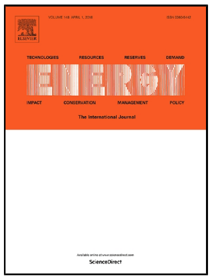
Accepted Manuscript



A new type of hydrokinetic accumulator and its simulation in hydraulic lift with energy recovery system

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PII:	S0360-5442(18)30644-3
DOI:	10.1016/j.energy.2018.04.040
Reference:	EGY 12679
To appear in:	*Energy*
Received Date:	24 July 2017
Revised Date:	08 March 2018
Accepted Date:	07 April 2018

Please cite this article as: Waldemar Latas, Jerzy Stojek, A new type of hydrokinetic accumulator and its simulation in hydraulic lift with energy recovery system, *Energy* (2018), doi: 10.1016/j. energy.2018.04.040

A new type of hydrokinetic accumulator and its simulation in hydraulic lift with energy recovery system

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ABSTRACT

The article presents a model and a simulation study of a new type of hydrokinetic accumulator with increased energy storage density. The basic elements of the accumulator are: a flywheel of variable moment of inertia (due to inflow or outflow of hydraulic fluid) and a variable displacement pump/motor. The first part of the article describes the construction and operation principles of the developed accumulator with three specified work modes. A mathematical model of the presented hydrokinetic accumulator and its simulation in a hydrostatic lift system with energy recovery are given. The results of the numerical simulations carried out during charging and discharging of the accumulator (i.e. values of the stored kinetic and potential energy and chosen working parameters) are presented. It is shown that, due to energy storage and extraction, in both hydrostatic and rotating kinetic domains, charging and discharging may be decoupled from pressure level. Additionally, the accumulator has the ability to control the pressure in the hydraulic system. An example of the control algorithm is also presented in the paper.

Keywords: hydrokinetic flywheel-accumulator, hydraulic energy storage, energy recovery, hydraulic hybrid, variable displacement pump/motor, hydraulic lift

1. Introduction

The possibility of recovering and storing energy in modern machines and devices constitutes an important technological problem which should be taken into account at the designing stage as well as during further maintenance. Energy stored in various forms, e.g. mechanical (flywheel), electrical (batteries), or hydrostatic (hydraulic accumulator) can originate from both maintenance excess and its recovery during device operation. The most important properties of the stored energy are easiness of its reuse, total obtainable amount (energy density), and its ability to be implemented in short intervals of time (power density).

Hydrostatic energy storage is an important problem given its frequent occurrence in many systems of machines and devices (e.g. hydrostatic drives of vehicles, hydraulic systems of heavy construction machinery, or systems of presses and lifts). The energy recovery in these types of applications can occur during vehicle braking, releasing working elements of machines from loading, or during swings of executing members of devices.

Currently, a generally applied component for storing hydrostatic energy is a hydraulic accumulator which stores potential energy of a gas, typically nitrogen, compressed by the addition of a hydraulic fluid (e.g. oil, hydrostatic emulsion) to the chamber. There are three types of hydraulic accumulators, commonly used in industrial and mobile applications, which differ in terms of the way in which the gas is separated from the fluid: by a piston, a bladder, or a diaphragm [1,2].

Hydraulic accumulators have an exceptionally broad range of applications and are basic components supplying means of controlling performance of hydraulic systems. The applications may be found in: construction machines, mining equipment, agricultural machinery, machine tools, wind power plants, hydrostatic drives, forklifts, presses, transportation vehicles, winches, etc. Hydraulic accumulators can perform the following tasks: compensation for pressure loss due to leakage, providing support for pump delivery flow, holding auxiliary power, supplying emergency power, energy recovery, damping of vibrations, or mechanical shock absorption [1,2].

The tendency for a continuous improvement of energy efficiency leads to the increased use of hybrid solutions. Hydraulic accumulators may be components of hybrid drives, serving