STEAM-Hydraulic Design for Engine Integration

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In a project, funded by the German Federal Ministry of Education and Research, a new system for mobile machines, named STEAM (Steigerung der Energie-effizienz in der Arbeitshydraulik Mobiler Maschinen), is being developed at the Institute for Fluid Power Drives and Controls in Aachen. The aim is to improve the total system efficiency by considering all the subsystems in the machine. This is done by integrating the internal combustion engine (ICE) into the hydraulic design process. By using a constant pressure system in combination with a fixed displacement pump, the ICE experiences a constant load in a region of high efficiency, so-called point operation. An additional intermediate pressure rail with independent metering edges is used to decrease adaptation losses and enables various discrete operating states.

1 Introduction

Due to rising fuel prices and more stringent emission guidelines, mobile machine manufacturers are being forced to develop more energy efficient hydraulic drives. As a result, much research has been conducted into improving the efficiency of hydraulic components and systems. An aspect, which has received less attention, is the interaction between the different subsystems making up the machine. Only optimising the hydraulic subsystem may actually cause another subsystem to operate poorly, thereby decreasing the total machine efficiency. To avoid such negative effects, it is, therefore, important to consider the system as a whole and not each subsystem separately.

As shown in Figure 1–1, a hydraulic excavator can be divided into five subsystems: internal combustion engine (ICE), pumping unit, pressure adaptation, energy storage, and actuators. Assuming no energy is stored during a cycle, the total system efficiency should be used to characterise the machine:

\[ \eta_{tot} = \eta_{ICE} \cdot \eta_{hyd} = \frac{P_{mech}}{E_{chem}} \cdot \frac{P_{act}}{P_{mech}} = \frac{P_{act}}{E_{chem}} \]  

(1–1)

The STEAM-System has been designed to improve the total system efficiency by integrating the combustion engine into the design process. By using a constant pressure system in combination with a fixed displacement pump, the ICE experiences a