Chapter 13
Overview and Optimized Design for Energy Recovery Patents Applied to Hydraulic Systems

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ABSTRACT

Due to their large application quantities with extremely low efficiency, pollutant emissions, high fuel consumption, and oil price, researches on the environment protection and the energy saving of construction machinery, especially hydraulic excavators, become very necessary and urgent. In this chapter, the authors proposed a complete study for the excavators' hydraulic energy recovery systems. This study is divided into two parts. In the first one, an overview for the energy saving principles is discussed and classed based on the type of the energy recovered. In the second part and once the energy recovery system is selected, the authors proposed a new approach to design the energy recovery system under a typical working cycle. This approach, the global optimization method for parameter identification (GOMPI), uses an optimization technique coupled with the simulated model on simulation software. Finally, results concluded that applying GOMPI model was an efficient solution as it proves its accuracy and efficiency to design any energy recovery patent applied to hydraulic systems.

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INTRODUCTION

The excavator is a machinery dedicated to long-time and high-power work. Its load power varies periodically in a large range that's why the working condition of the engine changes periodically too. The output power's variation of an excavator in digging working condition is shown in Figure 1. Due to these fluctuations, engine cannot always remain in a high efficiency state and results to energy losses and high fuel consumption.

Furthermore, the energy loss in the hydraulic system mainly refers to the losses of pressure and flow of the oil. In a typical working cycle, when lowering, the fluid draining from the actuator chamber of the excavator's arm to the tank has a pressure greater than the pressure of the fluid already within the tank. This fluid still contains some energy that is wasted upon entering the low-pressure tank.

When slewing stoppage, the fluid draining from the hydraulic motor of the excavator's turret to the tank still contains some energy, since the pressure of the fluid is much greater than the pressure within the tank.

Normally, the wasted energy is lost as heat energy on the surface of excavator's components. This heat increases the components' temperature and accordingly reduces their lives (Weidong et al., 2011). Moreover, energy is too valuable to waste and reducing fuel consumption directly leads to reduced emissions of global warming gases as well as costing the customer less in fuel.

In this study, we treat the energy saving systems applied on hydraulic systems and their optimized design.

In section 2 we present an overview on the energy recovery systems. Following that, and in order to design an excavator's energy recovery system, a new approach (GOMPI) is proposed then applied in section 3. The conclusions are given in the last section.

OVERVIEW ON ENERGY RECOVERY SYSTEMS APPLIED ON HYDRAULIC SYSTEMS

A lot of researches have been reported during the last two decades in the field of energy saving in heavy goods vehicles. USA, Europe, and Japan have spent a huge amount of capital on related projects and many valuable results are now available and can be used to provide solutions for construction machinery. Some studies tend to save the wasted energy in storage devices, some tend to optimize the whole system; some automate the machine and some change completely the hydraulic circuit.

Due to a wide variety of energy recovery principles and type of storages, it was thought to divide these solutions into five categories: 1) potential energy saving; 2) kinetic energy saving; 3) hybrid systems; 4) system's control and automation; and 5) non-conventional machinery. Then each category, in turn, was divided into subcategories respecting to the type of the storage device. To recover the potential energy, we propose three subcategories: a) storing the energy in storage devices (hydraulic, electrical and hydro-electric storage devices); b) sharing power between actuators; and c) storing the energy in a hybrid system that combines the two subcategories a and b. To recover the kinetic energy, we present one subcategory based on storing the energy in storage devices (hydraulic, electrical, and hydro-electric storage devices). The third category contains each solution that combines potential and kinetic energy recovery. The category four is divided into two subcategories: control of the system and automation of the machinery. Category five only contains the non-conventional systems.