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The Dynamic Testing of the Elastic and Safety Clutches With Degenerated Followers in Equiangular Disposed Lamellar Springs

KEYWORDS: clutches, elastic, safety, testing, dynamic regime

Stroe Ioan

Transilvania" University of Brasov, B-dule Eroilor, No. 29, 500036 Brasov, Romania

ABSTRACT This paper presents the behaviour of the elastic and safety clutch in dynamic regime. The clutch in question is an elastic and safety clutch, as mentioned before, with equiangular cam and elastic follower. From a constructive point of view the clutch is a simple one that has the functions of both an elastic and of a safety clutch. The characteristics of the clutch under different operating regimes of a mechanical transmission are presented: start-up under load, operation in normal conditions with the appearance of shock torque which is kept constant for a time period, the shut-down of the transmission which works under normal conditions. Conclusions regarding the elastic and safety clutch's behaviour under different operating regimes are drawn.

INTRODUCTION

In the case of diverse applications, simple functions can be combined in order to obtain a combined coupling. In this case, the combined coupling is obtained by the connection of two or more simple clutches, in a certain manner, with the purpose of accomplishing the imposed complex functional role of the mechanical transmission accordingly [1], [3].

These combined clutches have a high complexity and large overall dimensions. The most commonly used combined clutches for mechanical transmission are those that from a constructive point of view have both an elastic and a safety clutch. The research in the field of mechanical transmissions led to the design of a simple clutch with multiple functions, called elastic and safety clutch, which fulfils the functions of two clutch types, as its name suggests, an elastic and a safety clutch.

STRUCTURAL SCHEME OF THE ELASTIC AND SAFETY CLUCTH

Figure 1 present the structural scheme of an elastic and safety clutch with metallic intermediate elements. The clutch contains the following elements [2], [3]:

the semi-couplings, 1 and 2;

the equiangular cam 3, assembled on the semi-coupling.

The intermediate elastic elements are executed from spring steel, in the shape of followers. The spring segments are assembled in packs, the number of which being imposed by the cam type. The segments can have different thickness and width, depending on the transmitted torque, the cam width and the maximum value of the axial displacement that can be taken over. The equiangular cam represents the semi-clutch 2 and it can either make one body with the shaft or it can be assembled on the shaft. Cams with multiple profiled faces, as well as with different shapes of the contact surface can be used.

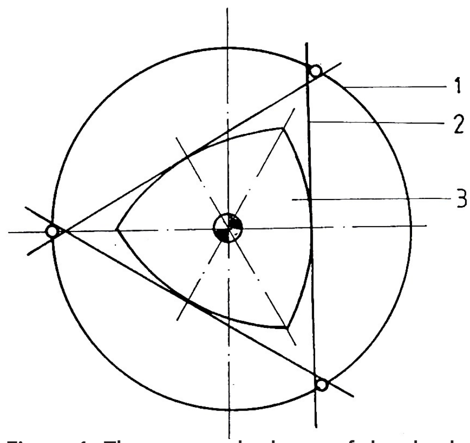

Figure 1: The structural scheme of the clutch

Figure 2 present the geometrical model of an elastic and safety clutch with intermediate metallic elements. It considers that the cam profile is defined by the circular arc. The determination of the cam's radians of curvature is eliminated. The cam geometry is described in a simple manner, by the circle radius, which defines it, and by the distance between the centers of these circles [3], [6].

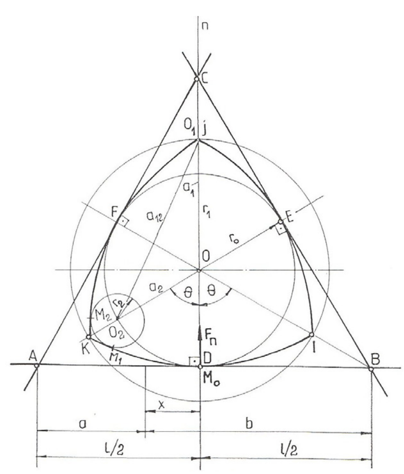

Figure 2: The simplified geometrical model

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STAND FOR DYNAMIC DETERMINATION

For the dynamic testing of the elastic and safety clutch a testing setup was made, based on the objectives of the dynamic testing. The block diagram of the setup is given in Figure 3 and a picture of the kinematic linkage is shown in Figure 4. The block diagram uses the following notation: 1 – electric motor; 2 – belt transmission; 3 – velocity transducer for the driving semi-clutch; 4 – elastic and safety clutch; 5 - velocity transducer for the driving semi-clutch; 6 – gear box; 7 – torque transducers; 8 – flywheel; 9 – mechanical brake; 10 – force transducer; 11 – spiral pair (screw – nut); 12 – direct current motor; 13 – programmable interface; 14 – microcomputer; 15 – printer.

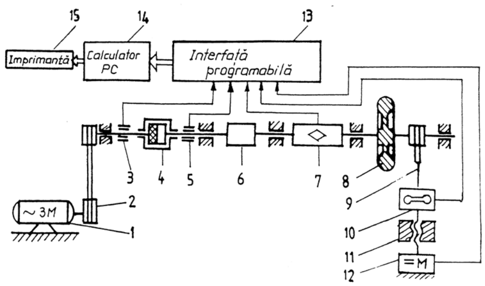

Figure 3: Kinematic block diagram of the setup

The setup allows the loading of the system with different resistant torques, the control of the mechanical brake being done by the force transducer, while the programmer achieves the active control of the dynamic load.

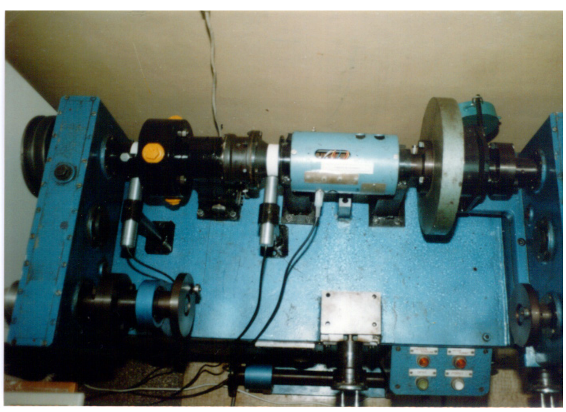

Figure 4: Picture of the actual setup

Experimental determination

The experimental determinations for the elastic and safety clutches were conducted for the representative testing regimes. The experimental determinations are illustrated in following diagrams [2][3].

The start-up with a resisting torque, that is build up from a moment of inertia and a transmitted torque by a load of 5000 Nmm, is shown in Figure 5. The resistance torque increases suddenly, reaching a value of 14500 Nmm in a time interval of 46.6 ms, followed by an oscillating variation of the torque, which is characteristic of the starting shock damping. The torque stabilizes afterwards at a value of 5000 Nmm in a time period of 450 ms.

The regime of decoupling under shock followed by stabilization is presented in Figure 6. The load decoupling takes place at a shock moment of 16500 Nmm within a short time period, causing the relative rotations angle between the two semi-clutches to become 60°, followed by the stabilization at the load torque, in a time interval of 225 ms. It takes the setup 150 ms to stop running after the supply to the motor has stopped.

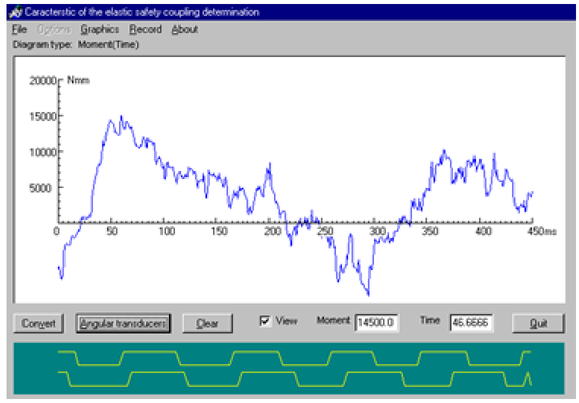

Figure 5: The start-up of the transmission

The load decoupling at a shock moment of 18750 Nmm in a time period of 62.97 ms, while the shock is kept constant for 102 ms, is depicted in Figure 7. In this regime repeated decouplings are taking place, causing the transmission to stop.

The shutdown of the setup is presented in Figure 8. This takes place at a torque of 10000 Nmm, with a shock that produces fluctuations of the resistance torque (14875 Nmm) for a time interval of 146 ms. As it can be seen in the figure the resitance torque reaches zero value after 450 ms.

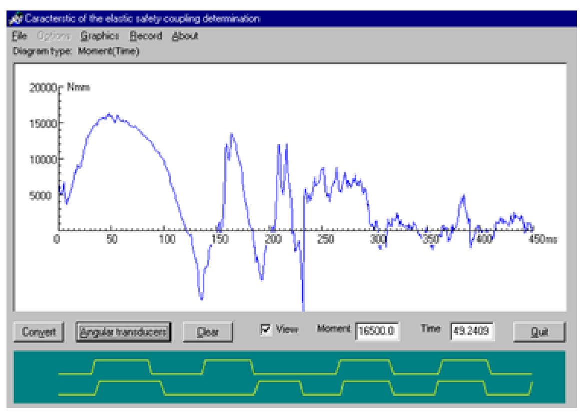

Figure 6: The regime of decoupling under a shock

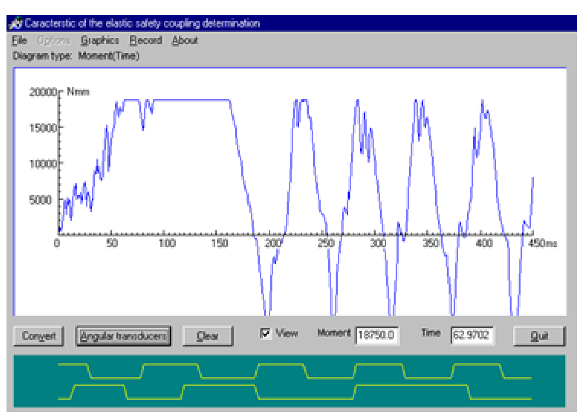

Figure 7: The regime of repeated decouplings

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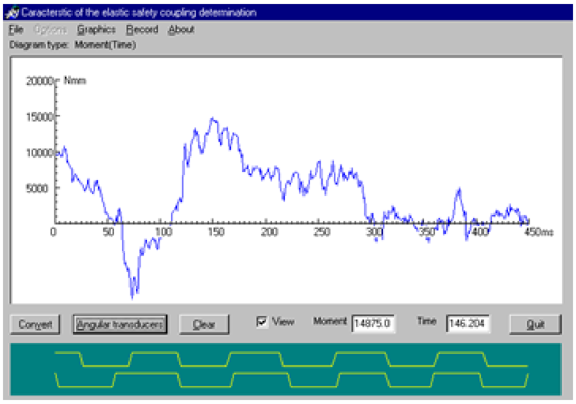

Figure 8: Transmission shutdown

After the study and the analysis of the diagrams the next remarks are made:

- the start-up and the shutdown have a progressive, respectively regressive characteristic, lasting for 50 ms;
- the clutch has a high elasticity, which allows a good damping of the torque shocks;
- for the same cam profile the period of time needed for passing over the profile's contour represents the ratio between the transmitted load torque and the decoupling load, given by the appearance of a shock which lasts for 30 – 40 ms;
- the rise time is smaller than the fall time on the cam's profile, causing the damping of the torque shock;

Conclusions concerning the experimental determination of the elastic and safety clutch

After the study and analysis of the experimental determination, both in static and dynamic regime concerning the elastic and safety clutch with degenerated followers as multilamellar springs, the next conclusions are formulated:

- The elastic and safety clutch's characteristics are progressive;
- The clutches have a large elastic deformation capacity;
- Due to the high elasticity, the clutches have a high capacity of damping the tensional shocks;
- The clutches can withstand radial deviations, of 2-4 mm, and large relative angles;
- The start-up and the shutdown can be made without large shocks;
- The load decoupling within the framework of the overcharge or the gear deficiency is made without the destruction of the elastic elements and without any additional shocks.

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