CHOOSING A SOLUTION TO GENERATE THE SINUSOIDAL SIGNAL FOR A DINAMIC IDENTIFICATION OF PELTON TURBINES

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Abstract: During the function of Pelton turbines**,** due to the periodical changes of the temporary position betwen the water spurt and the palette having the form of a cup, the flow is unstatic and has a free surface. So, due to this specific features, a precise theoretical analise of the Pelton turbines becomes more difficult and the validation of the proposed model can be made only with the help of the dinamic identification. In the case of this type of turbine I chosed in purpose to determinate the dinamic specific features to use the periodical signals for tests and more specific the sinusoidal signal. The obtained results must be verified by experiments in purpose to validate the proposed theoretical model.
Before this experiment we must take into consideration the praparation phases which means – to choose the machinery needed and to establish its characteristic and a preliminary study of the precess. Within the preliminary study must be established the orientative values of the frequency, its character and the intensity of the sources of perturbation, the aproximate structure of the transfer function, etc. Achieving the preparing phases will allow the passing way to planification and complete the experiment.
Taking into consideration the details mentioned above, based on the measurments for a static treatment, I have determined the approximate shape for the transfer function.
For a dinamic identification, the entrance value, which means the move of the injector needle of the turbine, must have a sinusoidal variation. This means to create an instalation that allows this variations to be obtained.
This paper analises for a given case of a Pelton turbine, several solutions to obtain a sinusoidal variation of the entrance value of the process and also looks to find an optimal solution from thr point of view of the experimental spa used.

Keywords: Pelton turbines, water jet, dynamic identification, transfer function, frequency domain, cams, mathematical model.

1. INTRODUCTION

Pelton hydro turbines are impulse turbines, which are specifically suitably for high heads and low discharge. In Pelton turbines, the mechanism of motion has been simply explained by using the angular momentum theory for time averaged flow. Inspite the fact that Pelton turbines have known a significantly improvement regarding the efficiency and reliability, the flow analysis through injectors and rotor buckets is still in research stage and the physical phenomena are far to be completely understood and described. The precise theoretical analysis of Pelton turbines becomes more difficult due to a few particularities of the flow, such as: free jet flow and unsteady flow with free surface on the bucket.
A specific aspect of Pelton turbines simulation is the fact that due to periodic change of the relative position between the water jet and the bucket the flow is unsteady and has a free surface. Also, the flow in the Pelton turbine bucket is three-dimensional, unsteady, and turbulent, features a free surface, and is influenced by the

rotation-induced forces. It is difficult to investigate how the energy transfer takes place between the water flow and the bucket inner surface.
Taking into account all these aspects that we mentioned above, it is very difficult to establish an exact model for Pelton turbines. Much more, with the ongoing liberalization of the European Interconnected Network, developed dynamic models for the power plants and power systems are necessary. These models, including that for hydro turbines, have to be generated in such a way that they are reliable for all operating points of the system from zero to full operation. But, only the dynamic identification of the system will validate or deny the proposed models.
This paper represents the first step in the dynamic identification of the Pelton turbine. That mean we need to choose the right system for generate sine wave signals for the testing rig.

2. DYNAMIC IDENTIFICATION FOR PELTON TURBINES

The real meaning of the notion of identification is to conceive the model of the process by modeling, with the help of a simple and efficient mathematical machinery, some experimental results obtained in term that can assure concludent information to be able to describe the considered process.
To fulfill all the mentioned dezideratums a succesion of operations it is made, grouped in three steps, so: to organize and make the experiments on the process, to interpretate and work the results of the experimental determinations and inferation of the model by an mathema
tical aproximation of the results.
One of the category of the methods which are used for an experimental determination of the dinamic characteristics is the methode of identification through signal tests. The choose of the signal testes it is made taking into consideration the machine at the disposal of the researcher and the linear or non-linear character of the process, and also the intensity of the sound and turbulent sources which actuate on the researched process.
In this paper we will refer only at the identification with testing periodical and sinusoidal signals. So, iff it is applied on the element a sinusoidal signal at the entrance on the this shape:

$$x_i(t) = A_i \sin \omega t \tag{1}$$

Then at the coming out of the element, after a period of time gone, there apear stabilised oscilations of the exit value $x_e(t)$, with the same pulse ω, but with a diffrent amplitude A_e and with a phase late towards the oscilations introduced at the entrance:

$$x_e(t) = A_e \sin(\omega t + \varphi) \tag{2}$$

In purpose to determine the frequence characteristic we only must compare the two signals, represented in fig. No. 1, for diffrent pulsations ω, and so it can be obtained φ(ω) and Y(ω), or other characteristics Re[Y(j ω)], Im[Y(j ω)], etc.

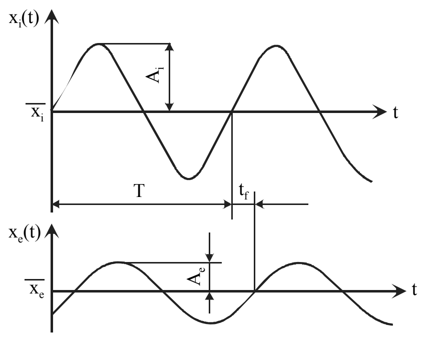

Fig.1 Signals of entrance and exit recorded

On the hidraulic turbines, to modify the function regime it is possible only by modifying the flow. On Pelton turbine to modify the flow must modify the position of the injector needle, which closes more or less the output part of the injector. In this case, the entry value of the process is the course of the injector needle. At the izolated function for diffrent charges, the exit value of the process is the turation of the unit formed from Pelton turbine and the electric power plant.
Considering all the mentioned, to determine the dinamic characteristics of the Pelton turbine at an unstationary treatments, it is applied values of entrance – the course of the injector needle – a sinusoidal variation of form (1) and it is obtained for the exit value – the turation of the engine a variation of form (2). Recording and comparing the two signal can be determined the ampleness characteristics – pulse and phase – pulse, which visualize the dinamic behavior of the hydroagregate – by a linear aproximation. So, can be investigated the unstationary treatments and for transition, showing off the stability of the machine, its resonance and also the posibilities to give in case of function within an automat system of regulation.
Pelton turbine belonging to the test rig has a rotor of 20 bucket shaped blades. The guide vane is axial – injector type. By opening or closing the needle tip from the regulating nozzle different operating points are achieved. The main sizes of the injector belonging to the Pelton turbine test rig are shown in figure 2.

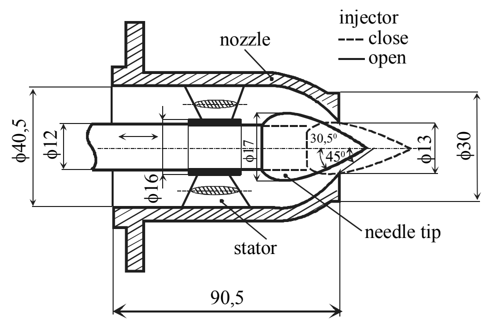

Fig.2 The main sizes of the injector belonging to the Pelton turbine test rig

3. CONSTRUCTIVE SOLUTIONS TO GENERATE THE SINUSOIDAL SIGNAL

In this part of the workpaper we will present a few constructive solutions to generate the sinusoidal signal for a dynamic identification of the hidraulic Pelton turbine. We must mention that there is a large variety of this kind of solutions which helps to fulfill the aim established. We choosed oly the solutions which matches to the lab instalation analized.
So, in purpose to generate the sinusoidal signals, we can resort to operational ampliflyers to mold the equation (3), a solution is a sinusoid with the pulse ω_n, presented in equation (4).

$$\frac{d^2x(t)}{dt^2} + \omega_n^2 \cdot x(t) = 0 \tag{3}$$

$$x(t) = x(0) \cdot \cos \omega_n t \tag{4}$$

The amplitude of the obtained signal at the exit can be modified changing the begining conditions x(0), and the pulse ω can be modifyed by the variation of the C capacities or through the variation of the resistences R or with the help of the potentionmeter R_1 and R_2 from the sinusoid electric generator scheme, presented in fig. 3.

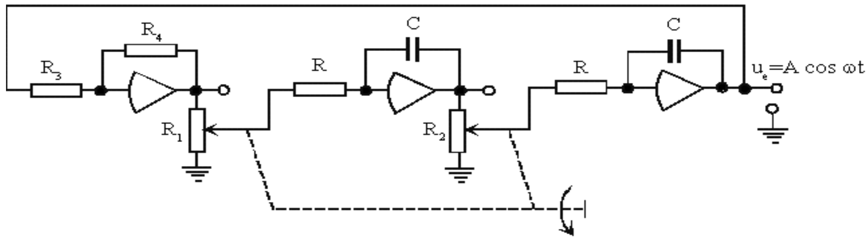

Fig.3 Electric generator of sinusoidal signals

This electric generators presents the advantage of a high precision together with an easy way of handeling, not having pieces in move.The desadvantage is a complicated electric scheme.
Together with the perfection of this scheme, a great diversity of electromechanics and pneumomechanics generators has been created. The solution for such a mechanic generator is presented in [2].
The generator has a came system excentric disposed. One of the cames is trained by an asinchron motor and its turation can be regulate without steps, with the help of a variator hidraulic. Regulation of the frequency ω of the entrance value it is made by choosing a desired turation n_k with the help of a reglating manual wheel of the the turation of the hidraulic variator. The amplitude of the entrance value can be reglated by rotating of the two circular cames one from the other from 0 to 180° whithout steps. In picture 4 are represented the two cames disposed eccentric.

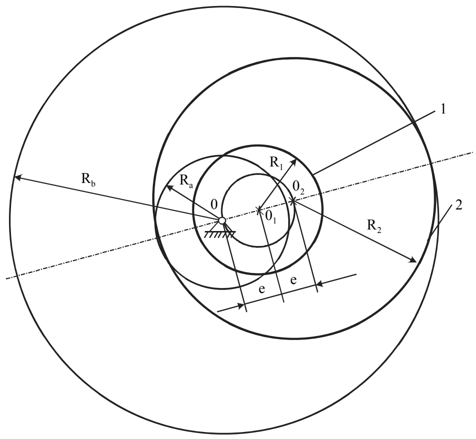

Fig.4 The cams of mecanic generator with sinusoidal signal

By rotation of came 2 around cam 1 can alter the oscillation amplitude from 0 to maximum value.The centre of the came 2 is turn around of O_1 on the circle that pass throu the fix point 0 of the came 1.Fig 4 is use to determinate value of the entrance amplitude.In figure R_1 represent came ray1R_2-came ray(2),R_a the minim rase realised by the cames, R_b the maximum rase realised by the cames, e- the eccentricity of came 1 equal with the came 2. The race of the cremalier is: $s=R_b-R_a$. For execution was chosen the solution from fig. 5

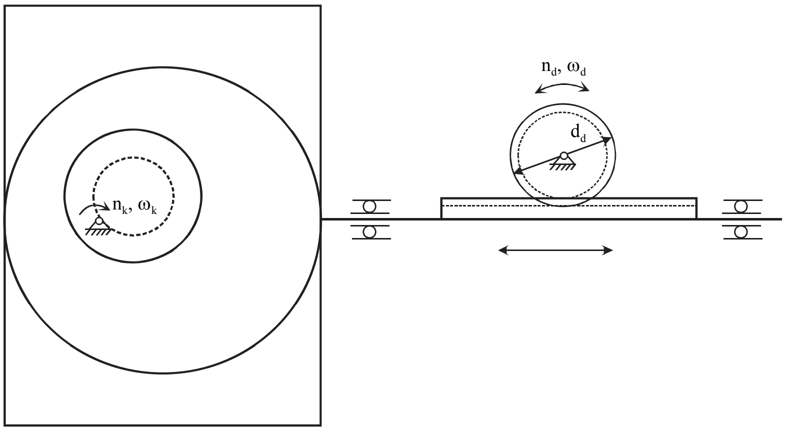

Fig. 5 Ensemble eccentric cams-the cremalier

The solution presented earlier offer the posibility of modyfi so amplitude as frecvency of sinusoidal signal applied to entrance magnitude. In this way we get the sinusoidal variation of injector needle from Pelton turbine , to identify dinamic. But, if we consider the configuration of experimental station with Pelton turbin part of Laboratory Hidraulic Machine from Universty „Politehnica" Timisoara, the mecanic generator examinated is hard to use forexperimental identification of turbine. This owe to clearance diagram high dimensionof the turatin variator comparing with disponibil place near station, so to couple dificulties at needle injector rod
Therefore, is presented the solution that was chosen for experimenal identification of Pelton turbine from station. The most simply way to get a periodic signal at the begining of considered procces, is to use a plan came with translation tachet because the movement law of this is sinusoidal. The device is project as the injector needle rod to coincide with cam tachet, in this way we ensure the sinusoidal variation of entrance magnitude.Because to determinate the dinamic caracteristics of turbine by identifing the periodic signals, are necessary difrent amplitude of entrance signal,so five cams are projected ,cams that tachet race is 4,6,8,10 and 12 mm. In this way we get five difrent amplitude of the sinusoidal signal . The cams were projected acording relation from mecanichs theory ,using a program in MatLab. By exemple in figure 6 is presented the variation of tachet move depending on φ angle (in radians, rising angle, superior stationary, descent, and inferior stationary) for race h= 8 mm,and in figure 7 is represented the real profile of came.

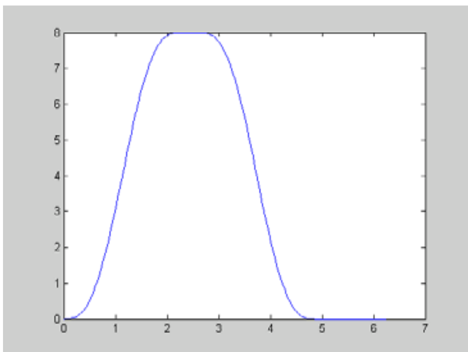

Fig.6 Variation of tahet move depending of angle φ

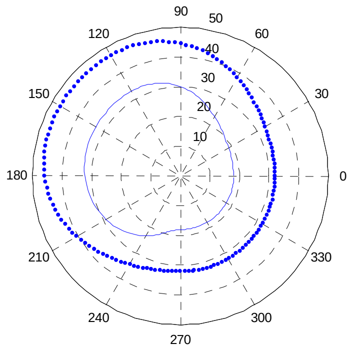

Fig.7 The real profile of came with h=8mm

In this way, we get difrent amplitude for sinusoidal signal from entrance. To get difrent freqvency of signal, the came axis is drive by an electric motor with continously curent, to whom rotation and freqvency is modify by tension alter.The installation describe previous, ensure geting the sinusoidal variation of entrance magnitude and so identify the dynamic of considered process.

4. CONCLUSION

This work present diffrent modes of generating sinusoidal signsl necessary for identifyng the sistems dynamic. We choose and we realised practicaly the last solution because this can be use in laboratory where we want to determin the transfer function of Pelton turbine.
This paper represents the first step in the dynamic identification of the Pelton turbine. That mean we need to choose the right system for generate sine wave signals for the testing rig. Then, we will propose the transfer functions for the turbine and only the dynamic identification of the system will validate or deny the proposed models.

REFERENCES

1. Penescu C., Ionescu G., Tertişco M., *Identificarea experimentală a proceselor automatizate*, Ed. Tehnică, Bucureşti, 1971
2. Draşovean I., *Studiul, proiectarea şi realizarea unei stațiuni de laborator pentru încercarea regulatoarelor hidraulice de turație*, Proiect de diplomă, I.P.T.V. Timişoara, 1970
3. Bărglăzan A., Anton I., Anton V., Preda I., *Încercările maşinilor hidraulice şi pneumatice*, Ed. Tehnică, Bucureşti, 1959
4. Bărglăzan M., *Turbine hidraulice şi transmisii hidrodinamice*, Editura Politehnica, Timişoara, 1999
5. Catanase A., Bărglăzan M., Hora C., *Numerical simulation of a free jet in Pelton turbine*, The 6th International Conference on Hydraulic Machinery and Hydrodynamics, Timişoara, Romania, October 21 – 22, 2004