myCro

Downsizing of hydraulic power units by revolutionizing the design

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Industrial technology is confronted with the constant demands for a reduction in investment and operating costs. Especially hydraulic power units as a core element for supply of flow and pressure for hydraulic actuation systems have a big influence by minimization of the required oil quantity used as well as by optimizing the targeted fluid condition. In addition to the reduction in the required size and weight, the cost of steel fabrications can also be significantly reduced by a smaller tank and the oil quantity during initial filling and maintenance can be reduced. With the innovative engineering-package "**myCro**" presented here, these advantages can be exploited by the customer.

Keywords: Downsizing, Hydraulic power unit, Degassing, Oil conditioning
Target audience: Design, engineering and usage of hydraulic power units

1 Introduction

Hydraulic power units (HPU´s) represent as capital goods the energy or power supply of hydraulic drive technology where low initial and operating costs are an important main focus. The initial costs of an HPU are, in addition to the attached and built-up components, largely influenced by the hydraulic oil tank and the amount of oil stored there, while the maintenance and repair costs make up a large part of the operating costs. In both cases, the percentage of initial or operating costs varies depending on the requirements of an HPU and can therefore not be generalized.

HPU´s are generally characterized by a large variety of sizes and shapes that arise from the requirements they need to meet such as the available footprint or space, the hydraulic power to be provided, the pendulum volume or attached peripherals. In the following picture, three different HPU´s are shown in order to make the broad variance clear.

Figure 1: Variance of HPU´s in terms of size and shape

In order to use hydraulic units in confined spaces in manufacturing plants or to apply them in narrow installation spaces of higher-level machines, the demand for a further increase in the power density of HPU´s (downsizing) is made more frequent.

2 State of the art in the consideration of the oil conditioning by the design of HPUs

Since the size and shape of HPU´s – and therefore also costs - are very much influenced by the tank, it is advantageous to size this as small as possible. In addition to the reduced initial costs due to the smaller tank, there are also lower costs for the initial oil filling. The quantity of hydraulic oil to be used also has a recurring aspect, since it occurs during the initial filling and at the change intervals.

For the regeneration of the fluid (e.g. degassing), a necessary resting time in the tank is usually defined in order to allow the air bubbles in the oil to rise from out of the fluid and to outgas. This process can be relatively slow depending on the size of the air bubbles as well on physical and chemical properties of the fluid. The necessary tank size is thus derived from approximately 3-5 times the circulated oil volume flow /1/. For example, in the current state of the art in the engineering of HPU´s, this would result in a minimum size of the oil tank of 600-1000 l in an HPU capable of permanently delivering a maximum flow rate of 200 l / min.

If the relationship between the circulated oil volume flow and the size of the tank and a corresponding oil conditioning are not taken into account, damage - and thus increased maintenance and repair costs – will result. In addition to contamination of the oil with solid particles, the contamination with air and water must be considered.

Air that is in dissolved form in the hydraulic oil is bound in the molecular structure which is initially unproblematic. The proportion of air dissolved in oil is largely dependent on pressure, less on temperature and viscosity, and not on base oil, refining or additives /2/. Major problems are caused by undissolved air that forms - depending on the type and viscosity of the oil - in a proportion of about 10% in the form of bubbles. For example, it leads to foaming at a proportion of about 30% /2/, which among other things adversely affects the dissipation of heat from the oil and worsens the lubrication of friction surfaces. Other negative characteristics due to undissolved air are accelerated oil aging due to the diesel effect or cavitation phenomena in hydraulic components. The same applies to water in hydraulic oil, which can also occur in dissolved form - bound in the molecular structure of the oil - or undissolved in the form of water droplets. The negative effects of water in hydraulic oil are corresponding to the problem with air.

3 New approach for the efficient design of HPU´s

However, the reduction of the required amount of oil represents an extraordinary challenge, since the hydraulic oil is a decisive factor for meeting demanding tasks in addition to power transmission, such as lubrication and corrosion protection of moving parts. Water and air deteriorate the required properties of the fluid by phenomena such as e.g. oxidation, corrosion, and diesel effect which reduces the life of oil and components and leads to undesired effects such as noise, erosion damage and a lack of system stiffness during operation.

From this it can be concluded that HPU´s can be dimensioned much smaller in principle if the above described phenomena can be treated by suitable fluid conditioning. This can be achieved by controlling the air and water content, the cooling and filtration or by a targeted management of the oil flow or tank design. Since these measures can vary greatly depending on the area of application and the application of the unit, Bosch Rexroth has developed the complete engineering package **myCro** - consisting of active and passive measures - to counteract the complex and multi-layered problems and reliably ensure appropriate oil conditioning. The following table shows the definition of **myCro**.

my	individual
Customized	Customer specific engineered
reduction	to build small and cost-efficient power units
option	Via optional add-on equipment

*Table 1: Definition of **myCro***

As shown in the following illustration, the modular engineering package **myCro** essentially consists of 4 different approach categories, which must be used according to the individual application.

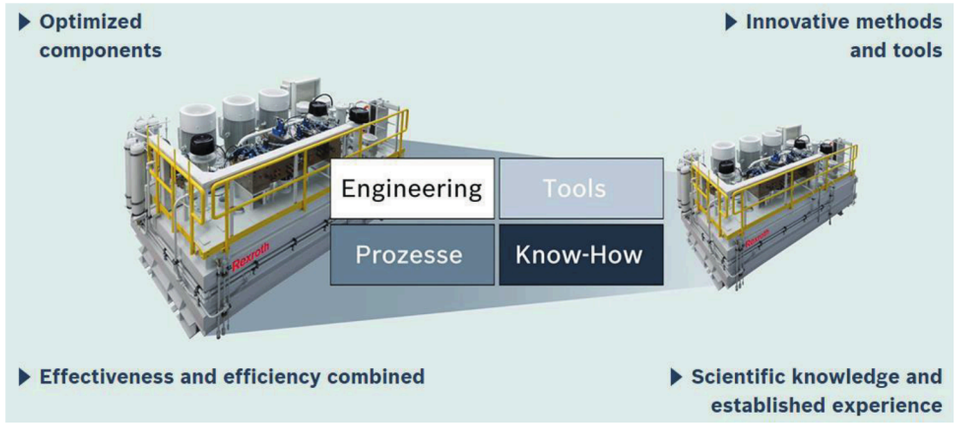

*Figure 2: **myCro** enhanced intelligent fluid management and downsizing of HPU´s*

In principle, **myCro** can be divided into measures for active oil conditioning and measures for passive oil conditioning. For a suitable oil conditioning by means of active measures, the desired parameter to be conditioned in the oil must be measured / interpreted and then possibly improved.

Here systems are available with **myCro** which operate a controlled degassing and dewatering of the hydraulic oil by means of suitable sensors. The systems work independently of the pendulum volume and have a scalable degassing and dewatering rate which makes a wide range of applications possible. In the same way, the filtration can be solved as usual via the secondary circuit. As an example, the degassing of an oil volume can be seen in the following picture.

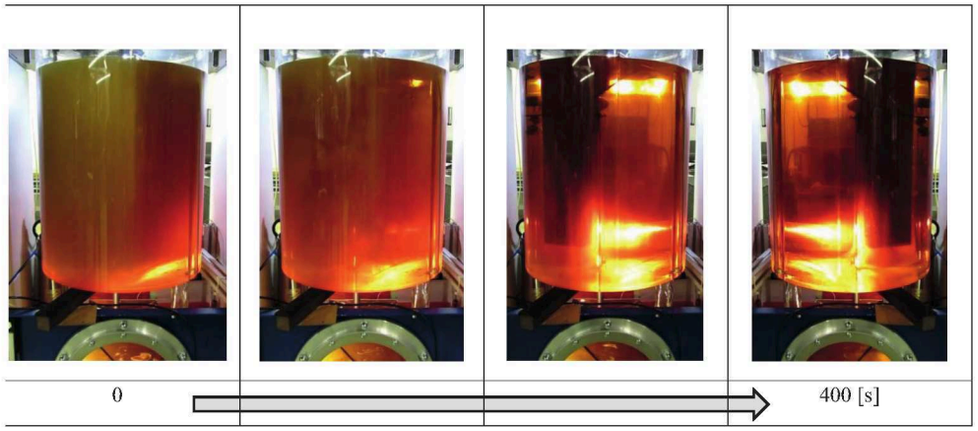

*Figure 3: Exemplary degassing of an oil volume as an active **myCro** measure*

In passive measures, the HPU is designed in such a way that by means of a targeted flow characterization or guidance an enrichment of the hydraulic oil with air or water is prevented or at least slowed down. For an optimized flow and the resulting tank design, modern simulation methods such as 3D CFD simulation are available.

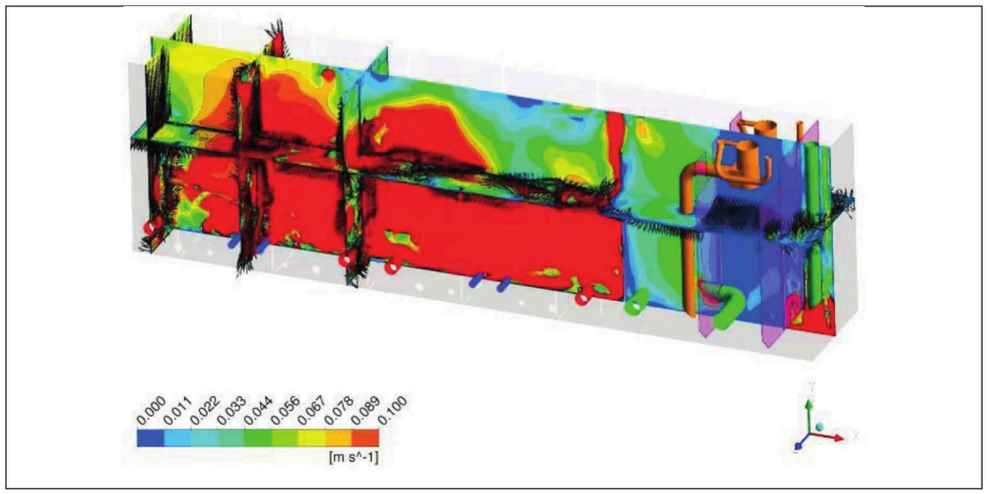

*Figure 4: Exemplary 3D-CFD-Simulation of tank interiror as an passive **myCro** measure*

The effort for the additional hardware or the intelligent tank design is often not justified, why trained and experienced sales staff carry out a corresponding initial evaluation and plausibility check. Thus, in the beginning technical discussions with the customer decisions in favor of smaller and cheaper HPU´s can be made.

Since all elements in **myCro** are modular and flexible (e.g. tank design using 3D CFD simulation, degassing module, etc.) they can be used optionally as needed, depending on the requirements of the HPU and the customer. Although the usage of further elements increases the effort - and thus the production costs - it opens up further potentials for miniaturization of the unit - and therefore a reduction of the production costs. Thus, the technical / economic optimum for each design case of the HPU can be determined individually with the customer and allows the optimal design of the hydraulic unit to the application with significantly less restriction from the above relationship between tank size and the desired oil condition. In the following the main focus areas of the defined **myCro** levels are described.

Optimized components • Standalone controlled degassing module • Sensors • Water separation module • Hydraulic components suitable for vacuum pressures	**Innovative methods and tools** • 3D-CFD Simulation • Initial assessment by **myCro**-Tools and experienced sales engineers
Effectiveness and efficiency combined By combining all the components and processes relevant to the degassing process, it is possible to optimize the hydraulic power unit in terms of tank size, oil volume and components in the shortest possible time	**Scientific knowledge and established experience** • Optimized internal tank design • Scientific investigation of air separation • Deriving customer-specific solutions • Simulation and evaluation criteria of tank design

*Table 2: Focus areas of the **myCro** levels*

For better comprehensibility and usability, **myCro** is subdivided into 3 different states of expression in which the possibilities of a reduction of the HPU are correspondingly exhausted by an increasing utilization of the individual elements of the modular engineering package.

The lowest state of expression is the package **myCro**, in which the oil tank is downsized with the least possible effort and only passive measures like described below.

myCro
• Initial evaluation of an application for oil tank downsizing by trained sales staff and supporting tool
• Passive measures (intelligent tank design) improve natural degassing to the desired level

The next or middle stage of expression is the package **myCro**$^{+}$, in which the options for reducing the size of the tank are further exploited with additional active measures like the degassing module.

myCro^{+}
• The degassing module further actively improves the oil conditioning and thereby enables even smaller power unit design
• Regulation and monitoring of the oxygen content in the operating medium

At the highest level of expression through package **myCro**$^{++}$, the additional use of the 3D-CFD-Simulation allows the possibilities of a tank reduction to be completely exhausted.

myCro^{++}
• 3D-CFD-Simulation of tank interior

4 Summary and Conclusion

Considering the technological change in industrial hydraulics towards electrification and electronification Bosch Rexroth offers with the modular engineering package **myCro** option a completely new approach for the efficient design of optimized system solutions using the latest technologies in terms of numerical methods, computational system assessment as well as newly developed fluid technologies and controls. Projects where **myCro** was implemented could achieve a reduction in tank size of up to 70% and the required floor space by up to 50% with an immediate return on investment (ROI), which underlines the efficiency of this approach.

References

/1/ The Hydraulic Trainer Volume 3, Planning and Design of Hydraulic Power Systems, Mannesmann Rexroth AG, 1988

/2/ Findeisen, D. , Ölhydraulik - Handbuch für die hydrostatische Leistungsübertragung in der Fluidtechnik, 5. Auflage, Springer-Verlag, 2006