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THE DYNAMIC CHARACTERISTICS OF A TORSIONALLY FLEXIBLE METAL COUPLING

Summary. At work a structure was presented to the new structural form of the metal coupling about the great torsion susceptibility and description of the research stands and methodology of determining its dynamic characteristics and also to get research findings determining exchanged characterizations which were presented.

CHARAKTERYSTYKI DYNAMICZNE METALOWEGO SPRZĘGŁA PODATNEGO SKRĘTNIE

Streszczenie. W pracy przedstawiono budowę nowej postaci konstrukcyjnej metalowego sprzęgła o dużej podatności skrętnej oraz opis stanowiska badawczego i metodykę wyznaczania jego charakterystyk dynamicznych. Zaprezentowano także uzyskane wyniki badań, pozwalające na wyznaczenie wymienionych charakterystyk.

1. INTRODUCTION

Applying in the arrangements of driving couplings, about the great torsion susceptibility is one of conditions of the correct work of driving arrangements applied in mining machines, of the dynamic burdens immune to the influence. It can provide with the appropriate torsion susceptibility of the clutch solution worked out at the Institute of Mining Mechanization, Faculty of Mining and Geology at the Silesian University of Technology. The structure of different structural forms of the metal flexible torsional couplings was described at works [6, 7].

The flexible coupling is characterized both with determined resilient as well as suppressing features which have the basic influence on the work of the driving arrangement through the change of the course and the stabilization of torsion oscillation and the loading moment. At using flexible couplings about inapt characteristics, it is possible to lead to the state of the incorrect work of the entire driving arrangement. Appointing characteristics of static and dynamic flexible couplings is becoming a necessity. Works contain examples of appointed static characteristics of the metal flexible coupling [2, 3, 5]

2. DESCRIPTION OF BUILDING AND PRINCIPLE OF WORKING OF THE COUPLING

Characteristics were appointed for one of structural forms of the new metal flexible torsional coupling with one thing with screw mechanism (fig. 1 and fig. 2). Essence of its action consists in the fact that the torque is being moved from the active voice to passive behind the aid of the sliding element with the executed screw mechanism and with splined connection. The screw joint is made between the in appearance tapped entrance shaft (1) and with sliding element (2). This element also has splined grooves tricked during the outside surface. These grooves are cooperating with made grooves in the casing (4), constituting the moving splines connection (5). Pitch of thread is big enough, that lead angle of screw line is bigger than its angle of friction [6, 7].

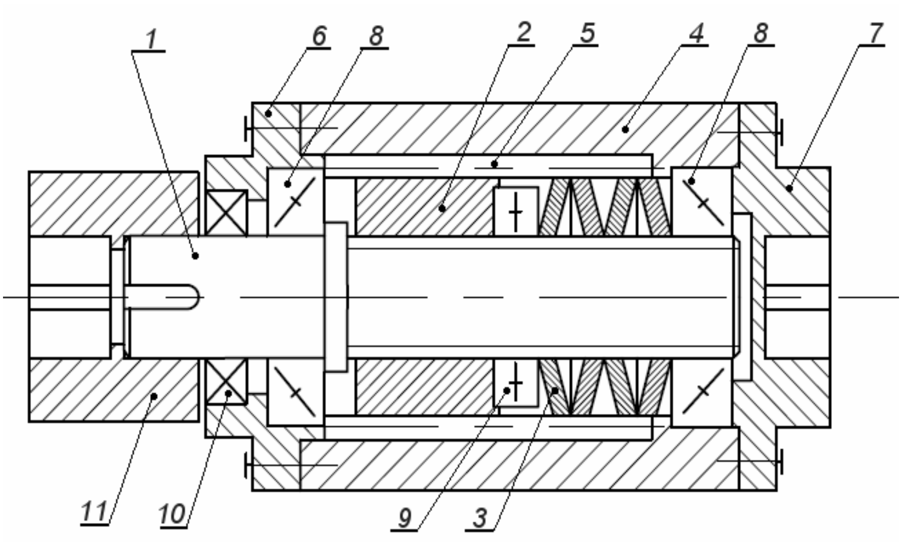

Fig. 1. The construction of the metal flexible torsional coupling with one thread connection
Rys. 1. Konstrukcja sprzęgła podatnego skrętnie z jednym mechanizmem gwintowym

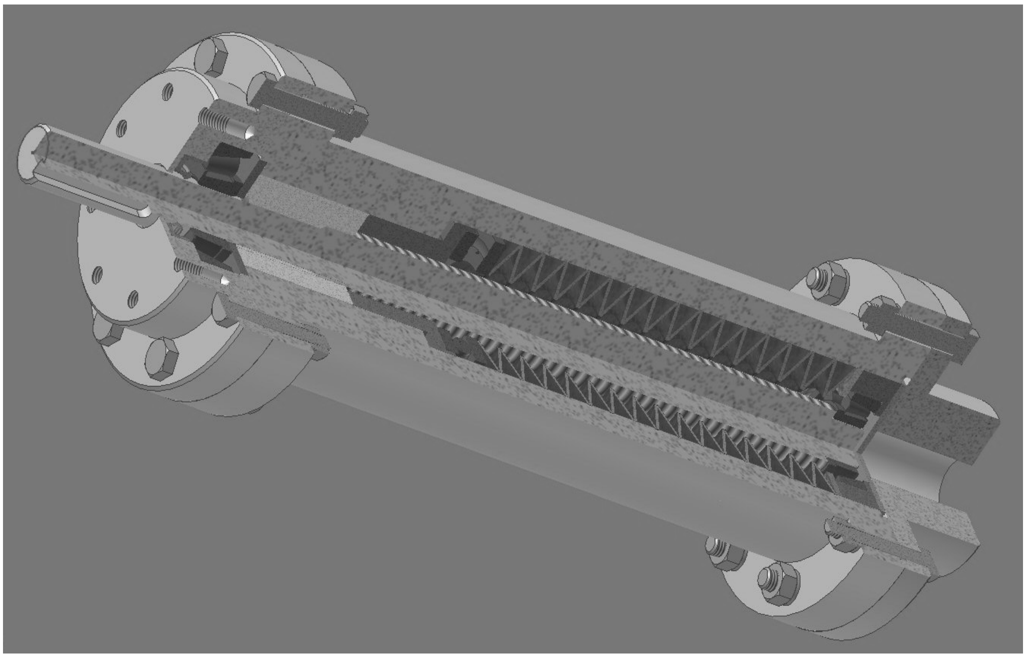

Fig. 2. View of the one-way prototype of the metal flexible torsional coupling
Rys. 2. Widok prototypu jednokierunkowego metalowego sprzęgła podatnego skrętnie

The input shaft is put on two conical bearings (8). The closed casing is a left lid (6) with the sealing ring put in it (10) and with output hub (7).

Tension of the appropriately selected set disk springs (3), triggered with rotary motion of the input shaft (1) and of connection case (11), a height of the component causes powers in district direction on the thread of the sliding element. The increase in this power causes increasing of torque, and when it achieves value of the moment loading machines, a rotary motion being a working movement at the same time is starting.

Additional hugging resilient elements but reducing burdening those causes momentary overloading the drive relaxing. After excluding the driving arrangement, sliding element (2) and axial bearing (9) pressed by springs, are coming back for preliminary putting on the input shaft. At appropriately big preliminary pressing the spring and after excluding the arrangement, the sliding element should return to the initial location.

3. DETERMINING THE DYNAMIC CHARACTERISTICS OF COUPLING

Determining dynamic characteristics of the coupling was carried out on the research stand in the Department of Logistics and Mechanical Handling, Faculty of Transport at the Silesian University of Technology in Katowice (fig. 3). The description of its structure and the principles of operation contain works [1, 4, 10].

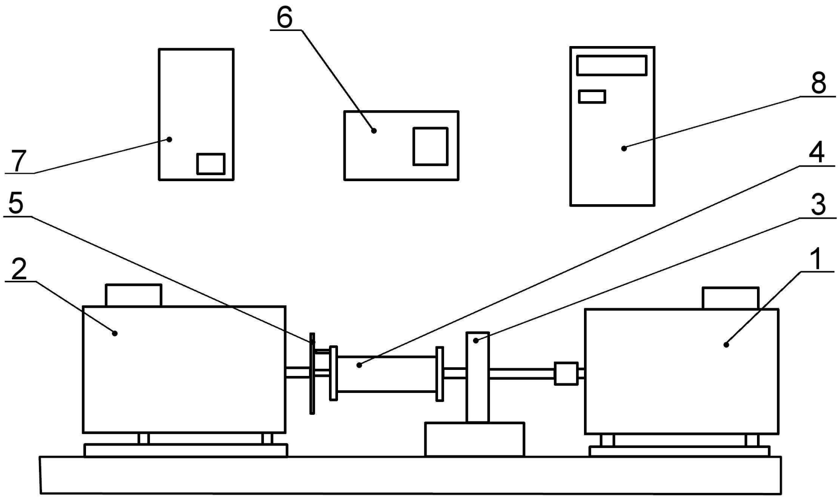

Fig. 3. Scheme of the research stand for research on the dynamic characteristics
Rys. 3. Schemat stanowiska do wyznaczania charakterystyki dynamicznej sprzęgła

With basic elements of the research position (fig. 3), are: triphase slip-ring induction motor M1(1), triphase squirrel-cage induction motor M2 (2), torque meter (3), inverter working as the booster of the frequency (7), microprocessor driver (8), linked the measuring system of the relative angle of the turnover of coupling elements (5). Tested coupling (4) together around torque meter (3) is put between motors M1 (1) and M2 (2).

For the measurement of the angle of the mutual turnover of coupling elements, an arrangement of the shield with an angular scale is being exploited (5), attached to one element of the coupling with a counter, which the pointer fastened to the second element of the coupling is moving for. Of reading of the whirling arrangement shield - the pointer is taking place with the strobe lamp (6). The strobe lamp enables seeming stopping the image and the direct reading of the angle.

Examinations were carried out on the prototype of the coupling with three different sets of disk springs. They made the selection of these sets on the way of earlier analysis of characteristics of disk springs arranged in all sorts of packages, creating sets. Sets were so well-matched, in order to at the established maximum torque, amounting M_{max} = 100 Nm, springs worked below the acceptable range of the work, i.e. 75 % of maximum bending.

Table 1 contains data concerning disk springs used in the coupling and sets which were put in it.

Tab. 1

Sets of disk springs used in the prototype coupling

Marking the examined coupling	Type of disk springs DIN 2093	Number of springs in the package	Number of packages in the set
Nr 1	50 x 25,4 x 3	2	18
Nr 2		3	13
Nr 3		4	10

Dynamic characteristics, is a relation between the amplitude of the torque M_{dyn} loading the coupling but the angle of the mutual turnover of coupling elements φ_{dyn}, at establishing, that while whirling of the entire driving arrangement together with the coupling, in the way periodically changeable is next value of the M_{dyn} torque being set at the simultaneous reading of value suiting them of the angle φ_{dyn} [8, 9, 10, 11].

On account of the specific structure of the coupling, the frequency of changes of load the coupling equal of 0.2 Hz and 0.5 Hz were accepted.

$$M_{dyn} = f\,(\varphi_{dyn}) \tag{1}$$

where: M_{dyn} – dynamic torque loading the coupling, Nm, φ_{dyn} – the dynamic relative angle of the turnover of elements of the coupling, radian or degrees.

3.1. Methodology of appointing the dynamic characteristics

While examining the coupling is whirling with the rotational constant velocity n_{obr} = 1470 min^{-1}. The torque M_{dyn}, loading the driving arrangement is, changed periodically, in the first variant as 5 sec., and in second what 2 sec., from value M_{dynmin} = 0 Nm to momentary value of the maximum amplitude of the torque M_{dynmax}. The momentary value of the amplitude of the moment is being changed with step 10 Nm, to value 100 Nm. The course of these changes is illustrating on picture 4.

The reading of the changing periodically torque and the reading and the recording answering to it of the relative rotation of coupling elements φ_{dyn},, is made with the help torque meter and pointers on the shield at applying the strobe lamp. Assurances of the correct reading of the angle, the registered image are for purpose behind the help of digital camera.

Periodically changeable torque $M_{dyn} = f(t)$, enables to get the dynamic characteristics of the susceptible coupling together with the loop of the hysteresis. The way of appointing characteristics was presented in picture 5.

Combining momentary values of the amplitude of the torque M_{dyn} with values suiting them of angles of the relative turnover of coupling elements φ_{dyn}, do we receive the characteristics of the coupling while growing of the torque $A'_1 – B'_1$, $A'_2 – B'_2$, $A'_3 – B'_3$ from value M_{dynmin} = 0 Nm to momentary value of the amplitude of the torque M_{dynmax}. While combining points of momentary value of the amplitude of the torque from points B_1, B_2, B_3 to C_1, C_2, C_3 with value suiting them of angles φ_{dyn}, do we receive the characteristics while tormenting the torque $B'_1 – C'_1$, $B'_2 – C'_2$, $B'_3 – C'_3$ from value M_{dynmax} to value M_{dynmin} = 0 Nm. Every next growing and tormenting the torque from points C_1, C_2, C_3 to B_1, B_2, B_3 etc., is characteristic of a work of the coupling along straight lines $C'_1 – B'_1$, $C'_2 – B'_2$ and $C'_3 – B'_3$.

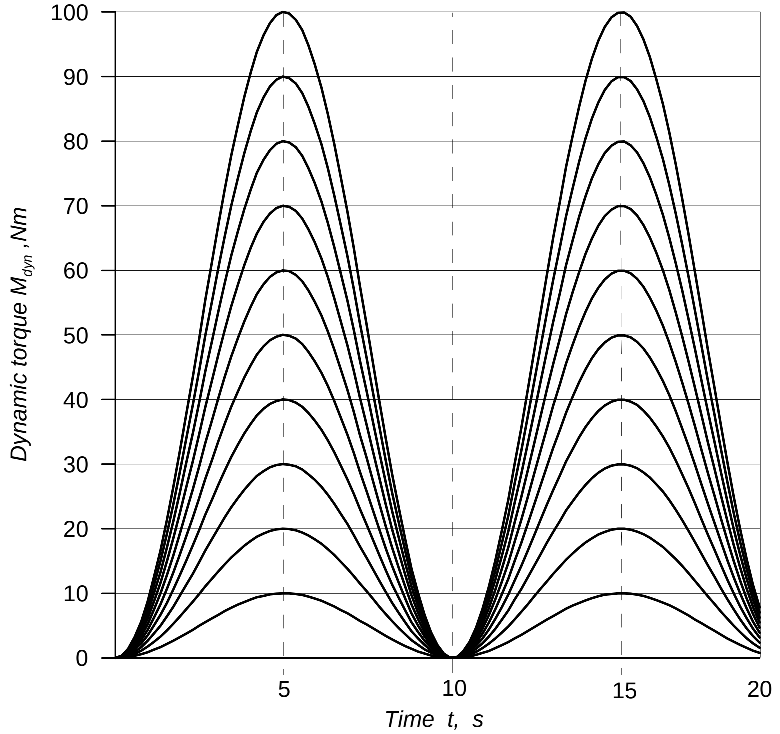

Fig. 4. Course of changes of the torque M_{dyn}, burdening the driving arrangement with the coupling
Rys. 4. Przebieg zmian momentu obrotowego M_{dyn}, obciążającego układ napędowy ze sprzęgłem

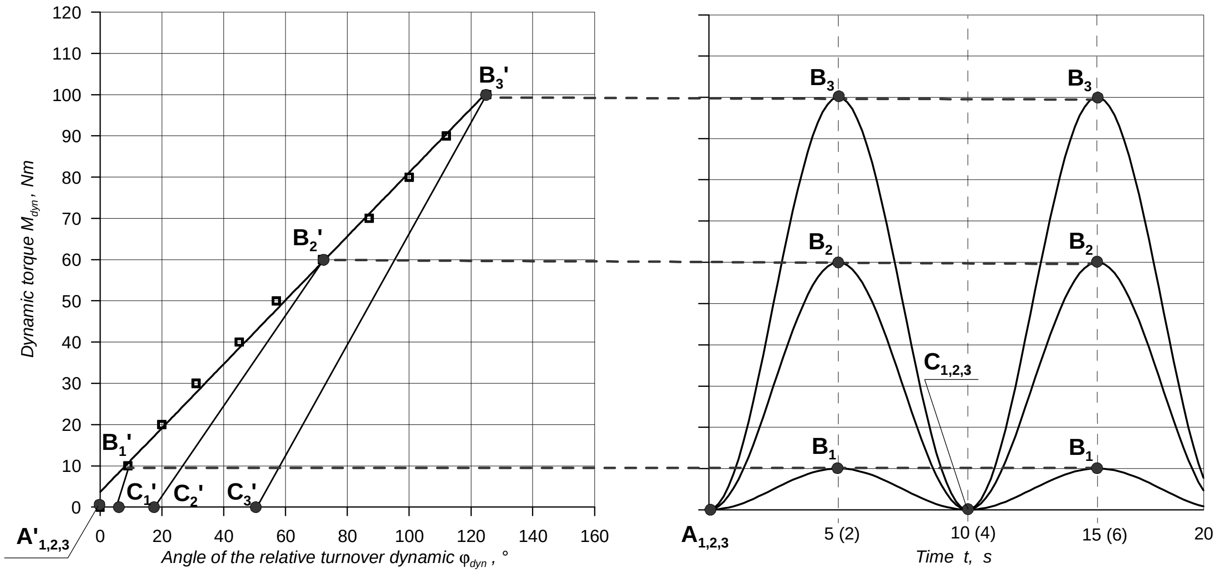

Fig. 5. Method of appointing the dynamic characteristics of the metal flexible torsional coupling
Rys. 5. Metoda wyznaczania charakterystyki dynamicznej metalowego sprzęgła podatnego skrętnie

3.2. Dynamic characteristics of the metal flexible torsionally coupling

On pictures from 6 to 8 dynamic characteristics of three options of the prototype of the metal flexible torsional coupling were presented.

a) b)

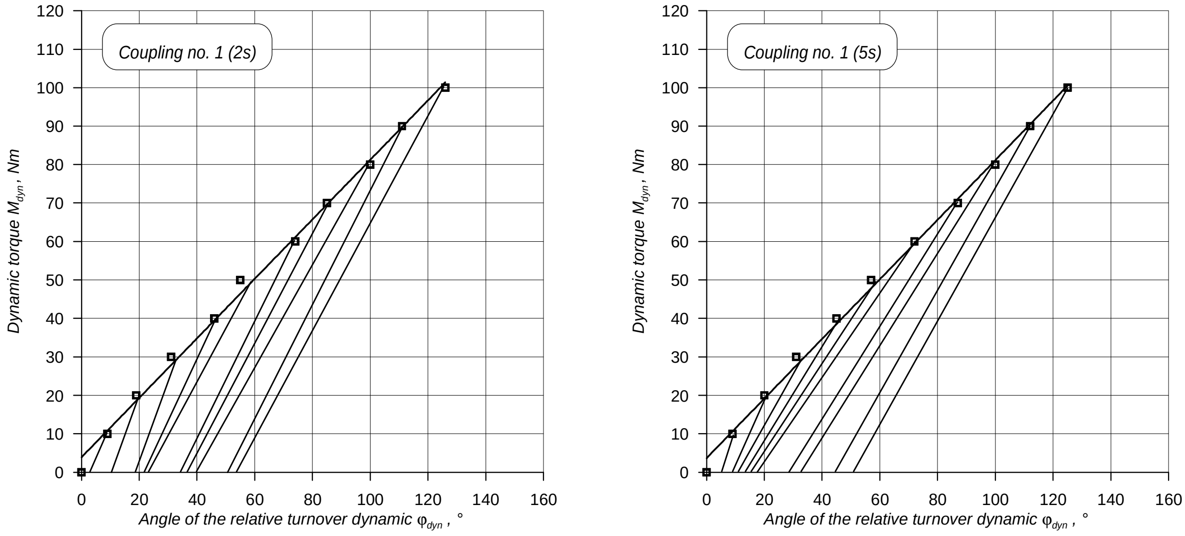

Fig. 6. Dynamic characteristics of the metal flexible torsional coupling No. 1, where: a – frequency 0.5 Hz (2 sec.), b – frequency 0.2 Hz (5 sec.)

Rys. 6. Charakterystyki dynamiczne metalowego sprzęgła podatnego skrętnie nr 1, gdzie: a – częstotliwość 0,5 Hz (2 s), b – częstotliwość 0,2 Hz (5 s)

a) b)

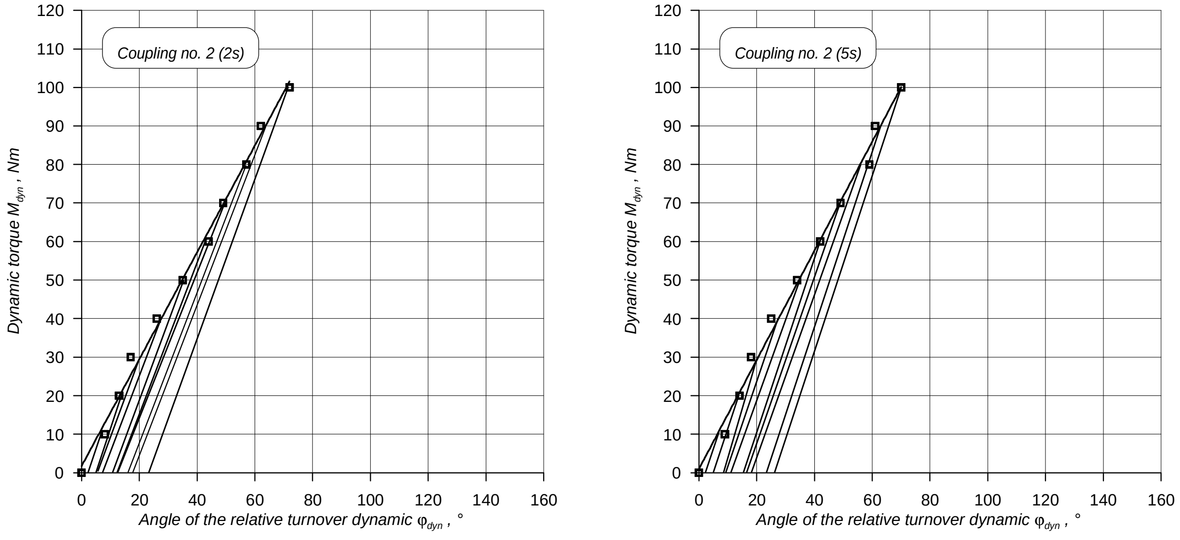

Fig. 7. Dynamic characteristics of the metal flexible torsional coupling No. 2, where: a – frequency 0.5 Hz (2 sec.), b – frequency 0.2 Hz (5 sec.)

Rys. 7. Charakterystyki dynamiczne metalowego sprzęgła podatnego skrętnie nr 2, gdzie: a – częstotliwość 0,5 Hz (2 s), b – częstotliwość 0,2 Hz (5 s)

a) b)

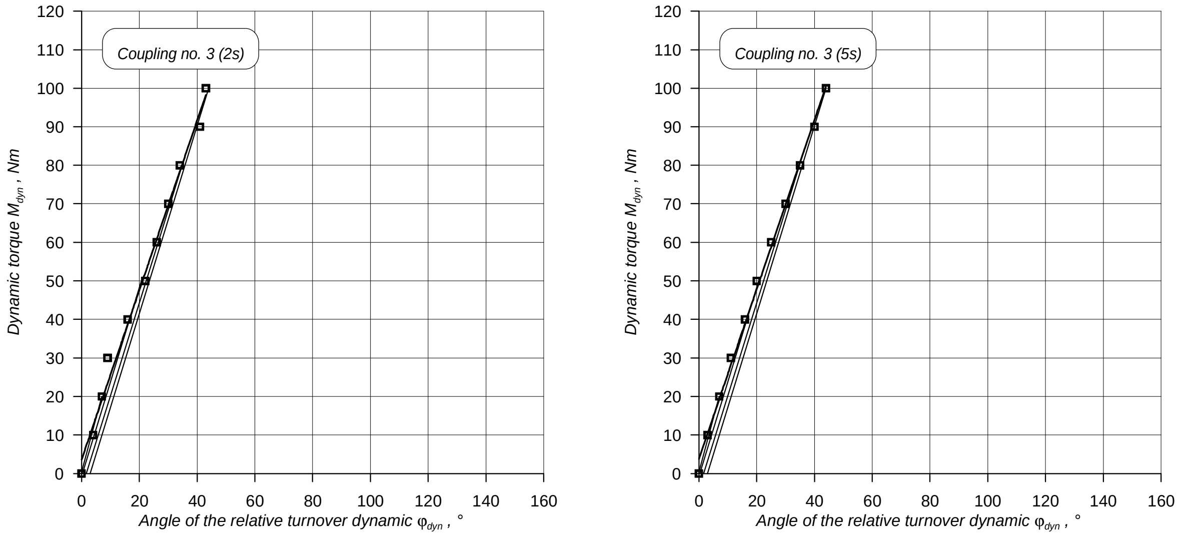

Fig. 8. Dynamic characteristics of the metal flexible torsional coupling No. 3, where: a – frequency 0.5 Hz (2 sec.), b – frequency 0.2 Hz (5 sec.)
Rys. 8. Charakterystyki dynamiczne metalowego sprzęgła podatnego skrętnie nr 3, gdzie: a – częstotliwość 0,5 Hz (2 s), b – częstotliwość 0,2 Hz (5 s)

In order to compare dynamic characterizations of the coupling, in picture 9, they were presented without taking the loop of the hysteresis into consideration.

a) b)

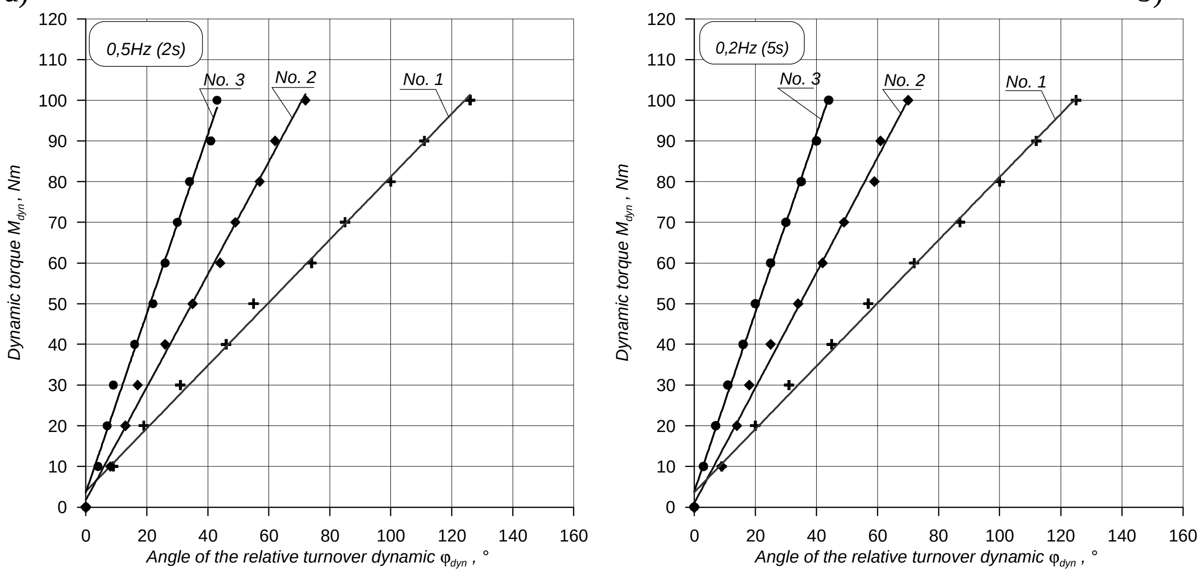

Fig. 9. Dynamic characteristics of three options of the metal flexible torsional coupling, where: a – frequency 0.5 Hz (2 sec.), b – frequency 0.2 Hz (5 sec.)
Rys. 9. Charakterystyki dynamiczne trzech opcji metalowego sprzęgła podatnego skrętnie, gdzie: a – częstotliwość 0,5 Hz (2 s), b – częstotliwość 0,2 Hz (5 s)

4. SUMMARY

Comparing dynamic characteristics at checked frequencies of changes of the torque: 0.2 Hz and 0.5 Hz show that registered differences between characteristics are slight. It is possible to put forward a motion, that as similarly as at static characteristics, these characteristics depend above all on design features of the coupling i.e. of type of the applied batch of springs and structural parameters of the screw mechanism and the splined connection, rather than from the frequency of coercions [2, 3, 5].

From described comparing characteristics static and dynamic, it results that their courses, defining the coupling stiffness *k*, they depend on the type of batches of disk springs put in the coupling, and more specifically from the stiffness c_{zest} of batch of springs.

However suppressing, expressed with damping coefficient ψ, depends from value of frictional contact appearing in the screw mechanism and from value of frictional contact in splined connection.

Above applications are taking the liberty of shaping characteristics of the coupling, in an optimal way selected to the type of the driven machine, directly through the selection of the appropriate set about given characteristics and the stiffness, with which it is possible straight to define springs into the way analytical at the stage coupled designs.

Similarly, there is a possibility of the appropriate selection of value of suppressing the coupling, through the selection of design features of the screw mechanism and splined connecting on the stage of designing it.

If necessary, it is possible to predict increasing damping coefficient ψ, by applying for example a controlled flow spreading oil by made holes in the movable element coupled. This flow can take place between the right and left side of the movable element to working spaces of the coupling. This solution can perform the role of the additional damper.

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