construction of machines; driving device; flexible coupling

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THE INFLUENCE OF THE METAL FLEXIBLE TORSIONAL COUPLING ON THE COURSE OF STARTING

Summary. The results of the investigations of the influence the metal flexible torsional coupling on the course of the starting, conducted on the investigative stand, makes up the experimental driving arrangement from installed studied flexible coupling were introduced in the work.

WPŁYW METALOWEGO SPRZĘGŁA PODATNEGO SKRĘTNIE NA PRZEBIEG ROZRUCHU

Streszczenie. W artykule przedstawiono wyniki badań wpływu metalowego sprzęgła podatnego skrętnie na przebieg rozruchu. Zostały one przeprowadzone na stanowisku badawczym, stanowiącym doświadczalny układ napędowy z zamontowanym, badanym sprzęgłem podatnym.

1. INTRODUCTION

The task of the flexible coupling in the driving arrangement this attenuate of the changes of the transferred torque which can come both from the driving motor, and from the external load of the working machine. The violent change of the torque can be softened through the flexible coupling. This process causes the decrease of the amplitude of the single impulses of the torque in the consequence of the absorption of the energy which in the flexible coupling the coefficient of suppression defines ψ. The condition of the correct work of flexible coupling in the driving arrangement choosing its profile to the drive is proper, through the correct selection of torsional rigidity k and the coefficient of suppression ψ. The course of changes of the softened torque has the character of damped vibrations [8, 9].

The suitable torsional susceptibility of coupling can assure the solution worked out at the Institute of Mining Mechanisation at the Silesian University of Technology. The various constructional figures construction of the metal flexible coupling was described stay in works [2, 3, 5, 6, 7].

In the aim of the identification of the reaction metal flexible torsional coupling on dynamic loads and delimitation of the course of the changes of the torque post investigations were conducted. The coupling was installed in the driving arrangement of the stand investigative, built at the Institute of Mining Mechanisation at the Silesian University of Technology, described in works [1, 4, 5].

2. STARTING OF THE DRIVING ARRANGEMENT WITH THE METAL
FLEXIBLE COUPLING

The investigations of metal flexible torsional coupling, they had on the aim delimitation of the course of the changes of the torque M_o coupling loading, as the reaction of driving arrangement on extortion formed during the electric motor starting, driving the investigative stand.

During the starting of the driving arrangement the overage surplus of the torque loading the coupling M_o exist, which is called out inertia driven elements suitably referred to the shafts of the active and passive side of coupling. On the value of the overage surplus of the moment, except the inertia of the elements of the stand, the direct influence also has torsional rigidity k and the coefficient of suppression ψ of flexible coupling [8, 9].

The illustration of the course of the changes of moment M_o transferred through the flexible coupling near the starting of the driving arrangement, are introduced on the drawing 1.

The maximum overage surplus of moments ΔM_{max} is defined, as the difference between the moment maximum M_{max}, transferred through the coupling during the starting, and the braking moment M_H, loading the driving arrangement with installed flexible coupling.
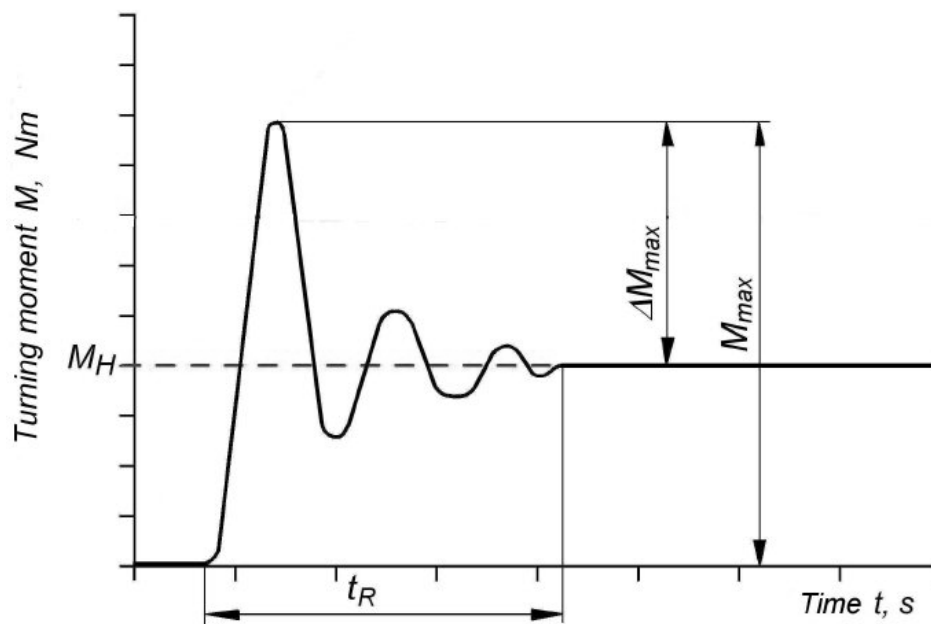
$$\Delta M_{max} = M_{max} - M_H \tag{1}$$

Fig. 1. The change of moment transferred through the flexible coupling near the starting of the driving
       arrangement
Rys. 1. Zmiany momentu przenoszonego przez sprzęgło podatne przy rozruchu układu napędowego

In the driving arrangement of the investigative stand, the moment of inertia I_1 makes up referred to the shaft the coupling the moment of masses being after the active side of the coupling and it comes from the inertia of the rotor of the asynchronous electric motor and elements of torque meter which turn together with the shaft. The value of this moment of inertia amount to $I_1 = 0{,}03 \text{ kg} \cdot \text{m}^2$.

On the passive side of a coupling the reduced moment of inertia I_H affects, the coming from the rotatory elements of the disc brake which is $I_H = 0{,}07 \text{ kg} \cdot \text{m}^2$.

Time since the moment of power-up of the electric motor to the point of stabilizing the course of the torque on the level of the value of the set braking moment M_H, it is defined, as the time of the starting t_R of the driving arrangement with the flexible coupling.

During the starting of the driving arrangement, the maximum angle of the relative turn of the modules of the coupling φ_{Rmax} was measured. The angle answers the values of the moment maximum M_{max} registered during the starting. The methodology of the measurement of the angle of the relative turn of modules coupling φ_{Rmax}, which was described stay in works [1, 4, 5].

During the realization cycle of investigations, it's having the aim of delimitation of the course of the changes of the torque coupling loading, occurring during the starting of the driving arrangement, the starting of the electric motor follows by the power supply the tension 380 V from omission of the arrangement of the switch the star-triangle. Such solution assures the quick and dynamic starting of the arrangement of the driving stand.

Additionally in next tests during the starting, the coupling is loaded the working braking moment M_H, produced through the brake the investigative stand. The whole course of the starting is measured in real time to help the torque matter and recorded through the measuring apparatus.

The measuring system also records in the real time, the course of the changes of the angle of the relative turn of coupling modules φ_R, answering the changes of the torque.

The inserted investigative programme found the execution of measurements for studied three options of the prototype of the metal flexible coupling. These options differed from the applied in the coupling set of the disk springs. The coupling no.1 it was characterizing the smallest torsional rigidity k however coupling no.3 the largest. The coupling no.2 it possessed indirect torsional rigidity.

Measurements were also conducted for the arrangement near the blocked flexible coupling. In this case all the elements of the driving arrangement were join by the help of rigid coupling.

Every option of the prototype coupling was studied near the sets following values of the braking moment M_H:

− $M_{H1} \approx 3$ Nm – the marking starting without the additional load, and the existing braking moment results from the resistances of troubling brake facings to the shield of the brake and the resistances of the movement in bearings,

− $M_{H2} \approx 35$ Nm,

− $M_{H3} \approx 45$ Nm.

The received values of the braking moment M_H result from the construction of the arrangement of the lever, burdening the hydraulic brake of the stand on which positions and the value of the weight were defined. The accepted during the preliminary investigations larger values of the braking moment, they made impossible the correct starting of the arrangement of the driving investigative stand.

3. RESULTS OF INVESTIGATIONS

First cycle of investigations hugged the starting of the driving arrangement with the coupling of no.1 near the load the braking moment $M_{H1} \approx 3$ Nm, $M_{H2} \approx 35$ Nm and $M_{H3} \approx 45$ Nm. On the figure 2 was introduced the registered course of the changes of the torque M_o coupling no.1 and the course of the changes of the angle of the relative turn of coupling modules φ_R during starting with the braking moment $M_{H1} \approx 3$ Nm. The value of the maximum moment amount to $M_{max11} = 40$ Nm. The time of the starting t_R of the driving arrangement even is $t_{R11} = 1,330$ s. In the moment the maximum torque M_{max}, the relative angle of the turn of coupling modules amounts to $\varphi_{Rmax11} = 55°$. The maximum value of the overage surplus of the moment was $\Delta M_{max11} = 37$ Nm.

Figure 3 represents the starting of the arrangement with the same the coupling no.1, near the load the braking moment $M_{H2} = 35$ Nm. The value of the maximum moment in this case amount to $M_{max21} = 58$ Nm. The time of the starting of the driving arrangement even is $t_{R21} = 1,500$ s, and in the moment of the maximum torque, the relative angle of the turn of coupling modules amounts to $\varphi_{Rmax21} = 73°$. The registered maximum value of the overage surplus of the moment is smaller than previous and amount to $\Delta M_{max21} = 23$ Nm.
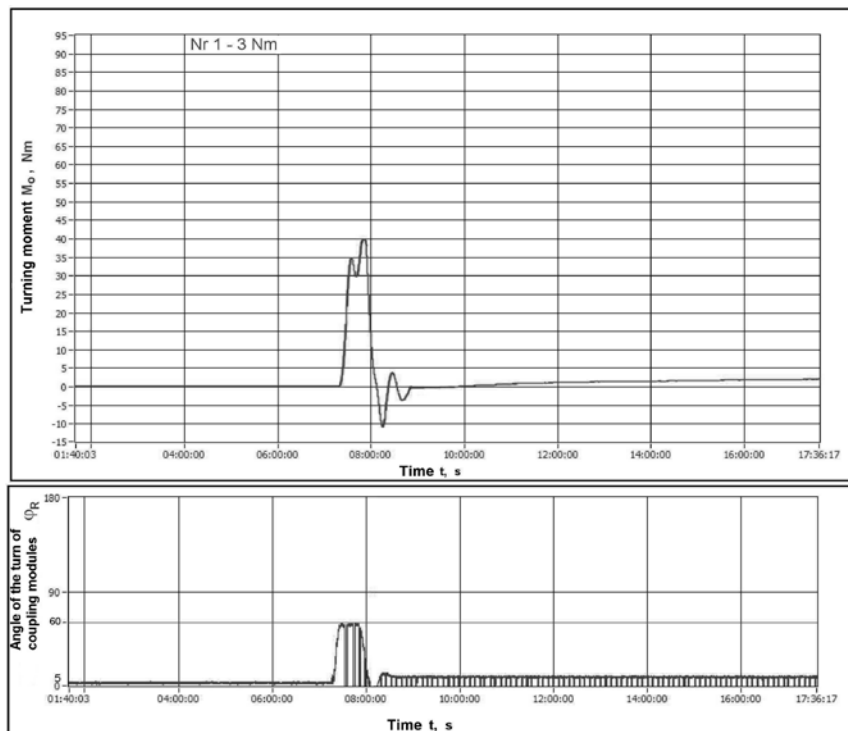
Fig. 2. The course of the changes of torque M_o during the starting of driving arrangement and the angle of the
relative turn of modules φ_R coupling the No. 1 and $M_{H1} = 3$ Nm

Rys. 2. Przebieg zmian momentu obrotowego M_o podczas rozruchu układu napędowego oraz kąta względnego
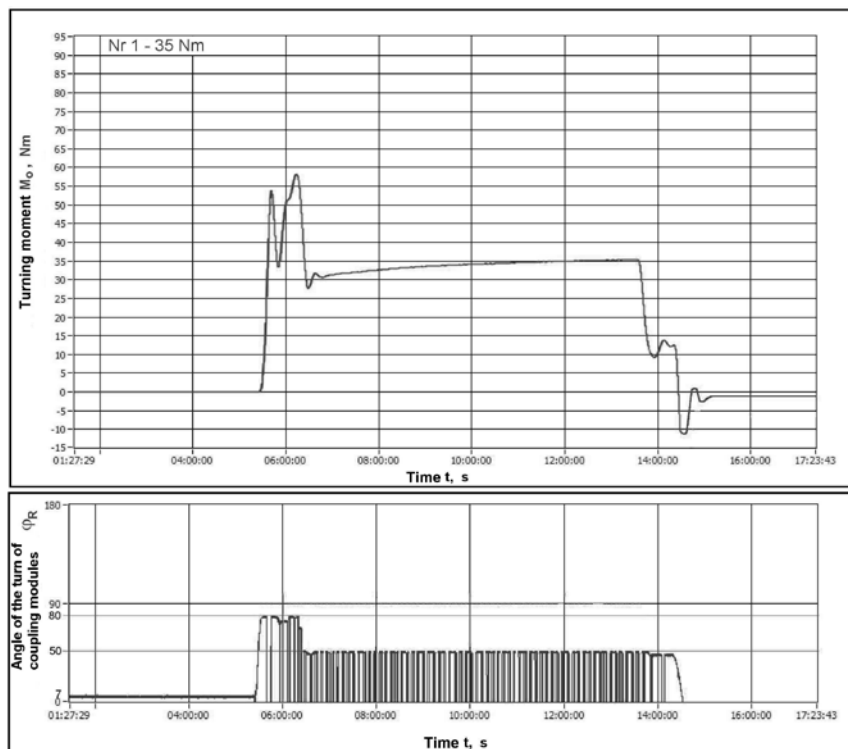obrotu członów φ_R sprzęgła Nr 1 i $M_{H1} = 3$ Nm

Fig. 3. The course of the changes of torque M_o during the starting of driving arrangement and the angle of the
relative turn of modules φ_R coupling the No. 1 and $M_{H2} = 35$ Nm

Rys. 3. Przebieg zmian momentu obrotowego M_o podczas rozruchu układu napędowego oraz kąta względnego
obrotu członów φ_R sprzęgła Nr 1 i $M_{H2} = 35$ Nm

The registered course of the starting of the arrangement on the figure 4, was introduced with the coupling of no.1, near the load the braking moment $M_{H3} = 45$ Nm. The value of the maximum moment increased to the value $M_{max31} = 63$ Nm. The time of the starting t_R of the driving arrangement extended and amount to $t_{R31} = 1,750$ s. The maximum relative angle of the turn of coupling modules was $\varphi_{Rmax31} = 90°$. The maximum value of the overage surplus of the moment is smaller than previous and amount to $\Delta M_{max31} = 23$ Nm.

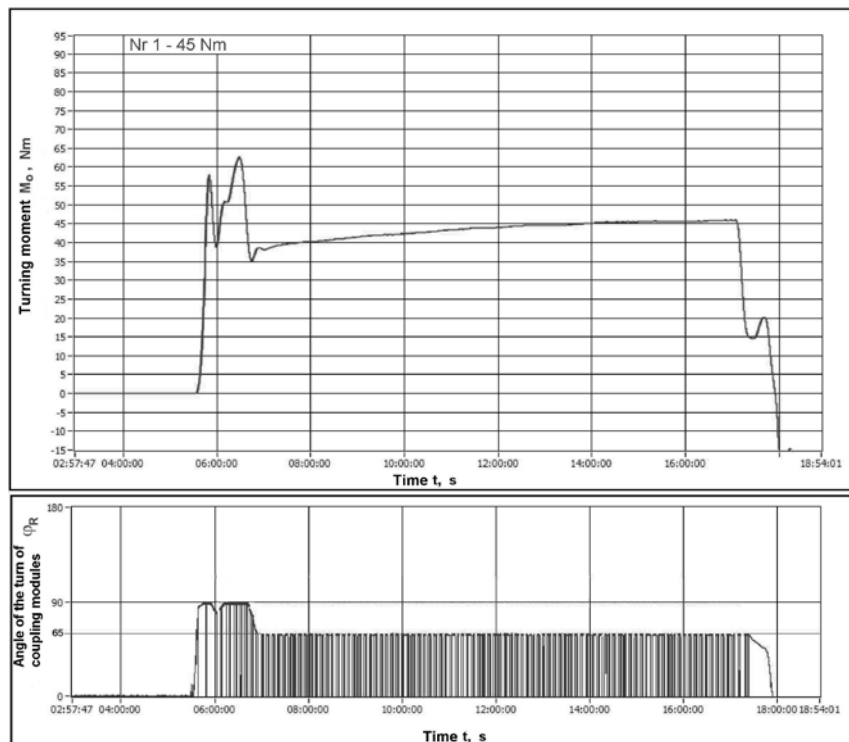Fig. 4.   The course of the changes of torque M_o during the starting of driving arrangement and the angle of the relative turn of modules φ_R coupling the No. 1 and $M_{H3} = 45$ Nm

Rys. 4.   Przebieg zmian momentu obrotowego M_o podczas rozruchu układu napędowego oraz kąta względnego obrotu członów φ_R sprzęgła Nr 1 i $M_{H3} = 45$ Nm

The courses of the changes of the torque M_o were registered in the order the coupling no.2 and coupling no.3, for the braking moments $M_{H1} \approx 3$ Nm, $M_{H2} \approx 35$ Nm and $M_{H3} \approx 45$ Nm. Similarly as the coupling no.1, together with the growth of the braking moment M_H, the value of the maximum moment M_{max}, the value of the relative angle of the turn of coupling modules φ_{Rmax} in the moment of the maximum torque and value the time of the starting t_R of the driving arrangement, undergoes the change. The appointed maximum value of the overage surplus of moments ΔM_{max} also undergoes the change. Character and tendency of registered changes in the couplings of no.2 and no.3 there is such as in the coupling of no.1.

The aim of comparison and the identification of the influence of parameters of the metal flexible coupling on the starting driving arrangement, conduct investigations and register the courses of the torque M_o than, near the blocked flexible coupling clutch. The blockade of the metal flexible coupling is possible, thanks to the additional special shield blocks, placed among cover and the entrance shaft. In this case, all elements of the arrangement of the driving investigative stand are join by the help of rigid couplings.

The value of the overage surplus of the load of motor during starting is the characteristic coefficient which can illustrate the working of the coupling. The time of the starting of the driving arrangement under the load can characterize the coefficient of the overload of the motor K_{RO} which one knowing

moment maximum M_{max} and load in the form of the braking moment M_H can mark, according to dependence:

$$K_{RO} = \frac{M_{max}}{M_H}$$

(2)

In the table 1 take down the received on the basis of investigations results of measurements: maximum torque M_{max} acting on the flexible coupling during the starting, the given braking moment M_H, making up the load of the driving arrangement, the time of starting t_R and the angle of the relative turn of coupling modules φ_R. Table complete the counted values of the coefficient of the overload of motor during the starting of the driving arrangement K_{RO} and the value of the maximum overage surplus of moments ΔM_{max}.

Table 1

The results of the measurements of the starting of the driving arrangement
with the metal flexible coupling

Coupling	Braking moment M_H, Nm	Maximum torque of starting M_{max}, Nm	Maximum overage surplus of moments ΔM_{max}, Nm	Coefficient of the overload during the starting K_{RO}	Time of the starting t_R, s	Maximum angle of the turn of coupling modules φ_{Rmax}, °
No. 1	3	40	37	(13)	1,330	55
	35	58	23	1,66	1,500	73
	45	63	18	1,40	1,750	90
No. 2	3	45	42	(15)	1,250	33
	35	62	27	1,80	1,330	55
	45	65	20	1,44	1,550	60
No. 3	3	48	45	(16)	1,160	25
	35	66	31	1,89	1,250	30
	45	73	28	1,62	1,420	35
rigid coupling	3	60	57	(20)	0,830	----
	35	75	40	2,14	1,160	----
	45	80	35	1,78	1,250	----

Next figures from 5 to 8 illustrate setting dependences between the measure values of quantity in the board 1, for three studied options of metal flexible coupling.
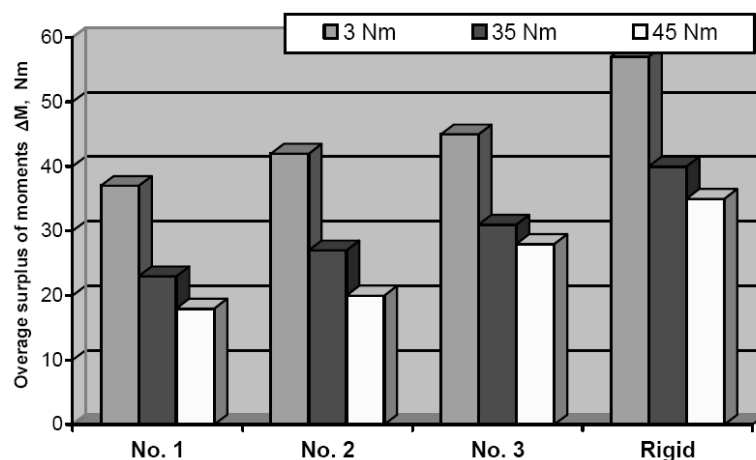

Fig. 5. The illustration of the changes of the maximum overage surplus of moments ΔM_{max} during the starting of the driving arrangement
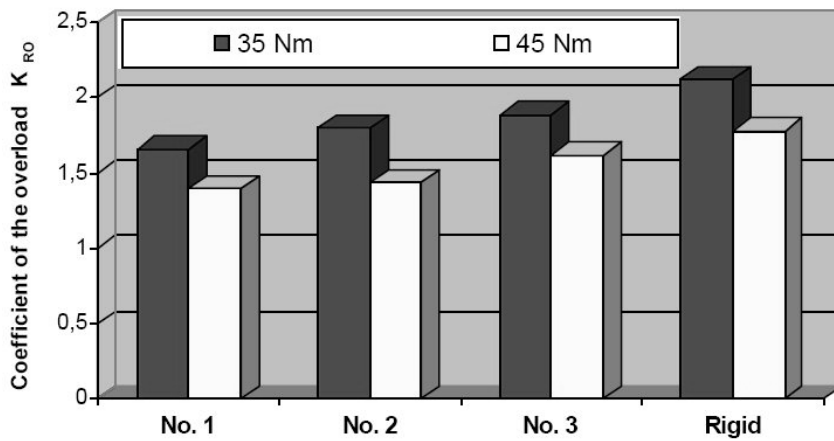Rys. 5. Ilustracja zmian maksymalnej nadwyżki momentów ΔM_{max} podczas rozruchu układu napędowego

Fig. 6. The illustration of the changes of the coefficient of the overload coupling K_{RO} during the starting of the driving arrangement

Rys. 6. Ilustracja zmian współczynnika przeciążenia sprzęgła K_{RO} podczas rozruchu układu napędowego
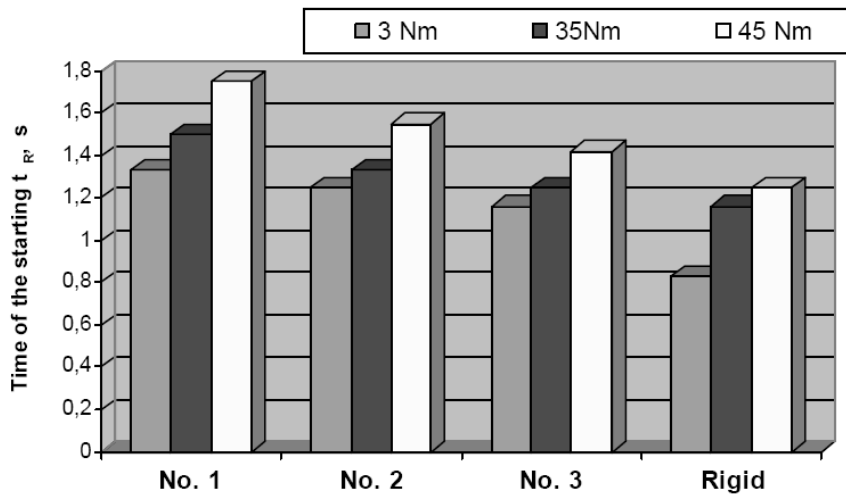

Fig. 7. The illustration of the changes of the time of starting t_R of the arrangement of the driving investigative stand with the coupling

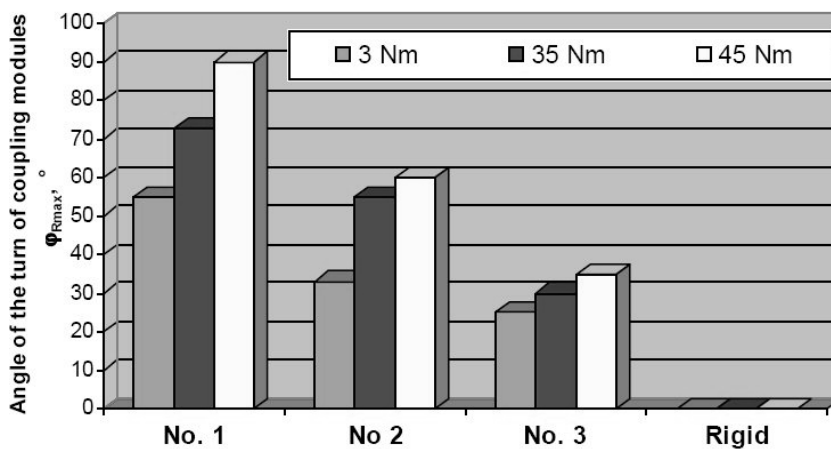Rys. 7. Ilustracja zmian czasu rozruchu t_R układu napędowego stanowiska badawczego ze sprzęgłem

Fig. 8. The illustration of the changes of the maximum angle of the turn of coupling modules φ_{Rmax} during the starting of the arrangement of the driving investigative stand

Rys. 8. Ilustracja zmian maksymalnego kąta obrotu członów sprzęgła φ_{Rmax} podczas rozruchu układu napędowego stanowiska badawczego

4. FINAL CONCLUSIONS

The analysis of the results of measurements, get during the investigations the starting the arrangement the driving investigative stand from installed metal flexible torsional coupling, it allows to formulate the following conclusions:

−   in studied flexible couplings, the maximum overage surplus of the moment ΔM_{max} grows up together with the growth of torsional rigidity k of the coupling (no.1 < no.2 < no.3), however it diminishes together with the growth of the load of the driving arrangement the braking moment M_H (Fig. 5).
−   the coefficient of the overload K_{RO} marked during the starting of the driving arrangement grows up together with the growth of torsional rigidity of flexible coupling, and diminishes with the growth of the braking moment M_H (Fig. 6).
−   the time of the starting t_R diminishes   together with the growth of torsional rigidity k of the coupling , however it grows up, from the growth the value the braking moment M_H, is which the loaded driving arrangement of the investigative stand (Fig. 7).
−   the maximum angle of the relative turn φ_{Rmax} of modules of the metal flexible torsional coupling it increases together with the growth of the load of the driving arrangement to the braking moment M_H, and diminishes together with the growth of torsional rigidity k of the coupling (Fig. 8).

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