UNIVERSITY OF MISKOLC
FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

CAPACITY CHANGES OF ALTERNATING CURRENT HYDRAULIC DRIVE IN THE USE OF FLEXIBLE PHASE PIPE

Booklet of PhD Theses

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1. INTRODUCTION

Man has been preoccupied since ancient times to create the conditions for himself to make a living. Over time, based on the personal and ancestral experiences of his ancestors, he sought to develop the means necessary for his livelihood in all areas, thus saving the effort of human strength in order to achieve his goals.

The 20th century can be considered an era of scientific, technical, health and social development. We can also refer to it as the age of world wars, which also had innumerable consequences for posterity. The mechanization of production and services began in the 19th century, and the construction of global communications networks continued at an ever-accelerating pace in the 20th century. In this century, all areas of life have fundamentally changed and the whole of human society has changed considerably.

The development of hydraulic and pneumatic technology is due to this process. Hydraulic and pneumatic technology has undergone an explosive development in the 20th century because it has been essential for various industries to increase the level of technology in terms of productivity. The rapid mechanization and automation of production processes, the increasing complexity of the kinematic design of machines, and the need to increase transmitted power have placed increasing demands on energy transmission and control. Different energy transmitters can be used for the mode of energy transmission. The selection of the appropriate energy transmission technology is based on different criteria and should be compared with the specific characteristics of the energy transmission modes, which may limit their scope. The use of a liquid energy transfer medium, the simple change of the characteristic parameters of the transmitted energy (force, torque), the simple protection against overload and the extremely high specific power make the hydraulic systems suitable for the fulfillment of highly and rapidly changing requirements.

After the Second World War, developments that were still secret at the time became more and more widespread in various fields of industry in addition to military technology. In the most developed countries of the world, companies manufacturing special elements have increasingly appeared and developed. Manufacturing plants specializing in a particular product type began to become more widespread, making it possible for suppliers to become large companies.

Due to the high-power density of hydraulics, there is a saying in the 20th century that:

"Hydraulics is the muscle of the 20th century, electronics is the brain."

Towards the end of the 20th century, with the advent of increasingly modern mechatronic systems, computer control also came to the fore with the use of electrohydraulic components.

The choice of the topic of my dissertation is due to the untapped potential of hydraulic systems.

2. OBJECTIVES

In the course of my research, my primary task was to design, fabricate, and operate an experimental equipment for a synchronous alternating current hydraulic drive. This was necessary primarily because little equipment was implemented on the subject and, accordingly, many questions were not yet satisfactorily answered. In most alternating current experimental drives, the transmission of hydraulic energy in the phase spaces was performed using rigid phase lines and their role was not discussed in detail. In the phase chambers of my new synchronous experimental equipment, after I also operated with pistons, I also used diaphragms on an experimental basis to eliminate the gap losses, as there was considerable gap between the cylinder and the piston. My next task was how to replace the rigid phase wires with flexible pipes. In the course of my research so far, the question has arisen as to what extent the temperature of the oil changes during operation, but no measurements have been performed before me in this regard. During my work, I have tried to examine these questions thoroughly in order to get a detailed picture of the properties of the drive, and to answer points that have arisen in previous research on alternating current drives but have not been examined.

To achieve this goal, I have completed the following steps:

a thorough review of the foreign and domestic literature, especially in the field of alternating current hydraulics;

placement of alternating current hydraulic drives in the mechanical sciences as a field of research;

design and construction of experimental equipment, taking into account the shortcomings of previous designs, which can be operated with both rigid and flexible elements;

allowing temperature, capacity, torque and pressure values to be measured on the experimental equipment (at idle and load conditions of the drive) so that the most important parameters can be examined simultaneously;

evaluate and summarize the measurement results and compare them with pre-defined relationships;

investigation of the development possibilities of the synchronous alternating current hydraulic drive.

3. INVESTIGATION OF ALTERNATING CURRENT HYDRAULIC DRIVE

Hydraulic drives can be grouped in several ways. Based on the electrical analogy, we distinguish between direct current and alternating current hydraulic drives.

In the literature, hydraulic systems in general are understood to mean direct current hydrostatic drives, which have a wide scope, but a special branch of this is the alternating current hydraulic drive, the literature of which is rather scarce. This has been little studied, so I will provide a link to this, in addition to the research results so far.

In order to be able to measure the operating conditions and properties of a synchronous alternating current hydraulic drive, I had to create an experimental device. Figure 1. shows the 3D CAD model of the experimental equipment designed during my research. Regarding the structural design of the hydrogenerator (and in this case the hydromotor), I chose the construction with a radially arranged phase space, because we were able to achieve this most accurately in our workshop in terms of manufacturability.

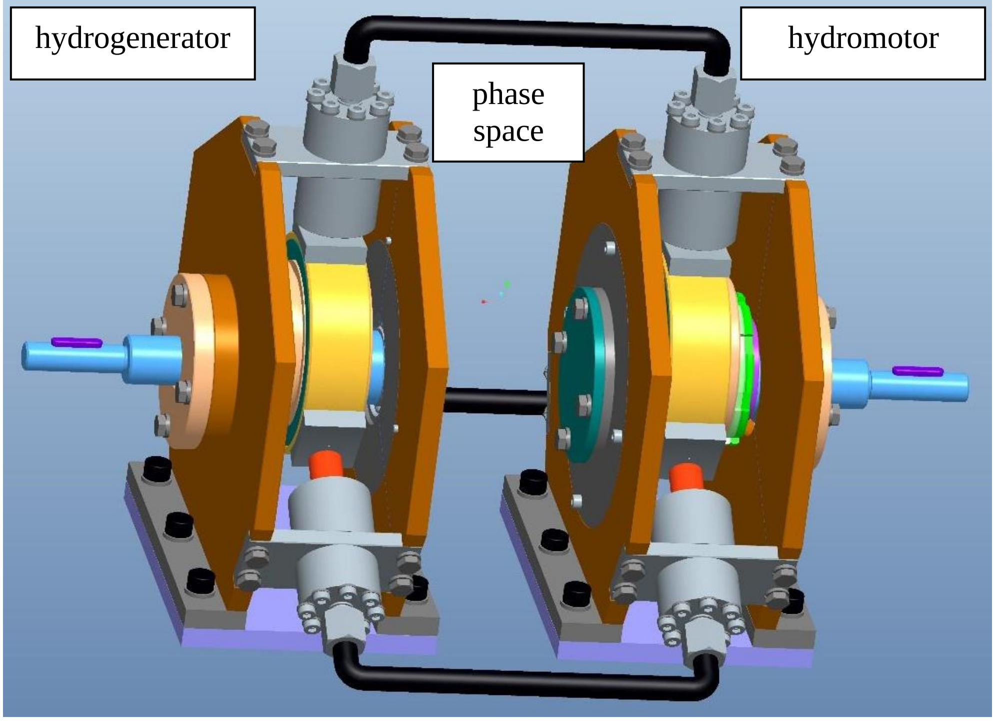

Figure 1. The 3D model of synchronous alternating current hydraulic drive in PTC Creo version 3.0.

After drawing the model, I also made the workshop drawings, based on which the individual parts were made. The experimental equipment required for the testing of the synchronous system alternating current hydraulic drive was prepared in the workshop hall of the Department of Machine Tools of the University of Miskolc. The design of synchronous alternating current hydraulic drives can be of several types. One of the main considerations I have considered in the design is how the alternating current fluid flow can be implemented. In the case of alternating current systems, I had to produce the movement (pulsation) of the liquid column, because it is used to transfer the hydraulic energy between the hydrogenerator and the hydromotor. Since the piston of the hydrogen generator and the hydraulic motor are subjected to the same amount of force, it can be examined together in the case of a synchronous system. A photograph of the equipment constructed is shown in Figure 2.

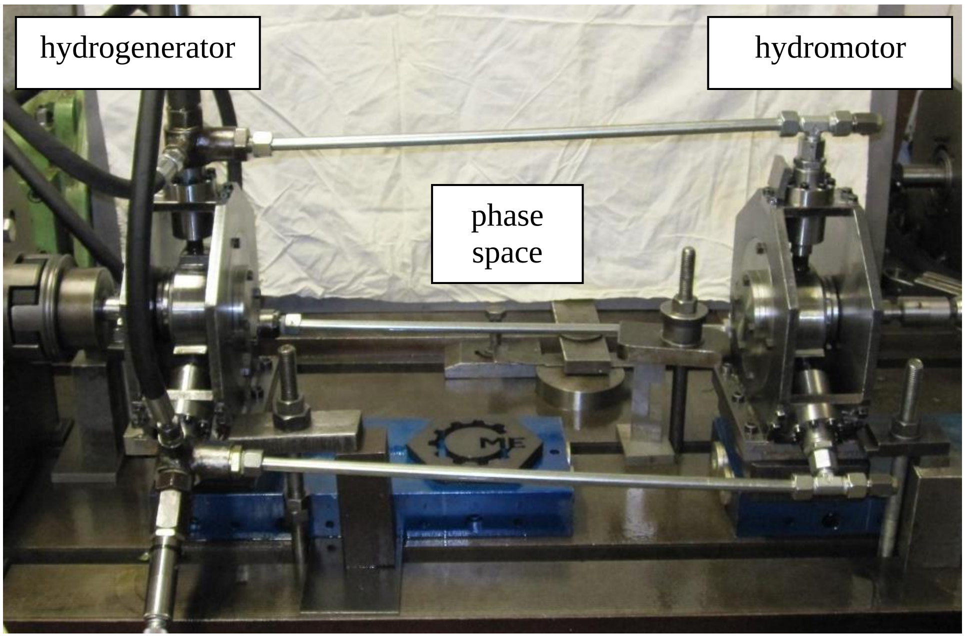

Figure 2. Experimental equipment for a synchronous alternating current hydraulic drive with rigid phase lines.

This type of drive can also be called a flexible shaft (this name is independent of the phase space material), as the unit of the hydrogenerator and the hydromotor allow the connection of shafts relatively close to each other in any space without torque or speed change.

In the experimental equipment, the rigid phase lines can also be replaced by flexible hydraulic lines. When using a flexible line, a drive with different properties is obtained, as the use of flexible phase lines affects the operation of the system. The experimental measurements were performed on the experimental equipment with the flexible phase lines shown in Figure 3. and on the versions equipped with the rigid hoses shown in Figure 2.

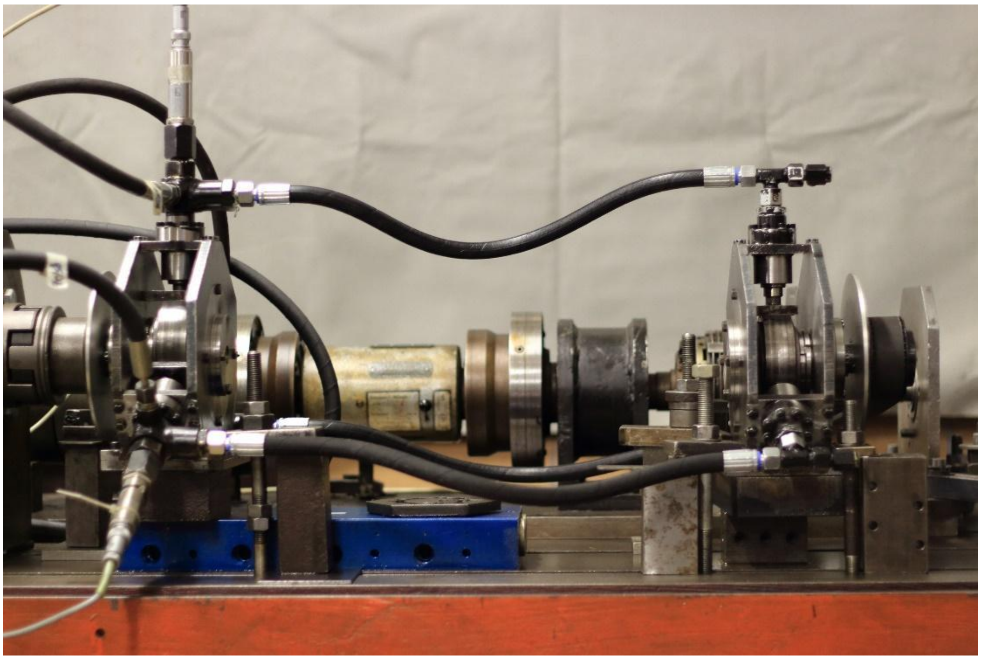

Figure 3. Experimental installation of a synchronous alternating current drive with flexible phase lines.

The aim of my measurements on the experimental equipment I have carried out is to get to know the operating properties of the synchronous, alternating current hydraulic drive, the relationships between the theoretical torque and the speed characteristics, both in the case of rigid and flexible phase spaces.

With the assemblies described above, I was able to determine the most important characteristics of the gear unit, the speed and load capacity of the hydromotor, and their correlations with the help of the appropriate measuring instruments. The arrangement of the measuring instruments is shown in Figure 4.

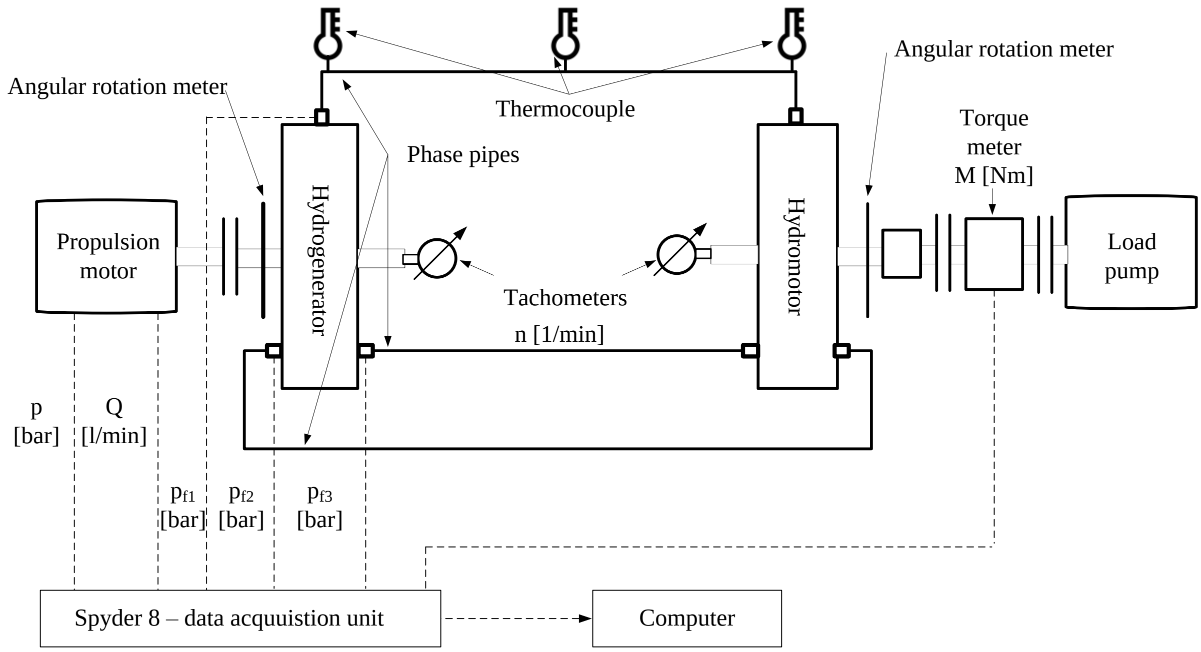

Figure 4. Location of measuring equipment used for experimental equipment.

4. NEW SCIENTIFIC RESULTS – THESES

T1. I proved with theoretical calculations and also confirmed with measurement results that the unequal load makes the operation of the alternating current synchronous drive unstable and then inoperable. Synchronous drive is a special case where the speed of the hydrogenerator and the hydromotor are the same, that is $n_g = n_m$. Hence, it can also be called a flexible axis.

T2. I proved by experiments on an experimental device that, in contrast to the alternating current (synchronous system) hydraulic drive with a rigid (steel pipeline) phase space, the alternating current (synchronous system) hydraulic drive with a flexible (hydraulic hose) phase space at the same settings (same speed of the drive direct current hydraulic motor and the stroke length of the phase pistons), it falls out of synchronism first, that is the load angle (the angle between the hydrogenerator and the hydromotor) is smaller.

T3. I proved theoretically and then proved with two types of measurement arrangements that the phase conductors are present in the system as capacitive resistors. That is, with an increase in pressure, energy is stored, which is returned to the system in the event of a pressure drop (in the case of the sinking position of the given phase).

T4. With the results of the measurements I proved that in the case of the alternating current, synchronous system hydraulic drive, the oil in the phase space does not heat up significantly, even under the effect of load. This is because the high degree of oil heating is caused primarily by fluid friction, but due to the slight displacement of the oil in alternating current systems, the parabolic flow pattern characteristic of a direct current system cannot be formed.

5. List of publications related to the topic of the research field

A peer-reviewed article published in a foreign journal

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[FT 2] Fekete, T.: Alternating Current Hydraulic Drive the Possibility of Applying in the Automotive Industry - Vehicle and Automotive Engineering, page:49-57, Springer International Publishing AG, ISBN: 978-3-319-51188-7, 2017

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Scientific publication, conference publication in Hungarian language

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[FT 14] Fekete T.: Háromfázisú váltakozó áramú hidromotor fázistereinek csillag- és delta kapcsolása és ennek konstrukciós kérdései. XXX. OTDK, oldal: 324, Baja 2011.

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An article in a foreign language that is published in a foreign journal

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