FOLIA FORESTALIA POLONICA
Seria B, zeszyt 27, 1996

ALDER WOOD AND ITS COMPOSITES AS A TRIBOLOGICAL MATERIAL APPLIED IN KINEMATIC PAIR WITH STEEL AND CAST IRON

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In spite of common applying in machine tools construction ball bearings, there are still on used and investigated plain bearings particulary in all these solutions, where is possible take advantage of their quality. Willingly they are used in working machines friction centres, creating a kinematic pair repeatedly very vast materials. Conducted investigations aim at modification and followly association such two materials, which - from angle of working centre tribology, assure the lowest values of friction coefficient.

Performed investigations were executed with samples of alder wood and its two composites making a kinematic pair with counter - sample of steel and cast iron.

Key words: Tribology, composite, treatment, friction, friction coefficient, counter - sample.

INTRODUCTION

Mutual motion two solid bodies accompany always friction, which counteract to this movement. In machine - tools the friction occurs generally is suitable to this goal elements, such like bearings, guides, etc.

Energy losses brought about with the friction are significant and very often not enough appreciated.

One asses, that about 70% of fetched to working machine energy is returnless lost only because of friction. The losses caused with this process, load significantly the economical balance of country. It is estimated, that summary losses because of friction, wear and failure amount in Poland about 1 milliard $ yearly. For compare, in USA - 16,25 milliards $ (Ścieszka 1995).

In mechanical engineering a plain bearing is the most intensive wearing element. Friction occuring in such construction is very far away from ideal one, which is fluid friction. Used rotational speed of shafts and applied machining technology of raw material forces interrupted, at least variable duty cycle of working machine tool. Reached in bearing this way friction is the most often a semi-fluid one, what brings about hasten wear of its components. That became a reason of a troublesome scientific inquires for the purpose in search the perfect and cheaper materials (Annienkov 1974, Biełyj et al. 1984) which can be appropriated for a friction - centres construction in working machines, especialy self - lubricating elements in slide bearings. This subject has a particular meaning, when we take into consideration the noxiousness of working conditions of plain bearing, occuring e.g. in chemical or food industry. And aggressive can be also surroundings with a high mineral dust concentration or natural origin (an example in wooden industry). Moreover, hazardous for a bearing work there are also the zones with an elevated temperature in centre, as well high humidity (Ścieszka 1995).

Bearing materials used up to now were based generally on zinc, lead and copper. They create a group so called white metals or babbits. Because of a limited stock these elements in the crust of the earth, we observe their regular increment of price, what has a bearing on a final cost of bearings. Besides, their slide properties are insufficient in dry and semi - fluid friction.

So popular materials like steel and cast - iron have lost already a lot of their attractiveness because of high sensitivity, when the lubrication system is not enough efficient, what can appear a bearing sleeve seizing.

Thus, the scientists began to search another materials and new construction slide bearings. This mean appeared multilayer materials, throughout advanced. The base for these bearings made an iron ribbon, on which were fixed with epoxide and phenolic resins such materials like: iron cotton, asbestos fibres, cloth of teflon threads, copper wire, bronze wire and babbit's wire gauze and everyone treated with polymers (PTFE or PA) (Biełyj 1976). Unfortunately it didn't protect this construction against faults, like high sensitivity on mineral origin polutions (Bugajski 1984).

Advanced constructions have been created on the base of iron and non - iron ferrous metal sinters. They are so called porous materials. Despite of their satisfied properties, unfortunately they characterize an elevated structure brittlenes especially on the edges. The other fault of this bearing there is too small stock of lubricant in capillaries.

Scientists activities go in two directions: first - to improve a lubricant properties and its chemical composition, second - develop a new, unconventional methods for slide bearings lubrication. Since a short time there is known gas and magnetic lubrication. In gas bearings, as a carrier supporting a rotary neck it is used a compressed air, which supplied to a friction centre under a high pressure brought about a convection and flow round on the whole circumference of neck. This solution requires still to fulfil one important and troublesome condition: high tightness a bearing chamber, what is connected with its great exactitude and high expenses (Kazimierski and Krysiński 1981). It is possible to realize, but ratio betweem our costs and obtained effects is very disadvantageous. The second kind of bearings to make the most a magnetic field for the reason to mutual separation rotaring shaft in relation to stationary housing. Lubricant - fluid metal, has to be an electricity conductor. In consequence of variable magnetic field, which interact with lubricant it follows a neck convection. This method is very expensive, applied in nuclear engineering, but totaly unprofitable in machine tools construction (Lawrowski 1993).

Another materials applied on slide elements, cheaper than described above and every now and again more often utilized, that are plastics and wood based materials.

In the literature concerning tribology, very often is met an opinion, that because of their advantageous self - lubricating properties, practicaly unlimited raw - material base and broad impregnation possibility, they will become the most utilized bearing materials (Biełyj et al. 1987, Bobrysheva et al. 1987, Chubov and Chubov 1981, Dimitrienko et al. 1991, Jermakov and Susłov 1991, Niemogaj et al. 1987, Ławniczak 1987, Prinazarkov 1991, Rudnicki 1990, Vrublevskaja et al. 1991, Wieloch 1988).

However, if we intend to use them rationaly in friction centres of slide bearings, it is indispensable to continue investigations of their tribological properties in various service conditions.

In our department there are conducted researches for a few years, which aim to explanation the questions connected to tribology of kinematic pair: treated wood - steel or cast iron (Kruszewski et al. 1995 a i b) .

The aim of presented investigations there was a determination a friction coefficient of natural alder wood and its two modifiers collaborating in kinematic pair with steel and cast iron.

EXPERIMENTS

The investigations were realized on a specialy constructed and executed stand. Scheme of its presents figure 1.

Principal part of this stand made a device for friction testing type "pin-on-disc". It comprise a holder (3), on which are fixed the samples (1).Whole is hanging on a feed machanism (10), which has a possibility to move towards counter - sample (2). This way we obtain a sample pressure to counter - sample, with required normal force. Counter - sample was manufactured in two versions: of steel and cast iron. The either have a target shape. The drive is transmited through V-belts from short - circuit engine (7). Rotational speed of engine can be regulated in a broad range of required revolutions. To this effect was applied the frequency converter AEG (8). Rotational speed of counter - sample disc was measured with exactitude 1 rev/min. It was executed by electronic tachometer (5) collaborating with magnetic probe (6). Measurement friction force, which occurs between sample and counter - sample, was executed through mensuration a deflection of sample holder under influence of friction force. Some tensometers collaborating with amplifier gauge (9) were seized on

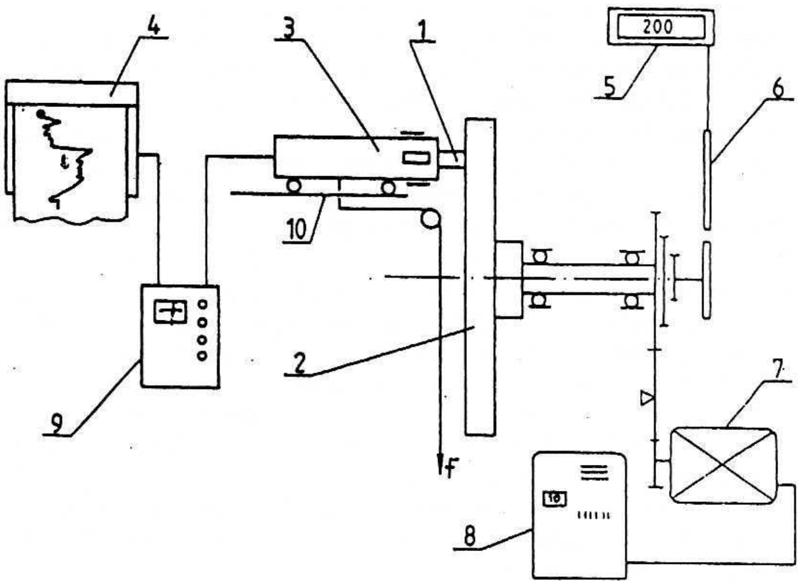

Fig. 1. Diagram of the post for friction coefficient testing
1 - sample, 2 - counter - sample, 3 - sample holder with tensometers, 4 - friction force recorder
5 - digital tachometer, 6 - magnetic probe for rotational speed measurement, 7 - engine,
8 - frequency converter, 9 - amplifier gauge, 10 - feed mechanism
Rys. 1. Schemat stanowiska do badań współczynnika tarcia
1 - próbka, 2 - przeciwpróbka, 3 - uchwyt próbki z tensometrami, 4 - rejestrator siły tarcia,
5 - tachometr cyfrowy, 6 - sonda magnetyczna do pomiaru prędkości obrotowej, 7 - silnik,
8 - przetwornica częstotliwości, 9 - wzmacniacz tensometryczny, 10 - mechanizm posuwowy

the holder. Deflections were registered on tension recorder x-t type TZ 4200 (4).

The researches has been conducted on the samples executed of alder wood. After this species decided its favourable features, like sufficient hardeness, advantageous structure, which characterize a small diversification of inner building, what assured uniform sample treatment on a whole investigated section. Because an alder wood it is a scamper - vessels species, there was no trouble with insertion an impregnant mean in cells.

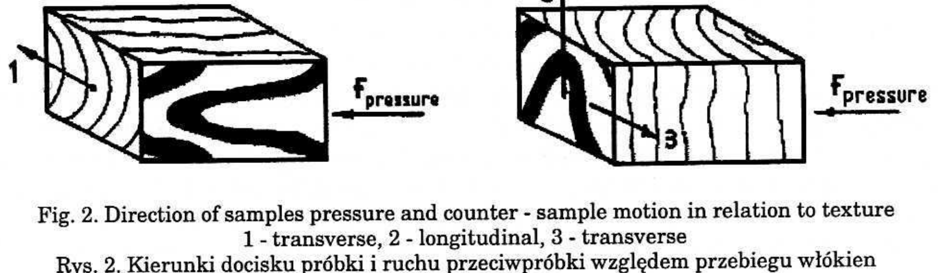

Fig. 2. Direction of samples pressure and counter - sample motion in relation to texture
1 - transverse, 2 - longitudinal, 3 - transverse
Rys. 2. Kierunki docisku próbki i ruchu przeciwpróbki względem przebiegu włókien
1 - poprzeczny, 2 - wzdłużny, 3 - poprzeczny

All the samples have had a rectangular prism shape with following dimensions: 10x10x30 mm. The grains direction was permanent. Friction coefficient mensuration has been done on three different kinds of samples: of natural alder wood, of alder wood treated with machine oil "8" and alder wood treated with PTFE preparation "Slick".

Mentioned above samples collaborated with two disc shaped counter - samples: steel one and cast iron one. Before impregnation the humidity of material under investigations didn't exceed 7%, but its density oscillated between:

- natural alder wood 538 - 571 kg/m^3,
- alder wood treated with machine oil 954 - 1024 kg/m^3,
- alder wood treated with Slick 892 - 979 kg/m^3

The sample pressure on counter -sample was constant and amounted 0,2 MPa. Rotational speed of counter - sample was properly selected, what corresponded with linear velocity of friction pair slide, which equaled 1 m/s . The sample was installed in a holder and every time grinded in with grinding paper "100". This process assured full surface contact with counter - sample. This disc was cleaned and degreased.

After setting a stand in motion, the friction pair were lapped within 5 minutes. The device was calibrated before investigations. Tensometric holder was loaded with 10 N force and registered distortion was compared with one, caused with friction force. The values of these parameters were recorded on tension recorder. Three samples were investigated for each one impregnant. Every measurement was repeated five times. Achieved results were averaged.

Two pressure directions of sample on counter - sample in relation to grains site were taken into consideration: for longitudinal pressure, for transverse pressure, but in radial direction.

For longitudinal pressure friction coefficient was determined in transverse direction (1) of sample movement in relation to counter - sample (fig. 2).

During transverse pressure the same coefficient was investigated in two directions of counter - sample motion: longitudinal (2) and transverse (3).

RESULTS

Collected results of investigations have been presented in table 1 as well as have been shown on chart - figure 3 - 5.

Analysing obtained findings it has been ascertained, that the highest friction coefficient reaches alder wood. It pays an attention the high increament of this coefficient, which hesitates from 55% - for transverse direction of sample pressure in relation to counter - sample and reaches 97% increament for longitudinal pressure, when cast iron counter - sample was used. Steel collaborating with natural alder wood sample, performs significantly more profitable slide parameters.

Wood based, treated materials reveals much lower values of friction coefficient, when counter - sample makes steel or cast iron alike.

Table 1
Tabela 1

Values of friction coefficient for different directions of sample pressure to counter - sample with consideration the motion direction of working surface
(in the brackets there is presented standard deviation)
Wartości współczynnika tarcia dla różnych kierunków docisku próbki do przeciwpróbki z uwzględnieniem kierunku ruchu powierzchni roboczej
(w nawiasach podano odchylenie standardowe)

Sample kind Rodzaj próbki	Direction of sample and counter sample pressure Kierunek docisku próbki do przeciwpróbki	Direction of sample movment in relation to counter - sample Kierunek ruchu próbki względem przeciwpróbki					
		transverse poprzeczny		transverse poprzeczny		longitudinal wzdłużny	
		steel stal	cast iron żeliwo	steel stal	cast iron żeliwo	steel stal	cast iron żeliwo
natural alder wood	longitudinal wzdłużny	0,290 (0,033)	0,570 (0,097)	-	-	-	-
olcha naturalna	transverse poprzeczny	-	-	0,250 (0,013)	0,465 (0,034)	0,255 (0,021)	0,395 (0057)
alder wood treated with machine oil „8"	longitudinal wzdłużny	0,184 (0,024)	0.250 (0,042)	-	-	-	-
olcha nasycopna olejem maszynowym „8"	transverse poprzeczny	-	-	0,186 (0,012)	0,229 (0,026)	0,174 (0,008)	0,254 (0,023)
alder wood treated with „SLICK"	longitudinal wzdłużny	0,234 (0,021)	0,250 (0,072)	-	-	-	-
olcha nasycona preparatem „SLICK"	transverse poprzeczny	-	-	0,206 (0,022)	0,233 (0,057)	0,223 (0,033)	0,259 (0,026)

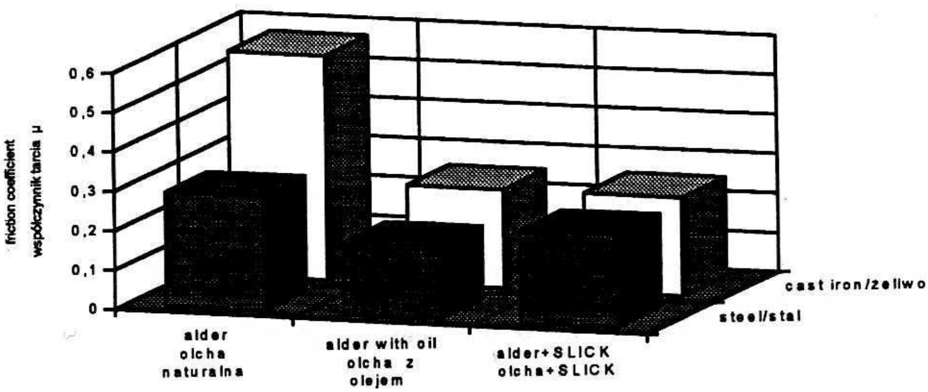

Fig. 3 Values of friction coefficient by longitundial direction of sample pressure to counter - sample. Motion direction - transverse
Rys. 3 Wartości współczynnika tarcia przy wzdłużnym kierunku docisku próbki do przeciwpróbki. Kierunek ruchu - w poprzek włókien.

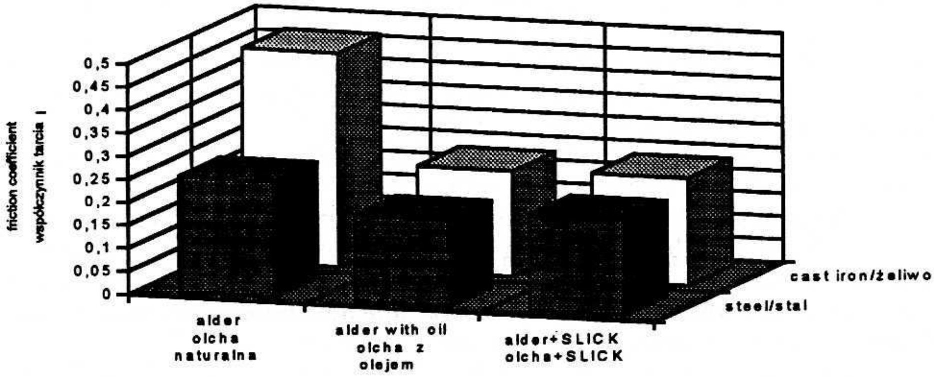

Fig. 4 Values of friction coefficient by transverse direction of sample pressure to counter - sample. Motion direction - transverse
Rys. 4 Wartości współczynnika tarcia przy poprzecznym kierunku docisku próbki do przeciwpróbki. Kierunek ruchu - w poprzek włókien.

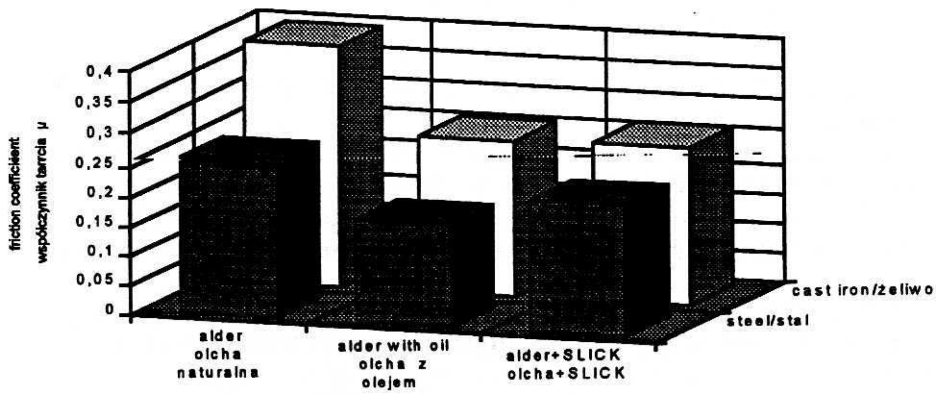

Fig. 4 Values of friction coefficient by transverse direction of sample pressure to counter - sample. Motion direction - longitudinal
Rys. 4 Wartości współczynnika tarcia przy poprzecznym kierunku docisku próbki do przeciwpróbki. Kierunek ruchu - wzdłuż włókien.

From among applied two impregnated materials, machine oil has negligible more advantageous slide parameters, then Slick preparation.

Friction coefficient value, for samples filled in with machine oil is the lowest, when mate with steel counter - specimen and a sample has a transverse pressure to counter - sample, but the direction of movement two rubing parts is longitudinal. The most unprofitable there is a transverse sample pressure and motion in relation to counter - specimen.

Cast iron counter - sample application brings about an increament μ, which reaches the highest value there, where utilization of steel counter - specimen were the most advantageous (increase 45 %). Vice versa, there where steel counter - sample presented the highest friction, the replacement of it with cast iron one, leads to lowest increament of friction coefficient (23 %). It concerns the transverse direction of mutual sample and counter - sample pressure, when the specimen treated with machine oil was used.

The specimens modified with Slick doesn't prove suspected decreament of friction coefficient value. Aplication cast iron counter - sample brings about a negligible elevation μ . The most profitable kinematic pair achieve one during - likewise in case the samples filled in with machine oil - transverse direction of pressure and movement of sample and counter - sample.

Vessels were throughout filled in with impregnant. This state was appreciated very positivly. Thanks to this, it has been observed a passing of impregnated mean on the counter - sample working path. Thus it was leading to a mutual slip two surfaces covered in majority with impregnant.

There was no significant diversification of friction coefficient findings in dependence from anatomical direction of working sample surface.

CONCLUSIONS

1. Treated wood presents significantly lower values of friction coefficient in comparition to natural wood.

2. Machine oil is a better impregnant than Slick one. It performs lower values of friction coefficient (it concerns short - lived experiments).

3. Natural alder wood or impregnated alder wood collaborating with steel counter - sample shows lower values of friction coefficient than for cast iron disc.

4. It has been not noticed any significant influence of grains direction on friction coefficient value, when modified wood goods were taken into consideration.

Received in April 1996

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DREWNO OLCHY I JEGO KOMPOZYTY JAKO MATERIAŁ TRIBOLOGICZNY STOSOWANY W PARZE KINEMATYCZNEJ ZE STALĄ I ŻELIWEM

Streszczenie

Mimo powszechnego stosowania łożysk tocznych do obrotowego podparcia wałów nadal stosuje się i bada łożyska ślizgowe szczególnie, gdy można wykorzystać ich zalety. Chętnie są one aplikowane w węzłach ciernych maszyn roboczych tworząc parę kinematyczną niejednokrotnie bardzo różnych materiałów. Prowadzone badania mają za cel zmodyfikowanie, a następnie skojarzenie takich dwóch materiałów, które z punktu widzenia tribologii pracującego węzła, zapewnią najniższe wartości współczynnika tarcia.

Badania wykonano na próbkach wyciętych z drewna olchy stanowiącej parę kinematyczną z przeciwpróbką z żeliwa i stali. Doświadczeniom poddano próbki z drewna olchy naturalnej, olchy nasyconej olejem maszynowym "8" oraz olchy wypełnionej preparatem na bazie PTFE - Slick.

Uwzględniono dwa kierunki docisku próbki do przeciwpróbki: wzdłużny i poprzeczny oraz dwa kierunki ruchu próbki względem przeciwpróbki - także wzdłużny i poprzeczny. Badania zrealizowano na stanowisku doświadczalnym typu "pin - on - disc". Podczas całego cyklu badań zachowano stałą wartość nacisków rzeczywistych próbki na przeciwpróbkę wynoszącą p= 0,2 MPa i niezmienną prędkość poślizgu powierzchni roboczych v = 1 m/s.

Analizując wyniki stwierdza się, że najwyższy współczynnik tarcia wykazuje drewno naturalne olchy. Materiały drzewne modyfikowane mają zdecydowanie niższe wartości tego parametru.

Para kinematyczna: drewno naturalne lub nasycone, we współpracy z przeciwpróbką żeliwną, wykazuje wyraźnie wyższe wartości współczynnika tarcia niż ze stalą.

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