Position Control of Direct-Driven Hydraulic Drive without Conventional Oil Tank for More Electric Aircraft

03/02/2015

Auteurs : Tatiana Minav, Matti Pietola
Publication MEA 2015 More Electric Aircraft
OAI : oai:www.see.asso.fr:10638:20147
DOI :

- Accès libre pour les ayants-droit

MEA 2015 More Electric Aircraft

Abstract

Collection

Authors
Ces dispositions s’appliquent également aux figures, illustrations, logos ou images.

**Publication externe des contenus du portail des publications**

Tout extrait des contenus du portail destiné à être utilisé dans des publicités, des communiqués de presse ou du matériel de promotion nécessite un accord préalable écrit de la SEE. Une version préliminaire du document proposé contenant ces extraits doit accompagner chacune de ces demandes. SEE se réserve le droit de refuser un tel usage externe pour quelque raison que ce soit.

**Responsabilités**

La SEE apporte tout le soin possible à la préparation des informations délivrées dans les contenus produits. Cependant elle ne peut être tenue pour responsable d’aucune perte ou frais qui pourrait résulter d’imprécisions, d’inexactitudes, d’erreurs ou de possibles omissions portant sur des informations publiées, ni des résultats obtenus par l’utilisation et la pratique des informations délivrées.

**Utilisation des informations recueillies lors du téléchargement de contenu**

Le portail des publications est susceptible d’utiliser des « cookies » afin notamment de permettre l’utilisation de paniers d’achat et de personnaliser les parcours sur le site. SEE se réserve la possibilité d’utiliser les informations recueillies lors des téléchargements pour ses besoins internes et notamment pour l’amélioration de ses services, sans qu’elles puissent être cédées à des partenaires commerciaux. Conformément à la loi “informatique et libertés” du 6 janvier 1978, chaque utilisateur du portail dispose d’un droit d’accès et de rectification aux informations qui le concernent. Pour exercer ce droit, les utilisateurs doivent s’adresser à SEE – 17 rue de l’amiral Hamelin – 75783 Paris Cedex 16, par simple lettre ou en utilisant le formulaire de contact disponible sur son site.

Paris, le 28 avril 2013

---

**Sponsors**

**Organizers**

---

**Sponsors**
Position Control of Direct-Driven Hydraulic Drive without Conventional Oil Tank for More Electric Aircraft Tatiana Minav(1), Matti Pietola (1) 1 : Aalto University, School of Engineering, Department of Engineering Design and production, Fluid Power, Finland Abstract The direct-driven hydraulic drive (DDH) combines the advantages of compact high power of the hydraulic system and flexible control of the electric motor. This paper investigates the direct-driven hydraulic setup for MEA application. In the proposed setup, the speed and position control of a double-acting cylinder is implemented directly with a Synchronous Torque Motor drive in a close-loop system without conventional control valves and oil tank. In relation to this, hydraulic accumulator is employed as a replacement of the conventional oil tank. On this research only single feedback is applied from motor’s rotor encoder for position and speed control of this closed-loop system. As a result, excellent control capabilities of a modern electric drive brings along safety functions and monitoring capabilities of the motor and controller to benefit the hydraulic system. The system is investigated by means of measurements. Introduction Similar to the automotive industry the aerospace industry is facing challenges in terms of improving emissions, fuel economy, and also cost. The increasing use of electrical and electronic features to improve performance, fuel economy and safety has already resulted in the growth of electrical proposals in both industries. Electrically powered control systems, electrical actuators, and electric de-icing are some examples of the aircraft systems under consideration. Low-power electrohydraulic compact drives are needed in automotive and aerospace industry. It needs to meet user requirements in terms of compactness and energy and cost efficiency. Therefore, the implementation combines the advantages of electric motor drive and reduction of hydraulic components. Using of a single rod cylinder creates additional challenge, as difference between cylinder’s areas creates unequal volume flow. Balancing the volume flow is disclosed in a number of publications (1-5). Previous research showed that hydraulic circuits’ modifications include complicated valve logic and/or variable-displacement pumps, for instance, in the following applications: power steering (6, 7), industrial press (8 -10) and non-road mobile machines (11-13). Removing of the conventional oil tank is common in airplane applications, where weight and size reduction is very important (14-16). Therefore, in this paper, direct-driven hydraulic setup (DDH) as a pump-controlled system is investigated without conventional oil tank to achieve a compact and efficient solution. Figure 1 illustrates the proposed ideal test setup. Fig. 1. Proposed Ideal test setup The working principle of proposal structure can be described as follows: A speed-controlled electric servo motor drive rotates a hydraulic pump to directly control the amount of hydraulic oil pumped into the system and at the same time, hydraulic motor pumped out oil from the second side of the double-acting cylinder. The hydraulic pump and motor create a flow depending on the rotating speed of the servo motor. Hydraulic accumulator is used as a conventional tank replacement. The remainder of this paper is organized as follows. Section 2 describes the realization of setup, schematics of the system and the components employed. Section 3 shows empirical results and analysis. Section 4 contains concluding remarks. Realization of test setup From Figure 1, displacement of pump/motor units should match cylinder dimensions. As a double-acting cylinder MIRO C-10-60/30x400 A-55 was applied, strict demand for choosing pump/motor of ideal pump ratio \(R_{\text{ideal}}=0.75\) was created. From Bosch Rexroth catalogues to match pump ratio following components were chosen: AZMF-12-AZMF 011U and 008U hydraulic pumps (17) with displacement of 11 \(\times 10^{-6}\) and \(8 \times 10^{-6}\) m \(^3\)/rev, respectively. Therefore, real pump ratio \(R_{\text{real}}\) becomes equal to 0.73. Based on the difference between ideal and real ratios proposed setup were realized with modifications as shown in the simplified schematics Figure 2. In this case of single rod cylinder combined with a pump-speed control, the challenge is to manage the unequal volume flows of the cylinder. The balancing volume flow caused by the rod has to be charged or discharged to accumulators, depending on direction of the motion. Hydraulic accumulator A (Figure 2, l) is applied as a conventional tank replacement. Hydraulic accumulator B (Figure 2, g) used as for flow balancing. Both accumulators manufactured by Parker were employed in test setup (18). The setup uses a speed-controlled electric servo motor IndraDyn T and a frequency converter IndraDrive manufactured by Bosch Rexroth (19, 20). Motor rotates two hydraulic pump/motors. This allows direct position control of double-acting cylinder. The frequency converter uses motor feedback system SEK90 by Sick (21) which mounted directly on the drive shaft and offers an accurate speed control in the test setup. Fig. 2: Simplified schematics of test setup: a) double-acting cylinder, b) wire-actuated encoder, c) pressure sensor, d) reversible gear