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Hydraulic fluid power — Application notes for the optimization of the energy efficiency of hydraulic systems

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Foreword

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This document was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 9, *Installations and systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Energy consumption of machines is primarily defined by the type of machine, e.g. lathes, injection moulding machines and excavators.

Additionally, the level of energy consumption is a function of the requirements of the machine manufacturer and duty cycle and frequency of use by the operator. It is only when the machines are adapted for specific applications (e.g. working cycle, control precision, level of automation) in an optimal manner, that energy efficiency concepts can have a positive impact.

Typical applications for hydraulics in machines are:

— clamping with high force;

— pressing with high force;

— motion, acceleration and braking of heavy loads;

— hydraulic weight compensation;

— hydrostatic transmission.

Hydraulic fluid power — Application notes for the optimization of the energy efficiency of hydraulic systems

1 Scope

This document gives advice on how to conceive hydraulic systems that can be operated with increased energy efficiency while maintaining the intended functionality of the machine.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5598, *Fluid power systems and components — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

4 Goal and principal design considerations

The goal is to reduce the energy consumption for specific functions considering the demand of power input (effective, reactive and peak) of a hydraulic system and related auxiliary systems.

The more precisely the requirements and characteristics of the machine operation and duty cycle are identified, the more energy efficiently machines can be designed.

5 Measures

5.1 General

Measures for the improvement of energy efficiency are only applicable if the requirements of all relevant safety standards (e.g. ISO 12100 and ISO 4413) are still fulfilled. The following list gives examples of measures with which a hydraulic system can be adapted in an optimal way to the requirements. In this context, it has to be considered that some of the listed measures exclude each other and that they need to be selected according to their requested functionality.

5.2 Principal measures

The following list contains principle measures for the improvement of the energy efficiency of hydraulic systems.

a) Obtaining a thorough understanding of the machine's specification, functionality and duty cycle.

b) Use of assessment matrices and simulation software for an application specific optimization of hydraulic power systems:

   — extensive functional sequences can be analysed with the support of simulations to provide an optimal solution of the hydraulic system;

   — simulation of load cycles to determine the energy consumption before optimization of the hydraulic system;

   — the architectural solutions can be compared, for example, in the case of independent motions of actuators.

c) Creating awareness for energy-efficiency among employees and appliers:

   — continual development of employee knowledge and understanding about the need for energy efficiency and the ways in which it can be optimized on machine hydraulic systems.

d) Avoiding oversizing, such as actuators, as well as under-sizing, such as valves, to achieve the best possible energy efficiency throughout the duty cycle.

e) Use of displacement controls instead of throttle controls, if applicable:

   — avoidance of throttling and bypass losses.

f) Reduction of internal leakages:

   — selection of components that minimise internal leakage, e.g. by using poppet type valves rather than spool valves, if possible;

   — use of lowest leak rotary unions.

g) Selection of the correct hydraulic fluid:

   — selection of the optimal viscosity class according to the existing environmental conditions.

h) Optimisation of the thermal management:

   — where possible, sizing the tank to allow optimal thermal performance in terms of heat rejection or system warming. Trying to reduce the need for supplementary coolers and heaters.

5.3 Measures concerning actuators

The following list contains measures concerning actuators for the improvement of the energy efficiency of hydraulic systems.

a) Matching pressure level and actuators:

   — selection of actuators that are appropriate for the pressure of the hydraulic system and the application duty cycle;

   — if this is not possible, pressure adjustment via pressure-controlled drive systems (e.g. variable speed drive, pressure controlled variable displacement pumps, "Power on demand");

   — consideration of the use of pressure intensifiers where high pressure and low flow is a requirement.

b) Autonomous hydraulic load compensation:

   — application of hydraulic counterbalance systems to compensate static and dynamic loads on machine axes.

c) Selection of the most appropriate actuator for the application based on duty cycles.

5.4 Measures concerning the hydraulic power supply system

The following list contains measures concerning the hydraulic power supply for the improvement of the energy efficiency of hydraulic systems.

a) Selection of the most appropriate pump for the application based upon duty cycles, e.g. axial piston, radial piston, gear or vane pump.

b) Selection of the optimal pump control arrangement:

— different functional sequences require adapted pump systems (pump combinations, i.e. high pressure/low pressure, fixed or variable displacement pumps).

c) Selection of the optimal prime mover:

— on-demand power provision according to the load cycle (e.g. constant driving speed with intermittent duty, variable driving speed);

— application of energy efficient prime movers where appropriate;

— design of the combination of prime mover and pump for use in the operating ranges with the best possible energy efficiency throughout the duty cycle.

d) On-demand/Stand-by:

— consideration of the application of power on-demand or stand-by systems that are not under load when not required and when safety and operational requirements allow.

e) Optimization of the power drive system cooling in on/off operation mode:

— consideration of the energy consumption of power drive system cooling in design with consideration to the ambient temperature, e.g. direct or separately driven fan cooling, fluid cooling.

f) Use of accumulators:

— use of hydraulic accumulators to bridge gaps between the peak flow rate from the pump(s) versus machine requirements. This approach is preferable to having excess flow where the system flow requirements are exceeded for extended periods.

5.5 Measures concerning the hydraulic distribution system

The following list contains measures concerning the hydraulic distribution system for the improvement of the energy efficiency of hydraulic systems.

a) Reduction of power consumption of solenoid operated valves:

— power drawing only during switching processes by impulse valves (detent);

— reduced power drawing with valve connectors having built-in automatic reducers of holding current;

— reduced power consumption by using valves with low power solenoids;

— system conception and the use of normally open versus normally closed valves. System designers should consider the duration of ON versus OFF and select the most appropriate concept in terms of energy efficiency.

b) Optimal filter selection:

— to minimise the pressure losses;