CONCEPTS OF ENERGY EFFICIENT ELECTRIFIED CTL FORESTRY MACHINES

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ABSTRACT

For forest materials to be sustainable the harvesting needs to be performed with a fossil carbon footprint that is as small as possible. In Swedish forestry the fuel consumption per volume of material has not changed significantly in the last decades. This pilot study has investigated what technologies are available today that can be implemented to improve the energy efficiency of forest machines. The aim has been to inspire our own research group and the research community to identify research topics in this area. Several different aspects have been considered such as energy carriers, energy conversion to mechanical work, energy distribution on the machine and the losses in different processes. A detailed analysis of the use of hydraulic functions was performed on data from a machine simulator, combined with modelling and fuel consumption statistics to describe energy use and estimate the effect of alternative machine designs. With the goal of reduced carbon footprint in mind we have formulated several machine concepts with existing technology of which some are unconventional in forestry machines. The concepts are based on final felling harvesters and forwarders and are meant to be functionally equivalent. The difference in components, energy use and cost between the concepts and conventional machines have been analyzed using life cycle assessment methodology. One significant source of energy loss is in the current hydraulic systems is the simultaneous use of several functions with different pressure and flow demands. To address this modern hydraulic pump are incorporated into the concepts. The energy that is needed for useful work is highly variable between and within work elements. This means the internal combustion engine needs to constantly be kept at a high speed and power capacity to meet sudden demands of high power. The internal losses of the combustion engine and the fact that it frequently delivers a low degree of useful work compared to its capacity are significant sources of energy waste. To address this the concepts are suggested to be either serial hybrid battery electric or fully battery electric. Electric motors are highly efficient and are better suited to handle sudden variations in load as they don't need to be kept at idle. Another advantage of electricity is that it can be distributed on the machine with less losses compared to hydraulic pressure. This can be used to provide energy to the harvester head where significant losses occur from the long distance to the pump. Serial hybrid electric concepts use a combustion engine to charge the battery which in turn powers electrical motors that power the drive train and hydraulic pumps. The efficiency advantage in a hybrid concept is that a smaller engine can be used to charge at its point of optimum efficiency and only need to be in use intermittently. One advantage of a hybrid machine over battery electric is that fuel distribution to the harvesting site is already established. For fully electric concepts the battery size and weight become significant factors and energy distribution to the site a challenge.

Keywords: hybrid, battery, electric, forwarder, harvester, energy, efficiency