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Research on a Control Strategy of Power System in Hybrid Hydraulic Excavator

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Hydraulic excavator which is most widely used among the construction machinery requires application of hybrid technique actually because it consumes a large amount of energy and its efficiency is comparatively lower. From these reasons, many researches have been done to solve the problems occurred in introducing hybrid technique in hydraulic excavators. Unlike the conventional hydraulic excavator, in the hybrid excavator, the engine operates in almost high–efficiency working region during the whole operation because of the coordination of two energy sources, the change of power occurred by the change of load is compensated by the dynamotor and energy storing device, therefore the engine can more effectively operate than a conventional excavator.

The simulation model of the hydraulic excavator was built by using MATLAB, and energy loss of each operating part was obtained. The energy loss in the main direction valve is about 36%, and occupies a lot of part in total loss. Meanwhile the energy loss in the check valve and the sequence valve also occupy a greater part (about 17–19%), and mainly occurs in the swing hydraulic system. This part of the energy loss can be removed by improving the structure of the hydraulic system. Therefore the energy saving hydraulic system which is suitable for the hybrid excavator is proposed.

The hybrid power controller consists of five controllers that are the main controller, the engine controller, two dynamotor controllers and the super capacitor charge–discharge controller.

Two hybrid excavators selected from the simulation are considered. In order to reduce the additional cost due to the hybridization, the conventional hydraulic system is changed into hydraulic system with two variable displacement piston pumps and closed oil tanks. In two kinds of the hybrid excavators, for comparing the energy saving effectiveness, the models of the loads attached to boom, arm, bucket and swing body were obtained respectively, and the opening of the flow speed control valve of the engine and the voltage changing of the capacitor under the same power control strategy were simulated.

From the simulation results, the average opening of the flow speed control valve is 0.8 in the parallel hybrid excavator and 0.54in the compound one. This shows that the energy saving effectiveness in the compound becomes 32.5% higher than the parallel.

Because the efficiency in the driving mode of the swing body by a dynamotor is much higher than a hydraulic motor, in the hydraulic excavator, the energy saving effectiveness became 32.5% higher and the rated power of the engine became 33% lower than the compound hybrid excavator. Also power components such as a dynamotor and a converter are added instead of the hydraulic system for driving the swing body. Therefore, the result is that it is appropriate to introduce the energy–saving hydraulic system and the compound hybrid system with direct driving the swing body by a dynamotor into the hydraulic excavator produced at nowadays.