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OPTIMIZATION OF A PLANETARY CHAIN SPEED INCREASER FOR SMALL HYDROS

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Abstract: *The paper objective is to optimize a planetary speed increaser in order to be integrated in a small hydropower plant equiped with a Turgo turbine. The turbine assembly was tested in the laboratory with the aim to identify its performances. Based on the results, the authors proposed an optimization by using a speed increaser (Jaliu, 2009) between the turbine and the generator. The speed increaser was dynamically analyzed (Saulescu, 2009), modelled and optimized. The next steps will be to manufacture the transmission and to test it in laboratory conditions. Then, the small hydropower plant that includes the speed increaser will be implemented in real conditions.*
Key words: *planetary, speed increaser, hydro, CAD*

1. INTRODUCTION

The paper objective is to optimize the constructive scheme of a proposed concept of speed increaser, in order to fulfill the imposed requirements of a small hydropower plant to be implemented near Brasov. Thus, the paper presents the input parameters for the embodiment design phase of the proposed speed increaser. These requirements are derived from the features of a Turgo turbine and an electric generator, which are part of the small hydro. The optimum solution of the planetary speed increaser is then selected by taking into account the transmission efficiency, overall size and a particular value of the multiplication ratio, given by the existing electromechanical equipment. Finally, the assembly turbine – speed increaser – generator will be tested in laboratory conditions. The next step will be to manufacture the prototype of the chain speed increaser and to test it in a small hydropower station.

In order to implement a small hydro plant in a specific location of Brasov area, a Turgo turbine assembly (Fig. 1) was purchased to be installed on the river. The turbine assembly and the generator were tested in laboratory conditions (see Fig. 1,b) for different nozzles (for diameters of 3, 10, 13 and 16 mm) and speeds.

a) b)

Fig. 1. The Turgo assembly (a) and the turbine testing (b)

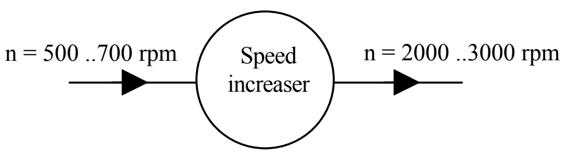


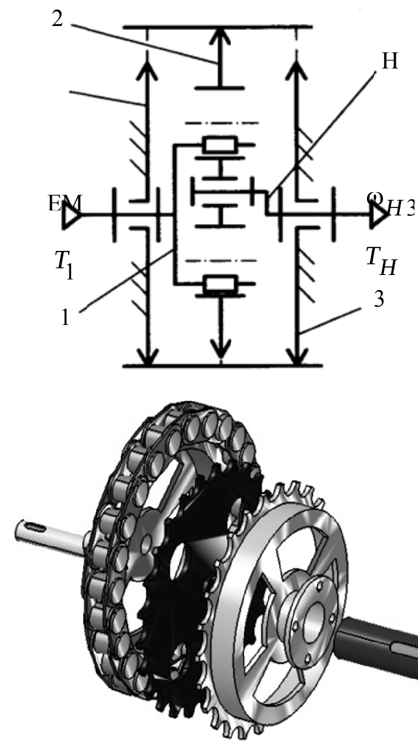
Fig. 2. The speed increaser block diagram

The results highlight the fact that the Turgo assembly performances are higher for smaller speeds and nozzles, while the generator performances are better for higher speeds. One of these performances is the efficiency.

Thus, in order to increase the performances of the Turgo assembly, the turbine speed has to be lower, while the generator has to work at higher speeds. Therefore, the speed increaser to be placed between the turbine and the generator has to multiply the turbine speed 3 to 6 times (see Fig. 2).

2. THE OPTIMIZATION OF THE SPEED INCREASER CONSTRUCTIVE SCHEME

Based on a generalized algorithm for conceptual design (Diaconescu, 2008, Jaliu, 2009), the authors proposed the concept of a planetary transmission with deformable element – Fig. 3,a (Jaliu, 2009). The proposed concept has an input central element 1 that has k>3 equiangular and equidistant pins; the satellite gear 2, belonging to the chain transmission that has equiangular and equidistant holes, connected to the correspondent pins of element 1, and the fixed sun gear 3, belonging to the chain transmission (Fig. 3,a). The speed increaser was dynamically modelled (Saulescu, 2009), the working point was identified (Jaliu, 2010) and, then, the constructive scheme was obtained (Fig. 3,b).



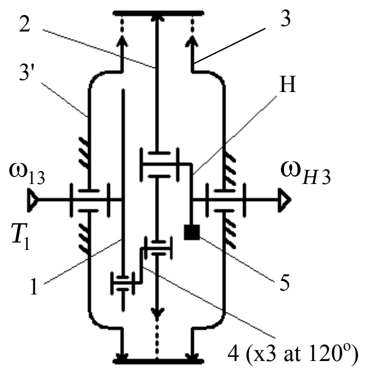
a)

b)

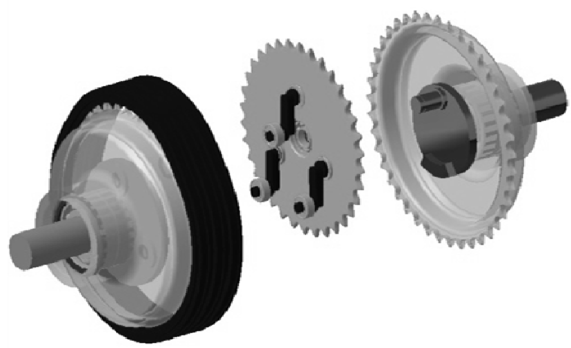
Fig. 3. The speed increaser with deformable element: the concept (a) and the 3D model (b)

The modelling allowed identifying the gears teeth numbers, the eccentricity and the transmission size, based on the requirements of a multiplication ratio between 3 and 5 (Harvey, 2005, Von Schon, 2007) and an average efficiency of 70%. But the optimum teeth numbers generate an eccentricity that doesn't allow the use of pins in holes. Therefore, for constructive reasons, the pin coupling from the conceptual solution (Fig. 3,a) was replaced by three parallel connecting rods 4, in an equiangular disposal (Fig. 4,a). The connecting rods are assembled to the chain transmission through bearings and, therefore, have similar values of the efficiency as the pin coupling. The parallel connecting rods 4 can rotate 360^0 without overlapping (see Fig. 4,b). The transmission uses a standardized chain (American Chain Association, 2005) , on three courses. A counterweight 5 is used to balance the inertial force of the satellite gear 2.

An example of simulation for the speed increaser multiplication ratio and efficiency is presented in Fig. 5, in which the number of teeth for the satellite gear (z2) is considered constant, while the number of teeth of the sun gear 3 is variable.



a)



b)

Fig. 4. The optimized model of the speed increaser with deformable element: the structural scheme (a) and the 3D model (b)

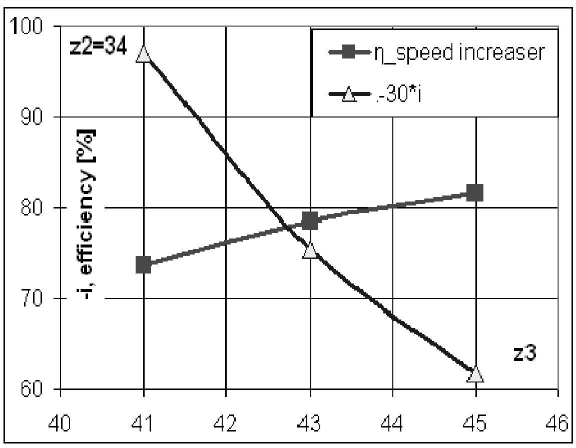


Fig. 5. Diagrams of the efficiency and multiplication ratio

3. CONCLUSIONS

The optimization of the planetary speed increaser with deformable element is made in several steps:

- It was decided to design a small hydropower plant to be implemented on a river near Brasov. Taking into account the hydrological parameters, a Turgo turbine assembly was purchased to be installed on the river.
- The Turgo assembly and the generator were tested on experimental stands; the results highlighted the fact that the generator has better performances at higher speeds, while the turbine performances are improving for lower values of the angular speed. This behavior justifies the use of a speed increaser between the turbine and the generator.
- The transmission for small hydropower plants has to increase the speed of the turbine shaft to the generator between 3 and 5 times.
- The initial concept of the speed increaser consisted in a pin coupling and a planetary chain transmission (Fig. 3,a).
- Unlike the conceptual solution, in the optimum constructive solution the distance between the two axes of rotation (the eccentricity) is not small enough and, therefore, doesn't allow the use of pins. Thus, the pin coupling is replaced by three parallel connecting rods with bearings (Fig. 4,a).
- The speed increaser 3D model is made based on the conceptual scheme of the planetary chain transmission (Fig. 4,a) using CATIA and Inventor software. The model demonstrates that the parallel connecting rods can rotate without overlapping.
- The planetary speed increaser will be manufactured, tested in laboratory conditions and, afterwards, implemented in a stand-alone small hydropower plant.

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