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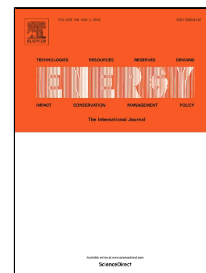
Potential energy directly conversion and utilization methods used for heavy duty lifting machinery<sup>1</sup>

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# Potential energy directly conversion and utilization methods used for heavy duty lifting machinery

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**Abstract:** Hydraulic driven heavy duty lifting machinery is widely applied in mobile machinery. In traditional systems, the gravitational potential energy (GPE) is usually dissipated as heat through the throttling effect of the control valve, resulting in huge energy waste. To address the above issue, this paper proposes two direct GPE recovery (GPER) solutions based on hydraulic-pneumatic energy storage (HPES) principle. For system driven by double hydraulic cylinders, an independent HPES hydraulic cylinder is added to the system. For system driven by single hydraulic cylinder, the HPES is integrated into the original single rod hydraulic cylinder, functioning as a storage chamber. In both schemes, the HPES hydraulic cylinder or chamber is directly connected to an accumulator. With the self-weight of the lifting machinery is balanced by the precharge pressure of the accumulator, the GPE and hydraulic energy can be directly converted mutually. Both schemes have been analyzed in detail. Experimental prototypes have been constructed based on one 76-ton and one 6-ton hydraulic excavator. Experimental results indicate that as compared to the original system, 49.1% GPE recovery rate and 26.2% energy consumption reduction per operation cycle can be achieved for the 76-ton excavator. For the 6-ton excavator, the GPE recovery rate reaches 70.9% and 44.4% energy consumption reduction rate can be achieved for each operation cycle. Besides hydraulic excavator, the proposed solutions can also bring significant energy saving for all other lifting machinery.

**Keywords:** Hydraulic excavator; hydraulic-pneumatic energy storage; three-chamber cylinder; gravitational potential energy recovery

## 1 Introduction

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