INVESTIGATION OF THE ASYNCHRONOUS ALTERNATING CURRENT HYDRAULIC (A-ACH) DRIVE

Erdelyi Janos, assistant lecturer, University of Miskolc
Dr. Lukacs Janos, retired associate professor, University of Miskolc

ABSTRACT

At the Department of Machine Tools of the University of Miskolc it means a several-decade theoretical and practical research to examine alternating current hydraulic drives. As the result of the research, studies, dissertations and inventions have been created (among which the patent on regulated asynchronous alternating current hydraulic drives with extra ignition torque is of outstanding significance) Recently, the final version of the asynchronous alternating current hydromotor (A-ACHM) operating according to the principle of electric alternating current asynchronous motors has been patented. In the present study we made calculations on the mathematical model of the driving process in order to define the pressure and speed characteristics of the fluid flowing in the pipelines. We completed the theoretical calculations with measurements, where we defined the characteristics of the neutral gear drive along with differing adjustments.

1. INTRODUCTION

At the Department of Machine Tools of the University of Miskolc it means a several-decade theoretical and practical research to examine alternating current hydraulic drives. The novelty of the drive, that the alternating current operates one way rotating elements but not linear moving pistons. The losses of the phase-spaces that include the rotating elements cause, the extra low rev (0,001 – 0,01 rpm) have realized more complicated then the phase-spaces with pistons. But the drive can operate at higher revolution (500-600 rpm) easily.
As the piston operated, the rotating element drive can also be controlled stepless. The controlling have realized by setting the frequency or the amplitude of the phase-flow. In the paper we want to demonstrate the mathematical-fluid mechanics model of the drive, the pilot model and the measuring results. These results can discuss and estimate by the analogy of the electrical asynchronous drives.

2. THE A-ACH PILOT MODEL

The alternating current hydraulic generator (ACHG) produces pulsing, sinusoidal phase-flow in the phase-pipelines to operate the alternating current hydromotor (ACHM). The operating element which exciting the piston of the ACHG is being divers (e.g.: crankshaft, periodic disks, like eccentric- and ellipse-wheels). The kinematic scheme of the A-ACH drive can be seen on Fig. 1.

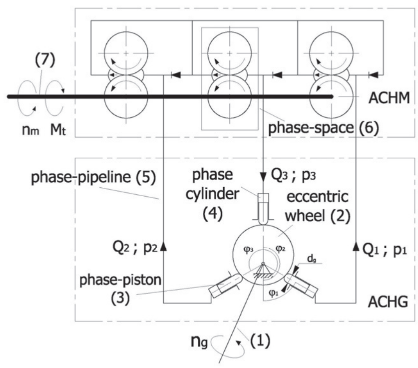

Fig. 1. Asynchronous alternating current hydraulic drive (kinematic draft)

Along the project we have made the pilot model of the A-ACH drive. The ACHG of the pilot model has an eccentric exciting element. The shaft of the ACHG is driven by a direct current hydro motor. By the applying a direct current hydro motor simply can be enable the frequency controlling by the setting of the driving flow. We can also set the amplitude of the phase-flow with a double eccentric wheel when the drive is standing.

3. MODELLING THE FLOW IN THE PHASE-PIPELINES

In the model we handle the phase-flow like a non-stationary, one-dimensional, flexible fluid in flexible tubing. We suppose that the speed and the pressure of the flow are only depends from the time and the position coordinates in the centerline of the phase-pipeline. The equations for the non-stationary flow are the motion equation:

$$\frac{\partial v}{\partial t}+v\frac{\partial v}{\partial x}+\frac{\partial Y}{\partial x}+\frac{\lambda}{2D}v|v|=0 \qquad (1)$$

where,

$v(x,t)$	velocity (m/s),
t	time (s),
λ	pipe friction factor,
D	pipe diameter (mm),
$Y(x,t)$	amount of energy contained (J),

as well as the continuity equation:

$$a^2\frac{\partial v}{\partial x}+\frac{\partial Y}{\partial t}+v\frac{\partial Y}{\partial x}+gv\sin\alpha=0 \qquad (2)$$

where,

a	wave velocity (m/s),
α	angle of landing (pipeline).

Induct the pressure wave velocity, which is:

$$a=\left[\rho\left(\frac{1}{E_f}+\frac{1}{E_A}\right)\right]^{-\frac{1}{2}} \qquad (3)$$

where,

ρ	fluid density (kg/m^3)
E_f	fluid module of elasticity (MPa)
E_a	pipeline mod. of elast. (MPa)

The (1) and (2) make up a differential equation system. Using the model below (Fig.2), we solve the equations besides its boundary conditions (ACHG piston diameter (d_g), stroke (2e), pipe length (l), pipe wall thickness (t), pipe module of elasticity (E), ACHM piston diameter (d_m)).

The phase-flow generated by the ACHG's piston which excited by the eccentric wheel. The rotating eccentric wheel with the phase-flow actuated the working surface of the ACHM. We inspect the phase-flow speed and pressure changing, at the working surfaces of the ACHG and ACHM.

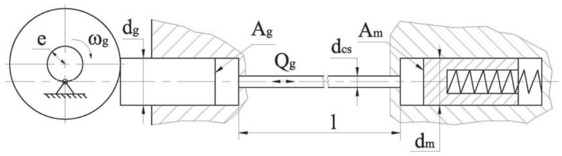

Fig. 2. Model for the hydrodynamic inspecting.

Besides the model's (Fig. 2) boundary conditions (n_g=1000 1/min, e=5mm) we solve the equation system composed (1) and (2), the results can be see on Fig. 3.

Fig. 3. Speed and pressure characteristics at the tube ends (green=speed, red=pressure).

We have verified the theoretical calculation with measurements. We were doing measurements to determine the phase-pressure at the ends of one phase-pipeline. Results can be see on Fig. 4.

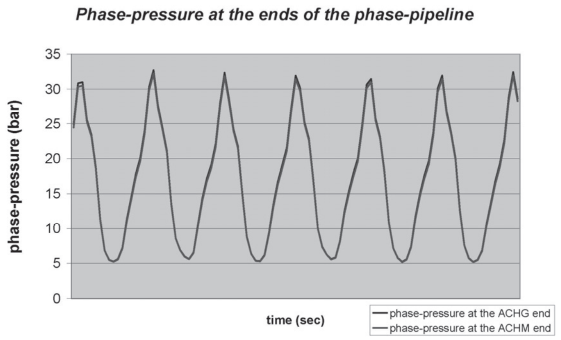

Fig. 4. Phase-pressure at the ends of the phase-pipeline

As we can see, the pressure is almost the same at the both end (the relative deviation is 1,4 %). Although we didn't have the possibility to measure the pressure in every section of the phase-pipeline, but the theoretical account and the given results underpin that the pressure and the speed of the phase-flow are constant in every section and every time. So hereunder we can handle the phase-flow like a concentrated parameter.

4. MEASUREMENTS AT THE A-ACH PILOT MODEL

We built the A-ACH pilot model for practical inspection at the Department of Machine tools at University of Miskolc (Fig. 5.).

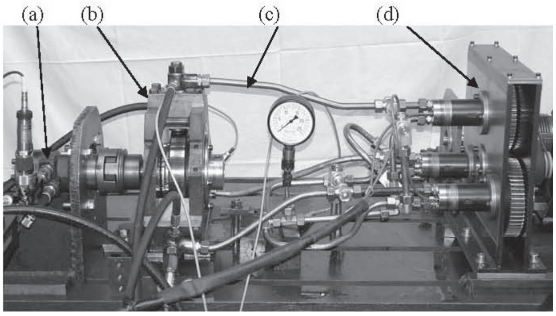

Fig. 5. Asynchronous ACH drive.

The A-ACH drive has three phases, the ACHG (b) has an eccentric actuating wheel. The drive shaft of the ACHG is actuated by a direct current hydraulic motor (a). The advantage of this solution that we can adjust the phase-flow frequency (frequency control) by changing the revolution's of the hydraulic motor. The phase-pipelines (c) are rigid and heavy steel tubes. The aim of the measurement is to get the static and dynamic characteristics of the drive as the ACHM revolution and drive torque. We took the characteristics besides no-load and load conditions. A no-load phase-flow characteristic can see on Fig. 6.

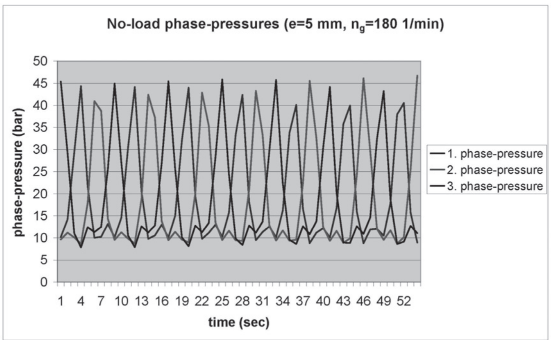

Fig. 6. No-load phase-pressure characteristic

As we can see the pressure characteristic is periodic. The lower values have given by the drain loss additional pump while the loading conditions indicate the upper values. The ACHM revolution and torque characteristics in load condition can be seeing on Fig. 7.

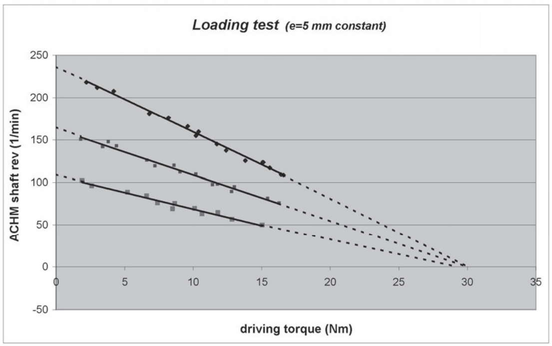

Fig. 7. Load characteristic of the ACHM.

In the test the eccentricity was constant (e=5mm) while we were changing the revolution of the ACHG. The A-ACH drive can operate in stellar- and delta coupling in accordance with electrical analogy. We were testing both couplings to demonstrate the difference between the ACHM's drive shaft revolutions. After the measurements we can say that using the electrical analogy is right. We proved the revolution difference which results can be seeing on Fig. 8.

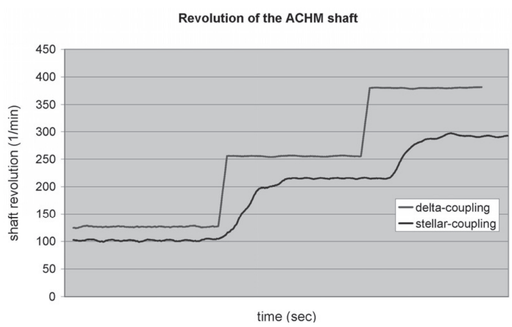

Fig. 8. The effect of coupling upon the ACHM revolution

By the theoretical calculations and the given measurement results we can say that the ACHM revolution is lower in stellar coupling then delta if we use the same setup (eccentricity, drive revolution) in both cases.

5. LITERATURE

Erdelyi Janos - Dr. Lukacs Janos – Dr. Tolvaj Bela: Theoretical and practical test of the asynchronous alternating current hydraulic (A-ACH) drive. Pneumatics, hydraulics, drives, automation. Vol. XIII. 2009. p. 25-29.