test sliding contact it must be covered with a wear protective coating. The application of DLC coating may reduce the coefficient of friction down to 0.02 [3].

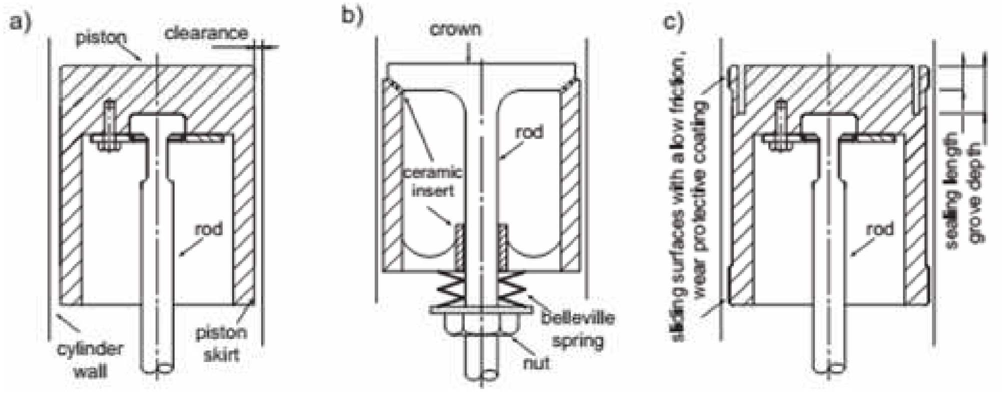

Fig. 2. Candidate ringless piston designs for an oil-free piston compressor:
a – clearance seal, *b* – the T-piston [3] and *c* – the U-piston

Conclusion

The piston will be designed as a self-lubricating (aerodynamic) piston and the working gas will be used as the lubricant. Low viscosity of the gas offers virtually frictionless operation. In order to fully benefit from the low friction potential of gas lubrication any contact between the piston skirt and cylinder liner must be avoided. However, because of unbalanced forces acting on the piston, it will also move laterally in the cylinder and occasionally hit the cylinder wall. These occasional contacts cause friction, wear and also noise eventually leading to failure. A good design must therefore provide a smooth and stable reciprocating motion of the piston and ensure that the gas film separating the surfaces is maintained during operation. At the same time the gas leakage along the piston needs to be limited. The sealing of the compressed gas in this case is obtained by the small radial clearance between piston and cylinder only, also called a clearance seal. To optimize the piston design a complete dynamic analysis of the reciprocating piston is needed.

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UDC 665.662.5

DEWAXING OF LUBRICANT BASE OILS

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Most paraffinic crude oils contain a significant amount of wax across the entire lube fraction viscosity range. Since the wax in base oil has a high melting point, as temperatures drop, the wax crystallises and thickens the lubricant until it finally stops flowing. Therefore, dewaxing processes are used during lube refining to remove waxy components from base oils to ensure that lubricants formulated with these base oils will continue to flow at low temperatures. Dewaxing is achieved by cooling the oil to below the crystallisation temperature of its waxes. The crystallised waxes are then removed by filtration. One of the most common dewaxing processes is solvent dewaxing [1].

Solvent dewaxing. In the solvent dewaxing process, the raffinate (a mixture of base oil and wax) is first diluted with a chilled solvent system using either propane or ketone/toluene. In both types of systems, the solvent is used to provide favourable conditions for the growth of wax crystals and to dilute the resultant chilled slurry so as to permit continuous oil wax separation using filter equipment. The mixture is further chilled and then enters a rotary drum filter where it is sprayed with more cold solvent and subjected to a vacuum. The wax crystallises and collects on the surface of the rotating drum and is then scraped off as slack wax. The liquid phase, called filtrate, passes through the filter. The solvent is then removed both from the dewaxed filtrate and from the slack wax, which is retained as a valuable byproduct that can be further processed into high margin hard wax [1].

Due to its complexity, the dewaxing of lubricant base oils is the most difficult and costly process in lube manufacturing. The waxy material in lube oil fractions is macrocrystalline (or simply crystalline) and/or microcrystalline, but under certain conditions may behave like a colloid. When the raffinate with solvent is chilled rapidly with moderate stirring, a wax is precipitated that is often difficult to separate by filtration. The conditions under which the wax crystals are grown are among the most important considerations in the dewaxing process. The size and shape of the crystals are affected by the nature of the paraffinic hydrocarbons in the oil, the nature of the precipitating solvents, the speed of chilling, and the agitation during chilling. While less economical, filtration of the precipitated wax can be facilitated by adding more solvent to the solution or reducing the cooling rate.

Paraffinic hydrocarbons from heavier lube oil fractions tend to form smaller crystals called microcrystalline wax that trap oil in pockets between crystals, to the detriment of achieving a good separation of wax from the filtrate. Thus the cake of the microcrystalline wax contains a relatively high percentage of oil, resulting in lower economic value for the recovered wax. Note, however, that these processes can be considerably improved with the use of an appropriate dewaxing aid [2].

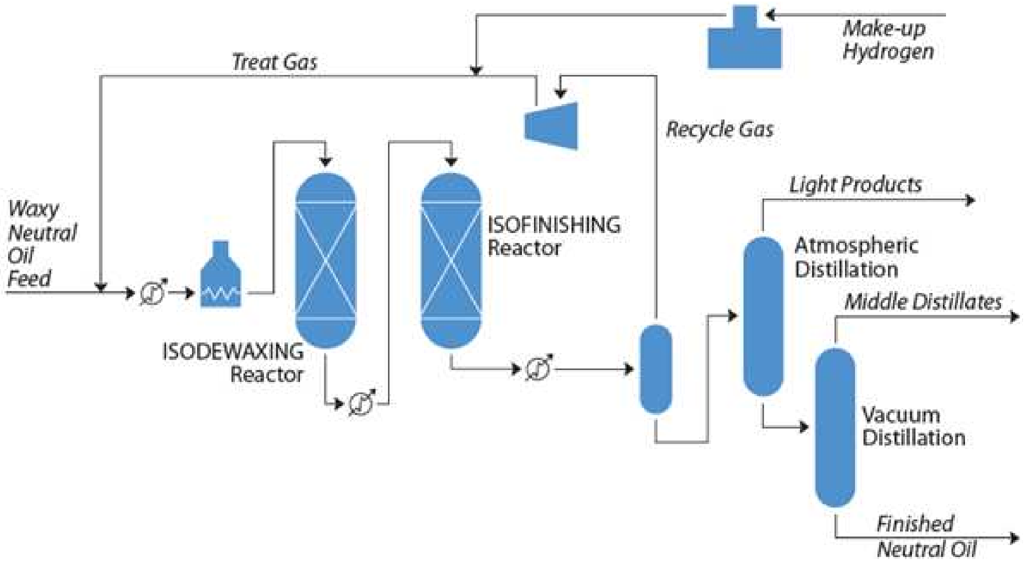
Dewaxing aid (wax crystal modifiers). A dewaxing aid is a polymeric material that cocrystallises with the wax and helps to develop larger, more uniformly sized wax crystals that enable higher filtration rates due to the improved filtrate separation from the agglomerated crystals. An appropriately selected and applied dewaxing aid thereby provides increased throughput, increased dewaxed oil yield, decreased oil in wax for the slack wax, and a decreased rate of filter blinding.

Two mechanisms have been proposed to explain the observed benefits of dewaxing aid treatment. Both are believed to be operative and depend on the ability of the wax crystal modifier to gain entry to the wax crystal lattice. One mechanism, called nucleation, treats the dewaxing aid as a seed which initiates wax crystal formation. As a seed crystal, the dewaxing aid promotes more controlled crystallisation. The second mechanism, absorption, takes the view that the dewaxing aid adsorbs onto the surface of the growing crystal and alters its subsequent size and shape [2].

Isodewaxing and isofinishing. The isofinishing technology uses noble metal catalysts to almost completely remove aromatics, obtain excellent oxidation stability and produce a practically water-white product. Noble metal catalysts require lower operating temperatures than base metal catalysts for the equivalent product oxidation stability, which in turn results in superior color. These exceptional results are achieved at lower pressures and smaller reactor volumes than those required when using base metal catalysts. When producing white oils, the isofinishing technology can be used as a stand-alone process.

Waxy neutral oil feed from a hydrocracker/hydrotreater process step, together with treat gas, is preheated and fed to the isodewaxing reactor. This reactor isomerizes some of the normal paraffins (waxes) to high VI isoparaffins and lowers the pour point. Other paraffins are cracked to highly saturated light products, such as high smoke point jet and high cetane index diesel. The effluent from the isodewaxing reactor is then sent to the isofinishing reactor. There the product undergoes deep isofinishing via aromatics saturation to provide a highly stable finished neutral oil product after atmospheric and vacuum distillation. The catalysts used in the isodewaxing and isofinishing reactors are highly selective for dewaxing and hydrogenation at maximum finished neutral oil yield. The catalysts are most effective in low sulfur and low nitrogen environments. As such, the isodewaxing/isofinishing unit generally utilizes a dedicated high pressure recycle gas loop, separate from that for the upstream hydrocracker/hydrotreater should the processes be combined in an integrated unit.

Combining lube hydroprocessing technologies – including isocracking, isodewaxing, and isofinishing – provides greater feedstock flexibility then solvent refining or other lube processing routes. The isocracking process boosts VI by converting low VI components to high VI base oil, thereby offering greater feedstock flexibility than solvent refining. Lube hydroprocessing can be integrated with existing solvent extraction lube plants to improve product quality, yield and flexibility to meet current and future base oils requirements [3].



Process flow diagram

Conclusion. Demand for bright stocks and other high quality base oils is likely to keep growing as world population increases and developing countries become increasingly mechanized. Even today, the availability of bright stock is less than demand.

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