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Oil Reservoirs

Optimizations for the Future

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Komplexes Hubsystem sorgt für festen Stand

Steuerungen und Regelungen
Proportional-Wegeventil passt sich der Anwendung an

Zubehör
Effiziente und flexible Kunststofflösungen

Oil Tanks – Optimizations for the Future

Andreas Busch, Jürgen Gottschang

The tank is one of the core components of a hydraulic machine. This technical paper reveals how performance can be significantly improved.

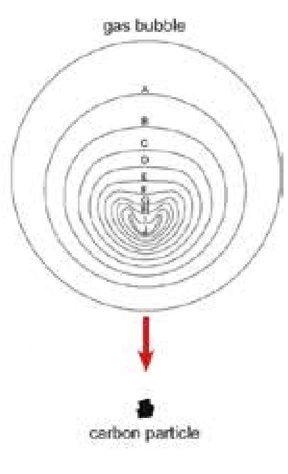
Author: *: Andreas Busch,HYDAC Filter Systems GmbH, Sulzbach / Saar, Germany,*
E-Mail: andreas.busch@hydac.com
Co-author: Jürgen Gottschang

These days oil hydraulics is increasingly in competition with electrical drive technology. Energy efficiency, resources management and faster process speeds are key demands which define the challenges facing machine manufacturers.
Clever combinations of various drive technologies in conjunction with reduced operating costs and smaller space requirements can take many hydraulically powered machine functions in new directions. The main benefits contributed here by OXiStop are smaller tanks and higher process speeds.

OXiStop is not some new, untested solution. There are already more than 100 existing applications around the world in the stationary hydraulics sector - with over 10 years‘ operating experience.
A conventional hydraulic tank performs the following tasks in the hydraulic system:

- Stores sufficient oil for the required differential volume and possible leakage compensation
- Solid, liquid and gaseous contaminants in the oil separate out after settling time in the tank
- Provides a convenient surface to mount other hydraulic components

Heat transfer via the reservoir surface is usually a secondary function generally carried out by a heat exchanger.
The HYDAC OxiStop tank solution revoluti-



Area	Pressure	Temperature
A	1 bar	38°C
F	69 bar	766°C
H	138 bar	994°C
I	207 bar	1140°C

02 Temperature rise in the gas bubble when pressure is increased rapidly (diesel effect) [1]

onizes the conventional tank design and typically reduces the tank volume by a factor of 10 compared to the conventional design. The tank volume is calculated on the basis of the differential volume of oil required by the components in the system.

In addition to the smaller tank, there are further advantages for the hydraulic design engineer:

- Conservation of resources by minimizing oil quantities and extending fluid service life
- Higher process speeds thanks to improved fill level of pumps and reduced cavitation in the system
- Environmental contamination is prevented through the use of a sealed membrane ("vacuum-packed" oil)
- Greater system cleanliness because it prevents the formation of sediments in the tank and deposits on surfaces in contact with oil, by continuous degassing, dewatering and more effective filtration

In order for the hydraulic tank size to be reduced to a minimum, the degassing function (separation of free air) must be managed differently. Instead of degassing the oil by allowing it to settle in the tank, with the OXiStop there is a hydraulically powered degassing unit that continuously removes free and dissolved air from the hydraulic oil.

Design and function of the vacuum-packed OXiStop solution

OXiStop is a tank solution with an integrated, hydraulically operated degassing unit. A flexible membrane on the oil surface prevents the absorption of air by the oil.
The degassing unit continuously separates out both free, visible air and air that is dissolved in the oil. The pressure level in the tank is the same as that in a conventional system (atmospheric pressure).

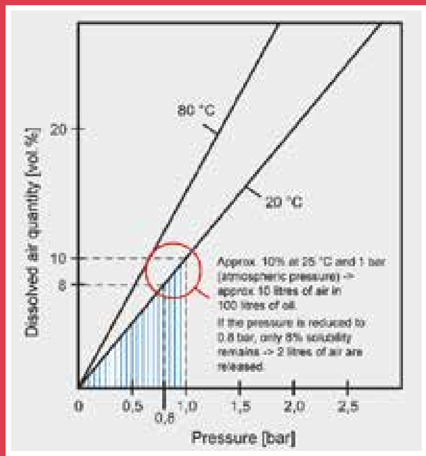
During normal operation a gas content of 1-2 % is achieved. The proportion of gas and air in conventional tank systems is over 10%. This corresponds to the saturation point of hydraulic oil at ambient pressure **(Fig. 03)**. In the OxiStop the oil is therefore under-saturated and always ready to absorb air/gas. Free and dissolved air is reabsorbed and separated by the degassing unit quickly. The low oxygen content in the oil increases the service life of the fluid by up to three times.

In order to ensure safe operation of the system, both the gas content of the oil and the membrane position are monitored. If air suddenly enters the system, e.g. air enters via the pump suction line, this is detected via a change in the negative pressure in the degassing unit. Since the oil volume in the hydraulic system is reduced, leakages are detected more quickly than in conventional systems and the hydraulic system reaches operating temperature faster.

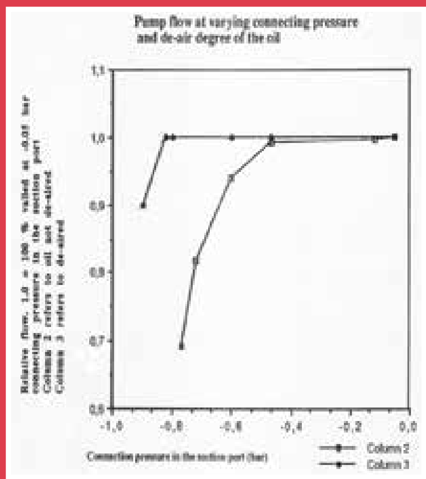
Characteristics of OXiStop during system operation

As well as the general characteristics of the OXiStop tank solution, specific advantages are to be had from operating with degassed oil. Cavitation – in addition to contamination in the hydraulic oil – is one of the main causes of short service life in components and oil. In this context, by cavitation we mean a sudden/explosive disintegration of the air in oil which is released when the saturation point is exceeded. In addition, when the gas bubbles are compressed and the temperature rises, the air and oil can react with explosive force (Diesel effect) **(Fig. 02)**. The effects of cavitation on the hydraulic system are as follows:

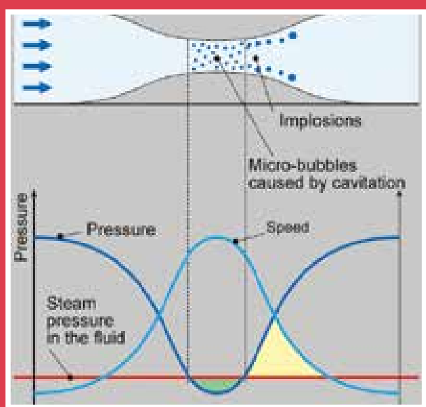
- Loud noise emissions
- Erosion of surfaces



03 Solubility of air in oil in relation to absolute pressure [1]

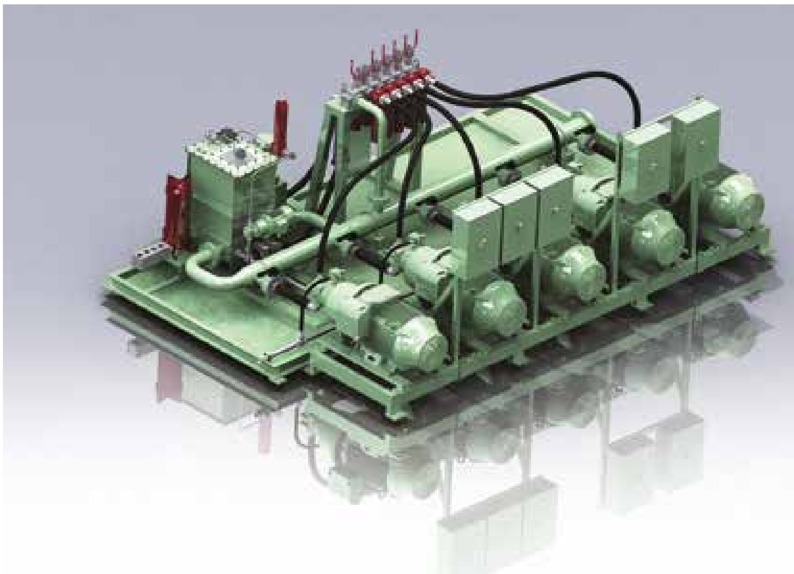


04 Pump flow in relation to negative suction pressure for degassed oil and non-degassed oil (Hakan Ingvast) [3]



05 Behaviour of oils saturated with air at specific points of high flow velocity.

06 BEFORE: Solution without OXiStop



07 AFTER: Compact solution using OXiStop

- Strong vibrations
- Oil turns very dark or deposits form on surfaces in contact with oil (varnish)

Hydraulic oil is made up of base oil, additives and air/gases. The solubility of air in oil depends primarily on the oil pressure [2]. In a complete vacuum, air cannot dissolve in the oil, whereas at atmospheric pressure the oil can absorb approx. 10% air **(Fig. 03)**.

This corresponds to the conditions in the tank. As long as there is no free/visible air in the oil, there is no measurable change in volume of the fluid as a result of degassing.

Figure 4 shows the difference in behaviour between a degassed operating fluid and one that is saturated with air when using in a fixed displacement pump. When the negative pressure falls below -0.4 bar, the volumetric efficiency of a pump falls rapidly. With a saturation level of 10 % at atmospheric pressure, approx. 4% free gas accumulates in the suction side of the pump. This gas is compressed adiabatically in the pump. Compression causes the diesel effect which reduces the oil service life. The volumetric pump efficiency is further reduced by the compressibility of the air.

Figure 5 shows oil flow through a pipe constriction. There is a local pressure drop as a result of the increase in flow velocity. If the pressure falls below the solubility threshold for air in oil, gas bubbles appear that implode when they are next compressed. The effects of this phenomenon are:

- surface erosion e.g. in valve cross-section and
- thermal-oxidative degradation of the fluid.

Similar phenomena were observed in highly dynamic processes. Accelerating oil columns and rapid release of pressure lead to areas of negative pressure where the solubility thresholds for air/gas in oil are exceeded and free gas is produced. This means that degassed fluids also contribute to the acceleration of processes and reduce the risk of component wear.

Real-world example: hydraulic press

The real-world example involves a hydraulic press that in its conventional design had a tank volume of 1,500 l **(Fig. 06)**. The maximum pump flow is 250 l/min and the electric motor rating is 100 kW. The required differential volume for the cylinders is just 12.5 l. This provides the basis for sizing the OXiStop tank. The usual rule of thumb: tank volume = differential operating volume x 2.

However, the actual tank volume for the OXiStop implemented in this application **(Fig. 07)** is 185 l, as the following considerations also needed to be taken into account:

- Additional tank volume required for the connection cross sections for pump, suction and return lines
- Thermal expansion of the hydraulic oil
- Local heating of oil, and temperature control
- Modification of the start-up procedure

The following important benefits were derived for the whole system when the design was based on the OXiStop:

- Just one tank instead of three separate ones
- Smaller anti-cavitation valves could be used as there is a less risk of free gas in the oil
- Reduced risk of operating the system as a result of smaller oil volume
- Longer oil service life and lower proportion of oil ageing products/deposits
- Use of tank membrane reduces contamination ingress and oil mist release

Direct comparison makes the distinction clear:
BEFORE: the classic solution **(Fig. 06)** and
AFTER: the compact solution using OXiStop **(Fig. 07)**

Photo: *HYDAC Filter Systems GmbH, Sulzbach / Saar*

www.hydac.com

Bibliography:
[1] HYDAC brochure E7660„Vacuum-packed: The cutting-edge, patented tank solution for hydraulic systems OXiStop OXS"
[2] O+P_2004_09_Schuster_Verringerung_der_Kavitationsneigung_bei_hydraulischen_Ventilschiebern [Reduction of cavitation in hydraulic valve spools, Schuster O+P_2004_09]
[3] Håkan Ingvast, Sweden; Diagramm Pumpenvolumenstrom in Abhängigkeit vom Saugunterdruck für entgastes Öl und nicht entgastest Öl [Diagram of pump flow in relation to negative suction pressure for degassed and non-degassed oil]