GENERAL LECTURE:

ZF VIEW ON FUTURE DRIVETRAINS FOR COMPACT AND MEDIUM SIZE WHEEL LOADERS

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1. INTRODUCTION

This paper discusses an investigation on a novel hydraulic pump concept. The idea aims on a pump principle to be directly connected to high-speed electric motors to build compact high-pressure drives. The pump can theoretically work without solid contact and has no kinematic pulsation. The composition of the pump is basically similar to cylindrical journal bearings. A journal bearing is used to support external loads on a rotating shaft. When the shaft rotates with the loads, hydrodynamic fluid force is generated in the fluid film, which compensates the external force and reduces an eccentricity of the shaft. The difference of the introduced pump concept from the bearing is that the eccentricity is fixed and it has an outlet port at the high-pressure area, through which the fluid can be transferred. To examine the functionality of the pump, a test bench is constructed and experiments are performed to investigate the pressure build-up and discharging flow of the pump concept. The experimental results are numerically analysed by using elasto-hydrodynamic lubrication (EHL) simulation, based on the Reynold's equation. From these results, the functionality of the pump concept is confirmed. Moreover, several variables that influence the characteristic curve of the pump are studied. Based on these results, geometric parameters of the pump are redesigned to discharge sufficient flow rate for usage as commercial pumps.

2. ZF STUDY ON FUTURE DRIVE LINES FOR WHEEL LOADERS

ICE will continue to be the primary mover for

small, medium and large construction equipment. Energy portfolio will be enlarged by Gas, eFuels,... Hybrid Topologies do not offer enough additional value. Reduction in fuel consumption by adding hybrid components to highly efficient conventional drivelines like power shift with higher number of gears and lockup converter, or power split transmissions is too small vs. cost (TCO).

With increasing energy density, continuously reduce cost and lower energy generation cost due to renewables, batteries will become an optional primary mover for more and more applications. Vehicle topologies will remain unchanged since conventional and alternative drivelines need to be realized on one platform to manage complexity and maintain scale effects.

For wheel loaders the central drive connected to front and rear axle is the most beneficial solution. Other architectures like axle drives, or individual wheel drives would need to be oversized because during bucket filling max torque is required on the front axle.

3. PRODUCT STRATEGY ON ELECTRIFICATION

So far, no legislative pressure on CO₂ emissions for Off-Highway, corresponding initiatives ongoing with scope and timing still undefined. Focus of municipalities on 0-Emission Zones in urban areas will drive the trend towards "Electrified Urban Construction Sites". Electrification is key to meet local exhaust and noise emission regulations. However, the path to electrification is not disruptive but a diversification - Different driveline solutions will co-exist, which leads to increased complexity of product portfolio. Commercially viable solutions are pre-requisite, technology by itself is not

enough. Lower entry barrier for 48V solutions. Electrification will start on compact applications. Medium applications will follow with a time shift of approx. 5 years.

4. SOLUTION FOR COMPACT WHEEL LOADERS (4 – 8 T EMPTY VEHICLE WEIGHT)

Central drive with single speed with two helical gear sets. Asynchronous E-Motor (ZF design), cost effective, high speed (15,000 rpm), water cooled. Central drive transmission directly mounted to standard compact wheel loader axles. Max. vehicle speed 20 km/h. Goal for tractive effort / weight factor 0,80.

Goal for E-Motor development was max. power out of 48V systems and a cost-effective solution. Permanent power level of 20 kW can be reached.

E-Motor as modular construction kit with constant diameter. Depending on power level only length of E-Motor will change. Same sheet metal cutting for all versions, but different wiring depending on voltage level.

Above 48 V the 96 V is interesting, mainly because of lower cost for power electronics (MOSFET vs. IGBT). For high power solution we see a voltage level of 650 V.

5. SOLUTION FOR MEDIUM WHEEL LOADERS (10 – 20 T EMPTY VEHICLE WEIGHT)

Also, in this weight class the central drive will be the preferred solution for ZF. We work on a system solution with integrated eDrive and ePTO incl. control system. Specification for system solution at lower and upper end of medium wheel loader range is ongoing.