ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering

Tome XII [2014] – Fascicule 2 [May]
ISSN: 1584-2665 [print]; ISSN: 1584-2673 [online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

[1.] Tamás FEKETE

THE ALTERNATING CURRENT SYNCHRONOUS HYDRAULIC DRIVE

[1.] University of Miskolc, Department of Machine Tools, Miskolc, HUNGARY

Abstract: The energy transfer at the hydraulic drives can be solving with direct current hydraulic drives and alternating current hydraulic drives. At the direct current hydraulic drives, the operating fluid flow in one way besides the alternating current hydraulic (ACH) drives where it alternating periodically between the hydrogenerator and the hydromotor.
Keywords: hydraulic drives, energy transfer, fluid flow

1. INTRODUCTION

The ACH drives have three types. The alternating current synchronous drive (S-ACH), the alternating current non-synchronous drive (ACH-M) and the alternating current asynchronous drive (A-ACH). The ACH drives have two main units: the alternating current hydrogenerator (ACG) and the alternating current hydromotor (ACM).

The A-ACH drive was patented by Dr. Janos Lukacs. Along the project he and his previous PhD student (János Erdélyi PhD) 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.

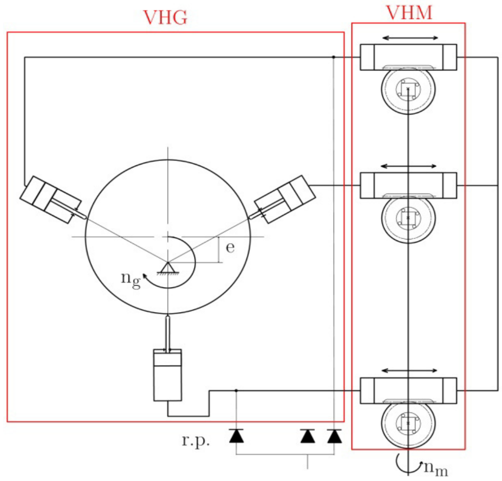

Figure 1. The alternating current asynchronous drive (A-ACH)

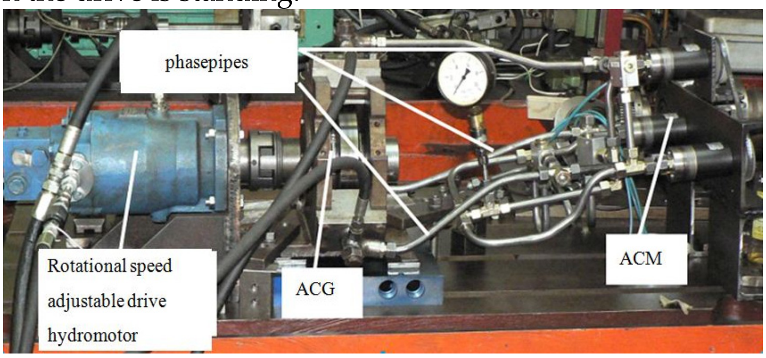

Figure 2. The constructed alternating current asynchronous drive (by János Erdélyi PhD)

According to the surveys, applying the alternating current hydraulic drive (ACHD) is preferable, if the parameters of the device are not possible to expend any more, because applying direct current hydraulic drive (DCHD) system is too intricate or even not practicable to carry out at all.

ISSN: 1584-2665 [print]; ISSN: 1584-2673 [online]

2. THE ALTERNATING CURRENT SYNCHRONOUS DRIVE (S-ACH)

The generator is energy source in the chain of the energy transfer. The main parts of the generator are: the phase cylinder, the implied phase pistons and the motion mechanism of the phase pistons. These all cause the generation of the hydraulic sections, which determine the liquid flow. In case of synchron drive case, the design of both the ACG and ACM is the same. In the first stage, transfer parameters of the S-ACH drives would be studied in piston construction.

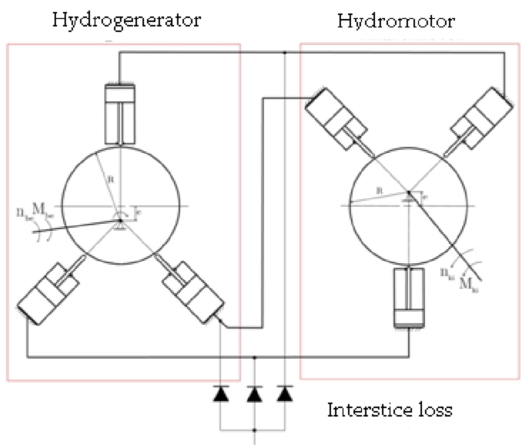

Figure 3. The alternating current synchronous drive (S-ACH) with rigid phase pipe and pistons

The increasing pressures have significant interstice loss, because conpressure on the interstrice (for example: piston-cylinder) cause significant back fluid. In case of a certain Δp pressure load determines lower liquid flow at one pump and more amount of needed liquid at a motor than the theoretical value.

Preventing the interstice loss of the phase piston diaphragms can be built in the hydraulic system. The diaphragms are made of rubber like elastic material, that make flexible and impermeable interface between two separated part meanwhile they have to allowed the volume changes of the two separated part. The ACG produce phase-pulse liquid flow, which is sinusoidal variable, in the phase pipe for the ACM. The unit, which control and exciter the phase pistons of the ACH, can be worked up in several ways (for example: periodic disk, which can be excentric or tilted-disc, crankshaft).

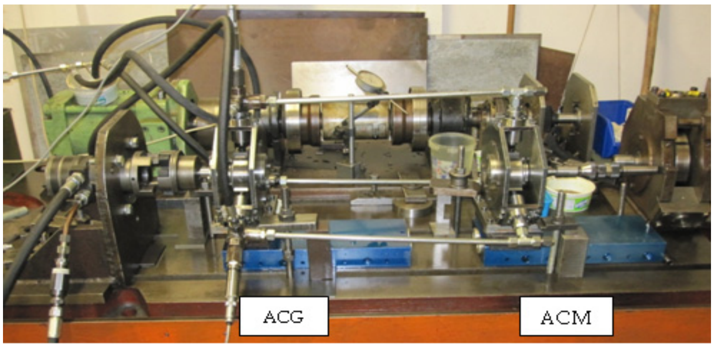

Figure 4. The constructed alternating current synchronous drive (by Tamás Fekete)

In terms of studies of DCHD with short pipe length, the professional literature applies the same context like the electrical analogy does. It can be also apply for hydraulic alternating liquid flow.

These relations are applicable to analyse transfer property of the ACH system.

The characteristic curve of the liquid flow, generated by ACG, is all most same like function sinus.

The $\tilde{Q}_i$ $(i=1,2,3)$ phase liquid flow can be calculated with the following equation:

$$Q_i = Q_0 \cdot \sin(\omega t + k \cdot \frac{2\pi}{3}) \tag{1}$$

in absolute value of the liquid flow is

$$Q_0 = A \cdot e \cdot \omega_g \tag{2}$$

A - surface of the piston (m^2), e - the eccentricity (m), ω_g - angular velocity of the generator (1/s).

The law of motions of the pistons in the three hydraulic cylinders are

$$x_{g_1} = r\cos\omega t, \tag{3}$$

$$x_{g_2} = r\cos\left(\omega t - \frac{2\pi}{3}\right), \tag{4}$$

and

$$x_{g_3} = r\cos\left(\omega t - \frac{4\pi}{3}\right) \tag{5}$$

the surface of the foreheads of the pistons are the same.

$$\varphi_{h_1} = L_{h_1} Q_1 \tag{6}$$

φ_h - the hydraulic flux, L_h - the hydraulic induction factor, Q - volume flow rate or. liquid flow, and

$$\varphi_{h_1} = \frac{m}{A^2}\frac{dx_{gl}}{dt} \quad (7)$$

from these relations

$$L_h = \frac{m}{A^2} \quad (8)$$

with substitution Q_1 the liquid flow is calculatedly:

$$Q_1 = -Ar\sin\omega t\,. \quad (9)$$

Like in the same way:

$$Q_2 = -Ar\sin\left(\omega t - \frac{2\pi}{3}\right) \quad (10)$$

$$Q_3 = -Ar\sin\left(\omega t - \frac{4\pi}{3}\right)$$

and (11)

The summing of the three liquid flows the following amount:

$$Q_1 + Q_2 + Q_3 = 0 \quad (12)$$

is gotten. This result makes the possibility to degrees the number of pipes.

The functioning of the hydraulic generator start the alternating current of liquid flows in the phase pipe, and these liquid flows forced the excenter disc of the motor to rotate.

The condition of continues rotating of the motor:

- the hydrogenerator and the hydromotor have the same structure,
- the balance between the source and absorbed has to be stand,
- synchron case,
- both the parameters and the size phase space is the same,
- the same eccentricity value, by generator and motor,
- suitable extender pressure.

From the start-up conditions, the definition of synchron case and the excenter filtering pressure must be checked.

The presented starting position (figure 4) if the ACG is rotated through the fixed excentred gear, a $+Q_{1g}$ phase current will flow from the first phase cylinder of the ACG to the first phase cylinder ACM. The 1' phase piston makes the yoke, included phase pistons, turn into the signed direction. If the yoke ACM can turn, the 3 phase cylinder will swallow the $-Q_{3m}$ back current, gone to the hydromotor. The phase cylinder 2 and 2' are in central position. Yoke of ACG (technically the excenter is turned) has to be turned forward from the starting position with $\Delta\phi_g$.

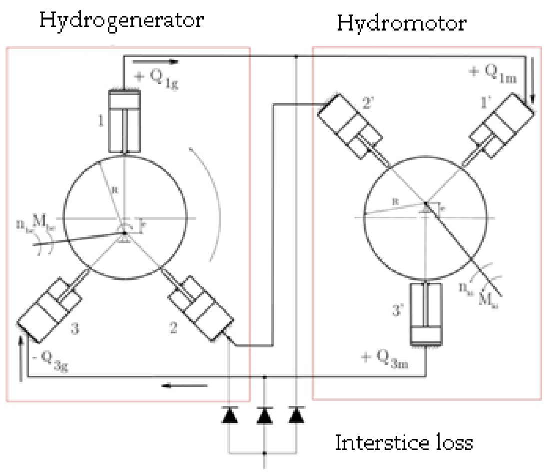

Figure 5. The start up position of the generator and the motor of the alternating current drive

The $+Q_{2g}+(-Q_{2m})=Q_{2fázis}$ phase current, which flows into the 2 phase space of the generator, generate rotating effect in the $-Q_{1m}$ liquid flow which has counter rotating effect then $-Q_{2m}$ current of the hydromotor.

Increasing of the $\Delta\phi_g$ will increase the anti-rotate effect. This issue is occurred by lock of the balance of the liquid flow.

The liquid flows of the generator (source) are absorbed by the hidromotor (drain), shown on fig. 4.

Concerning the previous things it follows, that the liquid flows of the system are not in balance (figure 4). Therefore the phase space of the ACG must be in counter phase with ACM.

$$Q_{1g} = Q_0\sin 60° = 0{,}87Q_0,\; Q_{2g} = 0,\; Q_{3g} = Q_0\sin 300° = -0{,}87Q_0 \quad (13)$$

$$Q_{1m} = Q_0\sin 120° = 0{,}87Q_0,\; Q_{2m} = 0,\; Q_{3m} = Q_0\sin 240° = -0{,}87Q_0 \quad (14)$$

Summarising the context, that

$$Q_{gi}=Q_{mi}, \quad (15)$$

$$\Sigma Q_{gi}=0, \quad (16)$$

$$\Sigma Q_{mi}=0, \quad (17)$$

liquid flows of the system are balance.

3. CONCLUSION

The essential condition for operating the system is that summarise of the three liquid flows must be zero ($\sum Q = 0$). If the condition does not come true, pressure increase will appear in the phase pipe.

In first context the transfer parameter of drive is studied with pistons and rigid phase pipe then with flexible pipe. Later the pistons will be replaced with diaphragms the transfer parameter is studied with rigid phase pipe then with flexible pipe.

Using elastic phase pipes between ACG and ACM gives the opportunity to build the system optionally but it also increases the capacitive resistance of the system.

Furthermore, it has to be studied that how far the capacitive resistance can be increased so much that the ACG is still able to transfer energy to the ACM.

ACKNOWLEDGEMENT

The described work was carried out as part of the TÁMOP-4.2.1.B-10/2/KONV-2010-0001 project in the framework of the New Hungarian Development Plan. The realization of this project is supported by the European Union, co-financed by the European Social Fund.

REFERENCES

[1.] Pattantyús Á. Géza: Gyakorlati Áramlástan. Budapest, Tankönyvkiadó 1951.

[2.] Ponomarjov Sz. D.: Szilárdsági számítások a gépészetben c. kötet. Rezgések Ütések. Budapest, Műszaki Könyvkiadó 1966.

[3.] Dr. Lukács, J. – Erdélyi, J.: A váltakozó áramú hidrogenerátor fázisdugattyúinak működtetési és konstrukciós kérdései. Pneumatika, hidraulika, hajtástechnika, automatizálás IX. Évfolyam - 2005. 60-63 page.

[4.] Erdélyi János, Váltakozó áramú hidraulikus aszinkron (A-VAH) hajtás (p. 113-116), OGÉT 2006. XIV. Nemzetközi Gépész Találkozó. Marosvásárhely. Románia.

[5.] Dr. Lukács János - Erdélyi János, Váltakozó áramú hidrogenerátorok (VHG) elméleti és konstrukciós kérdései, Tavaszi Szél 2006. Kaposvár