Krzysztof SICZEK[*], **Maciej KUCHAR**[**]

RESEARCH ON THE TRIBOLOGICAL PARAMETERS FOR MATERIALS COUPLES USED FOR VALVES, VALVE GUIDES AND SEAT INSERTS

BADANIA PARAMETRÓW TRIBOLOGICZNYCH SKOJARZEŃ MATERIAŁÓW STOSOWANYCH NA ZAWORY, PROWADNICE I GNIAZDA

Key words:

TiAl alloys, valve, valve guides, seat insert, tribotester, model

Słowa kluczowe:

stop TiAl, zawór, prowadnica, gniazdo, tribotester, model symulacyjny

Summary

Research on the tribological properties of TiAl alloys used for valves mating with valve guides and seat inserts, made of cast iron, has been done. The aim of the research has been to obtain values of the coefficient of friction for such tribological pairs and to simulate the dynamics of the

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[*]　The Chair of Precise Design, Technical University of Lodz.
[**]　Department of Vehicles and Fundamentals of Machine Design, Technical University of Lodz.

material sample – rotating plate assembly, characteristic used in the research stand. The modified research stand is presented in the article. During research the values of the coefficient of friction, the temperature of sample, the level of sound and the acceleration of material sample were measured. The model of the research stand was for the simulation of the dynamics for the material sample – rotating plate assembly. The plots of the coefficient of friction vs. loading, slide velocity, and the duration of the motion of material sample in respect to the rotating plate are presented in the article. Using simulation results, the values of the damping coefficient were estimated, which allow one to obtain the value for the amplitude of the modelled motion for the material sample in respect to the rotating plate near to the value of the amplitude for the real motion. This estimation allows one to forecast the dynamics of the mentioned assembly for other values of velocity and loading.
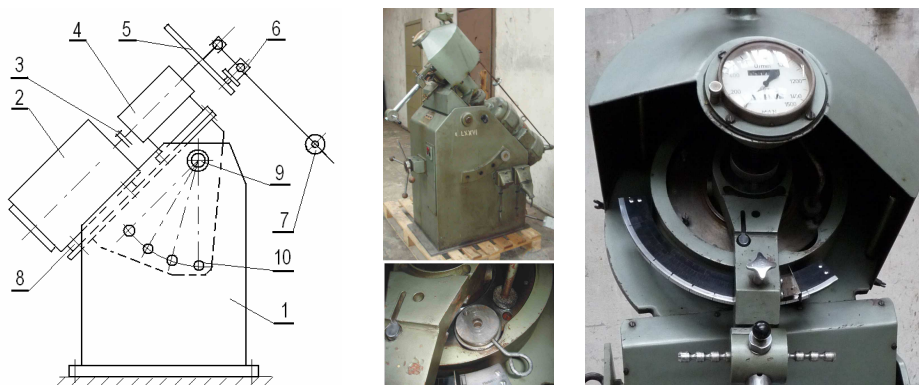
Fig. 1.   MAN tribotester: 1 – case, 2 – motor, 3 – coupling, 4 – bearing of plate, 5 – plate, 6 – sample holder, 7 – weights, 8 – cantilever, 9 – axis of cantilever, 10 – blocking

Rys. 1.   Tribotester MAN: 1 – korpus, 2 – silnik, 3 – sprzęgło, 4 – ułożyskowanie tarczy, 5 – tarcza, 6 – uchwyt próbki, 7 – obciążniki, 8 – wspornik, 9 – oś wspornika, 10 – blokada

RESEARCHES ON THE MAN TRIBOTESTER

Research conditions

All researches have been made on the MAN tribotester. The first analyzed sample has been made of Ti6Al4V alloy. Its diameter and height

have been equal 12.5 mm. The sample has mated with the plate made of cast iron GJL250 (with 1.2% Cr), rotating with 200 rpm.

The second analyzed sample has been made of TiAl6Zr4Sn2Mo2 alloy. Its diameter has been equal 5.98 mm and height has been equal 12.5 mm. The sample has mated with the rotating plate made of cast iron GJL250 (with 1.2% Cr), rotating with (200–1000) rpm.

The loading for each sample has been equal 22 N. The contact couple has been lubricated by kerosene. The initial value of environment temperature has been equal 294.5 K. The roughness of sample has equaled Ra = 0.8 µm and of the plate has equaled Ra = 0.68 µm.
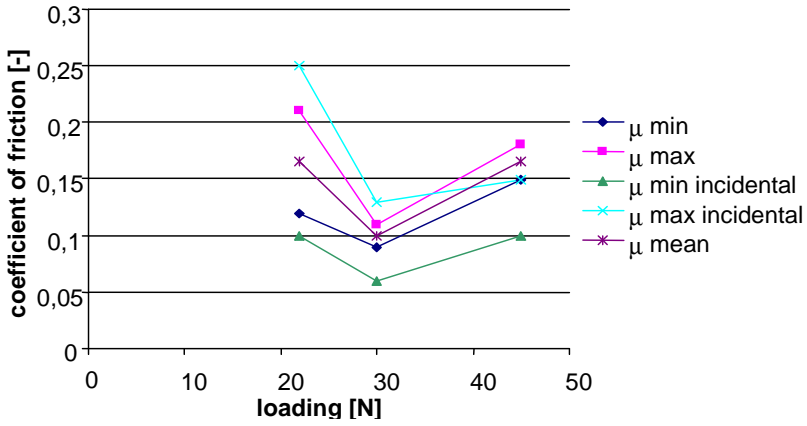
Results of researches

Results of friction force, acceleration of the sample in respect to the plate, of sound level, have been presented in **Fig. 2–6**, for Ti6Al4V, in **Fig. 7** – 10 for TiAl6Zr4Sn2Mo2.
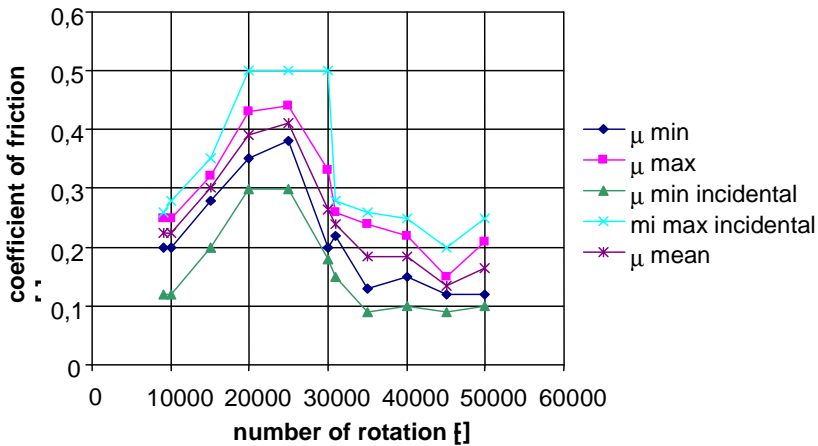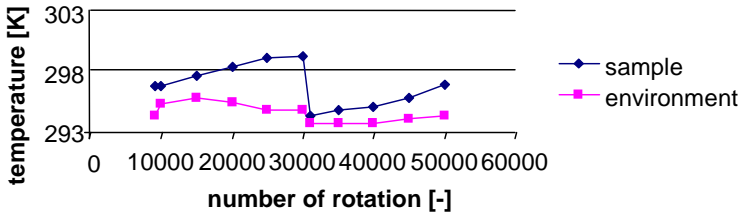

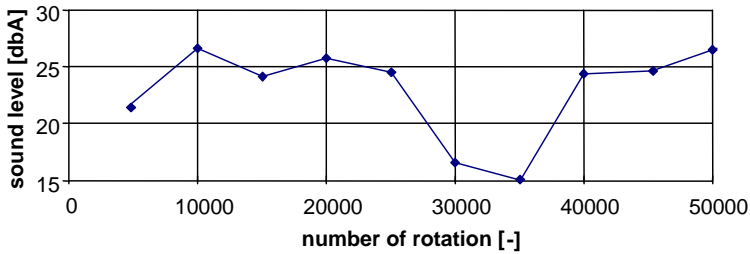**Fig. 2.**   **The measured coefficient of friction vs. number of rotation**
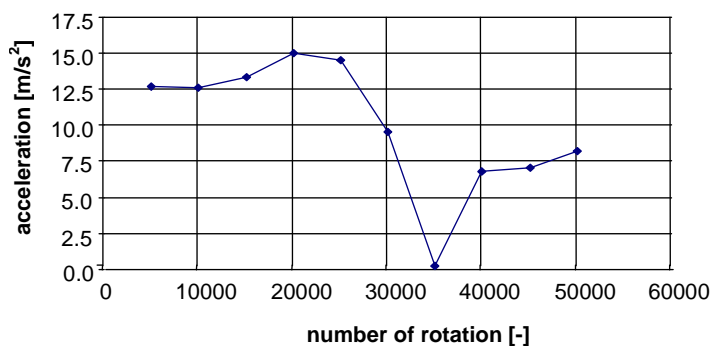Rys. 2.   Mierzony współczynnik tarcia w funkcji liczby obrotów

Fig. 3. The measured coefficient of friction vs. loading of sample
Rys. 3. Mierzony współczynnik tarcia w funkcji obciążenia próbki

Fig. 4. Measured temperature of sample vs. number of rotation
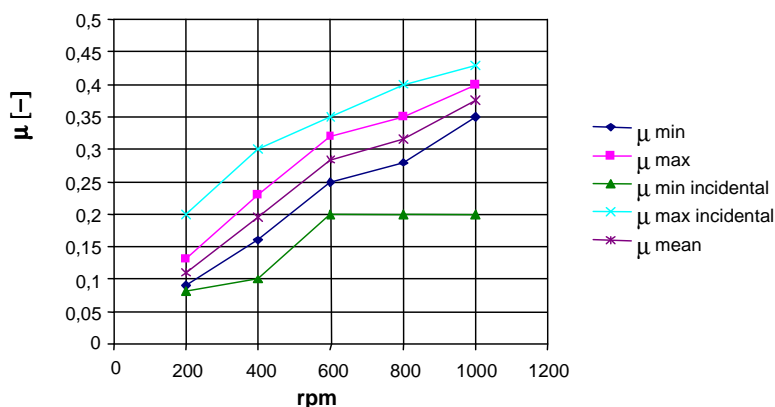Rys. 4. Mierzona temperatura w funkcji liczby obrotów

Fig. 5. The difference between the measured and of the environment sound level vs. rotation
Rys. 5. Różnica między poziomem hałasu zmierzonym i otoczenia w funkcji liczby obrotów
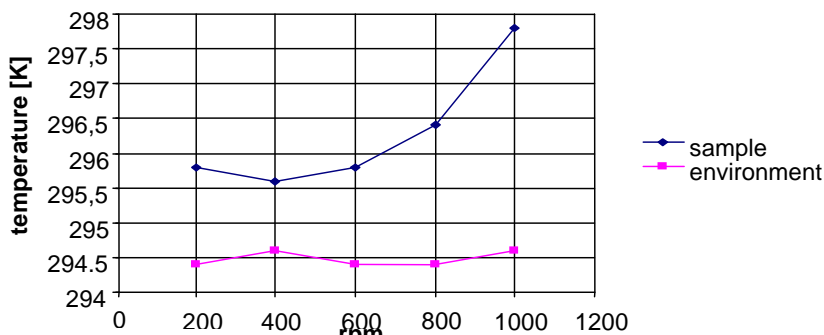
Fig. 6.　Mean acceleration of sample in respect to rotating plate vs. number of rotation

Rys. 6.　Średnie przyspieszenie próbki względem wirującej tarczy w funkcji liczby obrotów
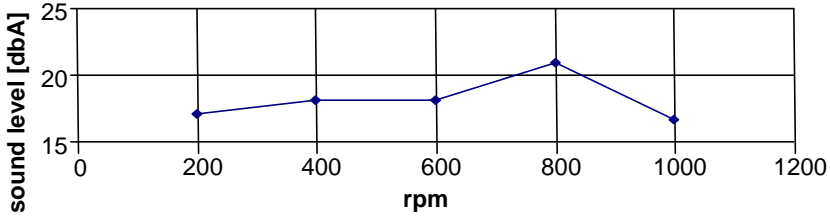

Fig. 7.　The measured coefficient of friction vs. plate rpm

Rys. 7.　Mierzony współczynnik tarcia w funkcji liczby prędkości obrotowej tarczy

Fig. 8.　Measured temperature of sample vs. plate rpm

Rys. 8.　Mierzona temperatura próbki w funkcji liczby prędkości obrotowej tarczy

Fig. 9. **The difference between the measured and of the environment sound level vs. plate rpm**

Rys. 9.   Różnica poziomów hałasu mierzonego i otoczenia w funkcji prędkości obrotowej
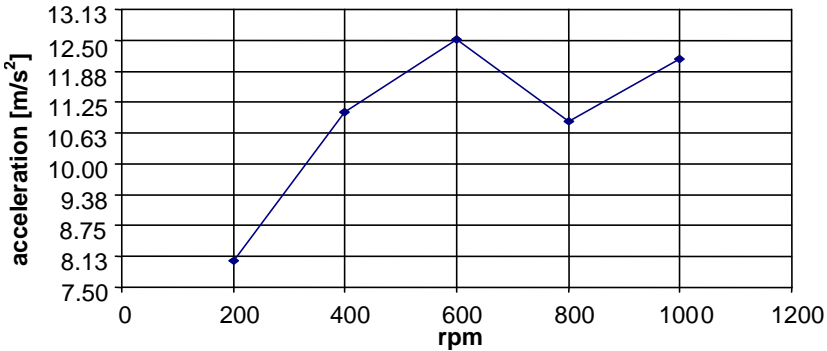
Fig. 10. Mean acceleration of sample in respect to rotating plate vs. plate rpm

Rys. 10. Średnie przyspieszenie próbki względem tarczy w funkcji jej prędkości obrotowej

SIMULATION

The model of research stand, (**Fig. 11**), similar to [**L. 2**], has been elaborated for the simulation of dynamic parameters for the material sample – rotating plate assembly. Basing on simulation results the values of damping coefficient have been estimated (c = 10 N·s/mm), which allow to obtain the value for the amplitude of the modeled motion for the material sample in respect to the rotating plate near to the value of the amplitude for the real motion. The estimation of such damping coefficient allows to forecast the dynamic parameters of the mentioned earlier assembly for other values of slide velocity and loading.
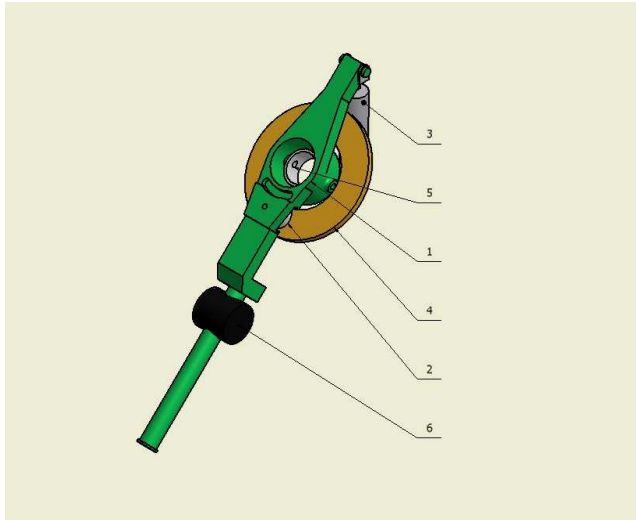
Fig. 11.　MAN model: 1 – lever, 2 – sample, 3 – contraweight, 4 – plate, 5 – bearing, 6 – weight

Rys. 11. MAN model: 1 – wahacz, 2 – próbka, 3 – odciążnik, 4 – tarcza, 5 – łożyska, 6 – ciężar

Simulation results for the TiAl6Zr4Sn2Mo2, mating with the plate rotating with 1000 rpm have been shown in **Fig. 12–14**. The dependency for the coefficient of friction between sample and plate vs. velocity of sample in respect to the plate, has been shown in the **Fig. 15**.
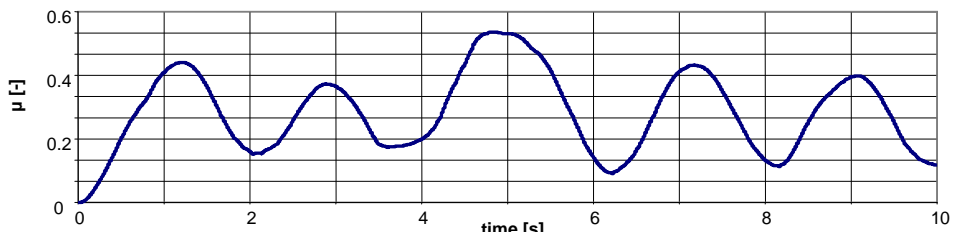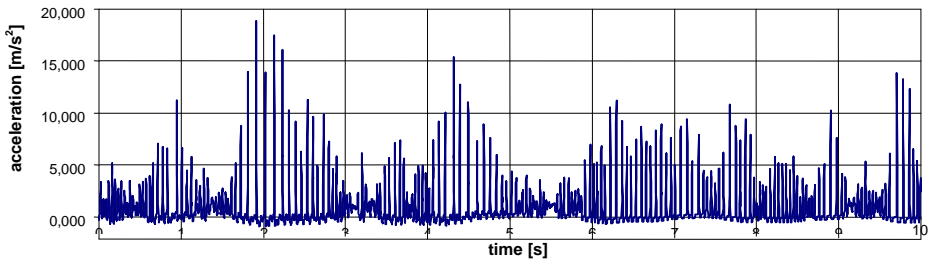

Fig. 12.　The coefficient of friction between the sample and the rotating plate vs. time

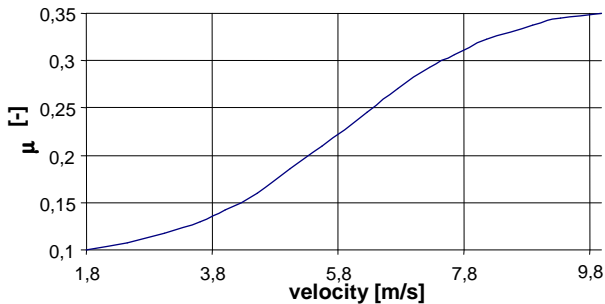Rys. 12. Współczynnik tarcia między próbką i wirującą tarczą w funkcji czasu
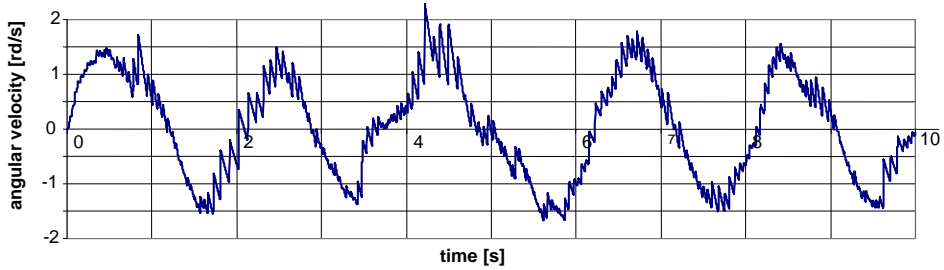
Fig. 13. The angular velocity of the sample in respect to the rotating plate vs. time
Rys. 13. Prędkość kątowa próbki względem wirującej tarczy w funkcji czasu

Fig. 14. The tangent acceleration of the sample in respect to the rotating plate vs. time
Rys. 14. Przyspieszenie prostopadłe próbki względem wirującej tarczy w funkcji czasu

Fig. 15. The coefficient of friction between sample and plate vs. velocity of sample
Rys. 15. Współczynnik tarcia między próbką i tarczą w funkcji prędkości próbki

CONCLUSION

1. The coefficient of friction between sample made of Ti6Al4V alloy and rotating plate made of cast iron has changed with the increase of number of rotation. After initial increasing up to 0.4, it has decreased below 0.2. The first increasing could result from permanent wear of

friction couple. Next the observed wear debries of cast iron mixed with kerosine could make the kind of the tribological film, what could allow to decrease the coefficient of friction.

2. The coefficient of friction between Ti6Al4V sample and rotating plate has initially decreased with increase of loading – the contact area has been greater due plastic deformation. Next the wear debries could increase the coefficient of friction with the increase of loading.

3. The measured and simulated coefficient of friction between TiAl6Zr4Sn2Mo2 sample and rotating plate has increased with the increase of plate rpm. It could be caused by centrifugal force acted on the kerosene, making smaller portion of hydrodynamic friction.

REFERENCES

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Streszczenie

Przeprowadzono badania własności tribologicznych stopów TiAl, używanych dla zaworów współpracujących z żeliwnymi prowadnicami i gniazdami. Celem badań było uzyskanie wartości współczynnika tarcia dla tych par ciernych i symulacja dynamiki układu próbka materiału–wirująca tarcza, odpowiadającej wykorzystywanemu stanowisku badawczemu. W artykule przedstawiono zmodyfikowany tribotester typu pin-on-disc. Podczas badań mierzono wartości współczynnika tarcia, temperatury próbki, poziomu hałasu i przyspieszenia próbki materiału, a ich zależności od prędkości, obciążenia i liczby obrotów przedstawiono na wykresach. Opracowano model tribotestera do symulacji parametrów dynamicznych układu

próbka materiału–wirująca tarcza. W oparciu o wyniki symulacji oszacowano wartości współczynników tłumienia, pozwalające uzyskać symulowana amplitudę ruchu próbki względem wirującej tarczy zbliżoną do amplitudy rzeczywistego ruchu. Określenie tego współczynnika tłumienia pozwala przewidywać parametry układu przy innych wartościach prędkości i obciążenia.