Technische Hochschule Ingolstadt

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Zukunft in Bewegung

Tribological Investigations of Brass alloys

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28.05.14

Objectives

Motivation:
Brass alloyed with lead finds its application since many years in bearings and machining. Besides the possibility to embed wear debris in the soft lead phases, lead lowers the friction coefficient of the tribological system and provides at mixed friction conditions dry-running properties. The motivation for this investigations was to compare the tribological properties in the mode of dry friction of one brass alloys with precipitated lead phases and without any lead phases.

Investigated Alloys

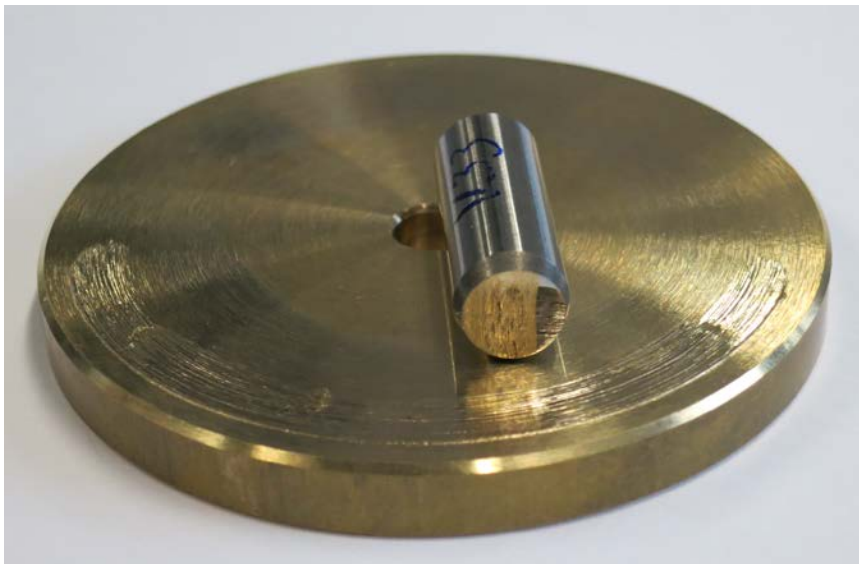
- Z33, α-brass alloy containing lead phases, the Zn amount offers the highest possible solid solution strengthening in the Cu-Zn-System
- SW1, α-brass alloy containing silicon phases (Ecobrass®)
- BlueBrass, α/β-alloy (BlueBrass) with a small amount of precipitates containing the elements Fe, Si, Mn.

Alloy	Cu	Si	P	Zn	Pb	Härte [HB]
SW1* (Ecobrass®)*	76 %	3%	0,03%	rest	-	175
Z33*	57,5%	-	-	rest	3,3 %	133
Alloy	**Cu**	**Fe, Ni, Sn**	**Si, Mn**	**Zn**	**PB**	**Härte [HB]**
Blue Brass**	57,0-59,0	0,1-0,5	max. 0,1	rest	<0,1	154

* Chemical composition taken from Wieland,** Chemical composition taken from Arubis

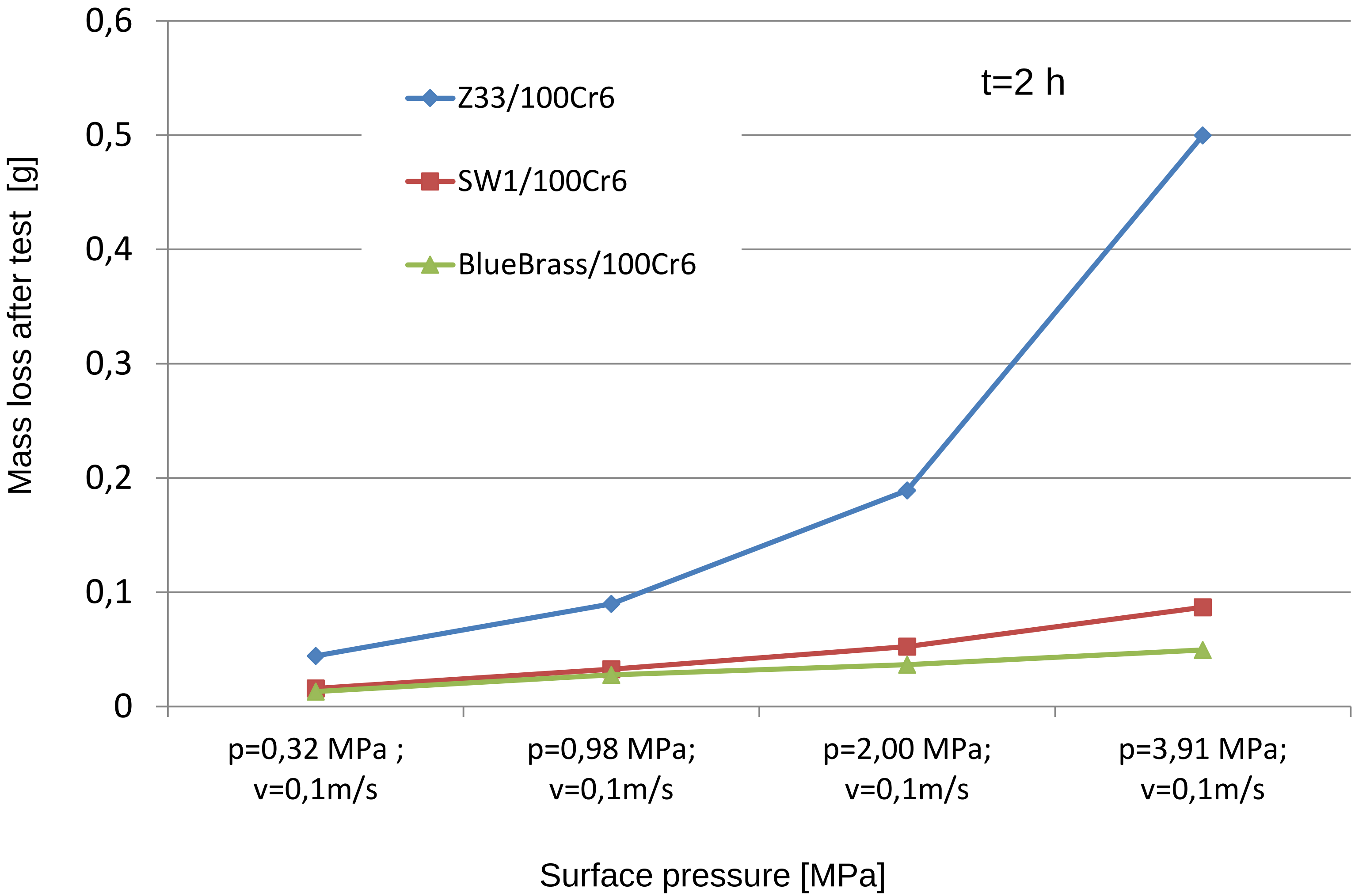
Experimental

- tribological test with a pin to disk tribometer (Wazau GmbH)
- 100Cr6 pins (Rz ca. 0,1-0,2µm)
- disk brass alloys (Rz ca. 0,7-0,9µm)
- Surface pressure (1-4 MPa) at a constant relative velocity of 0,1 m/s
- 140° oscillating movement



Example for pin and disk specimen

Comparison of the mass changes of the tribological components after test -Disks



Comparison of the mass changes of the tribological components after test –Disks – Discussion of results

- the comparably high mass lost of the lead containing Z33 can be explained by low hardness of this material

- SW1 shows compared to Z33 a higher wear resistance due to a higher hardness and small precipitates (Cu_4ZnSi or Cu_8Zn_2Si) which acts as points of support

- the slightly better wear resistance of BlueBrass compared to SW1 can be probably attributed to
  - a slightly higher E-Module, which is useful to reduce the indentation of the pin
  - a higher thermal conductivity, which reduces the temperature between the pin and the disk and therefore reduces the decline of the properties
  - β precipitates, which have a higher hardness compared to the α-phase and act as points of support

- the main wear mechanism for all specimen is adhesive wear, as it can be seen on the pictures. The specimen of the SW1 material exhibit depending on the applied stress (surface pressure) also the abrasive wear mechanism

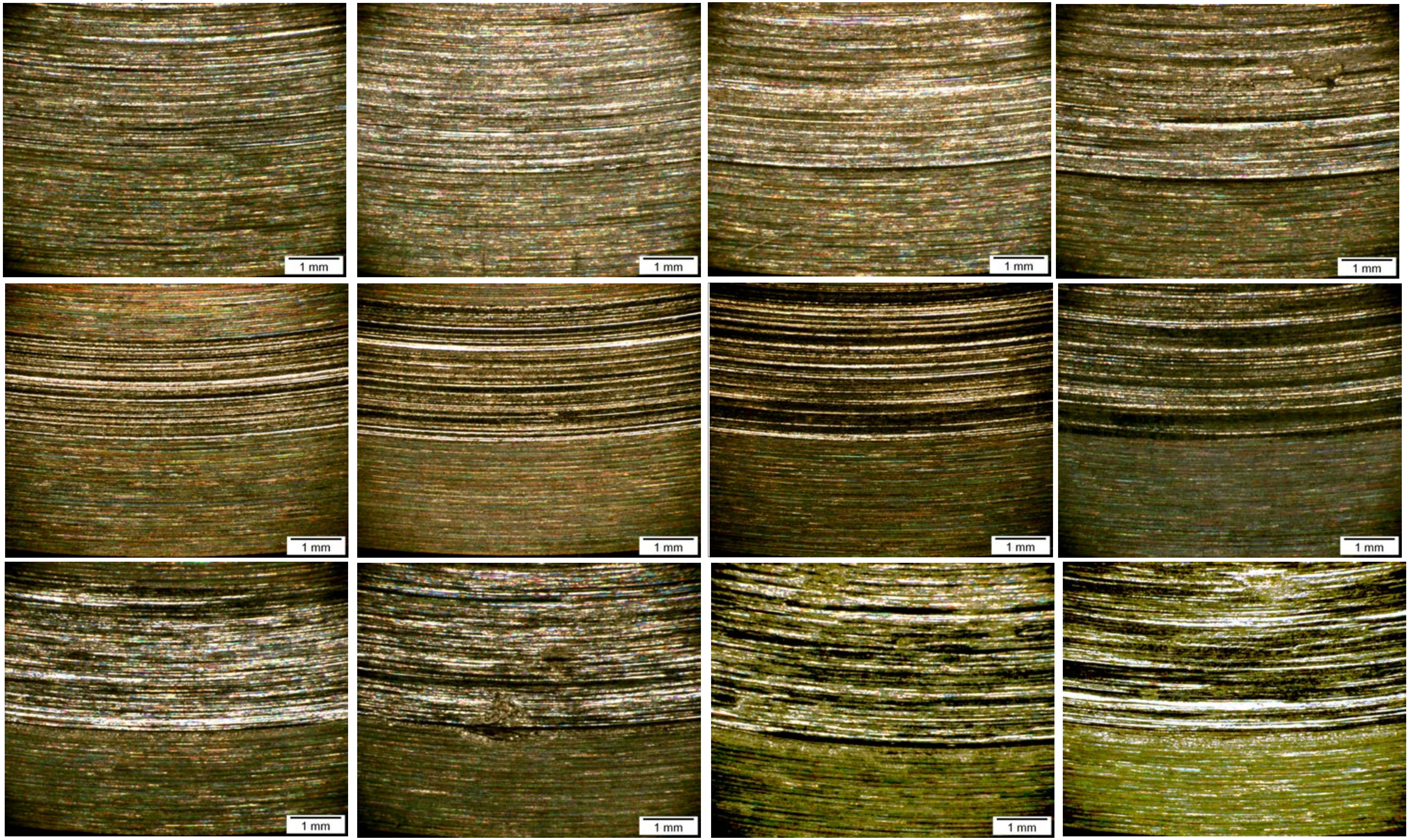
Macroscopical comparison of the disks after test

0,32 MPa | 0,98 MPa | 1,96 MPa | 3,91 MPa

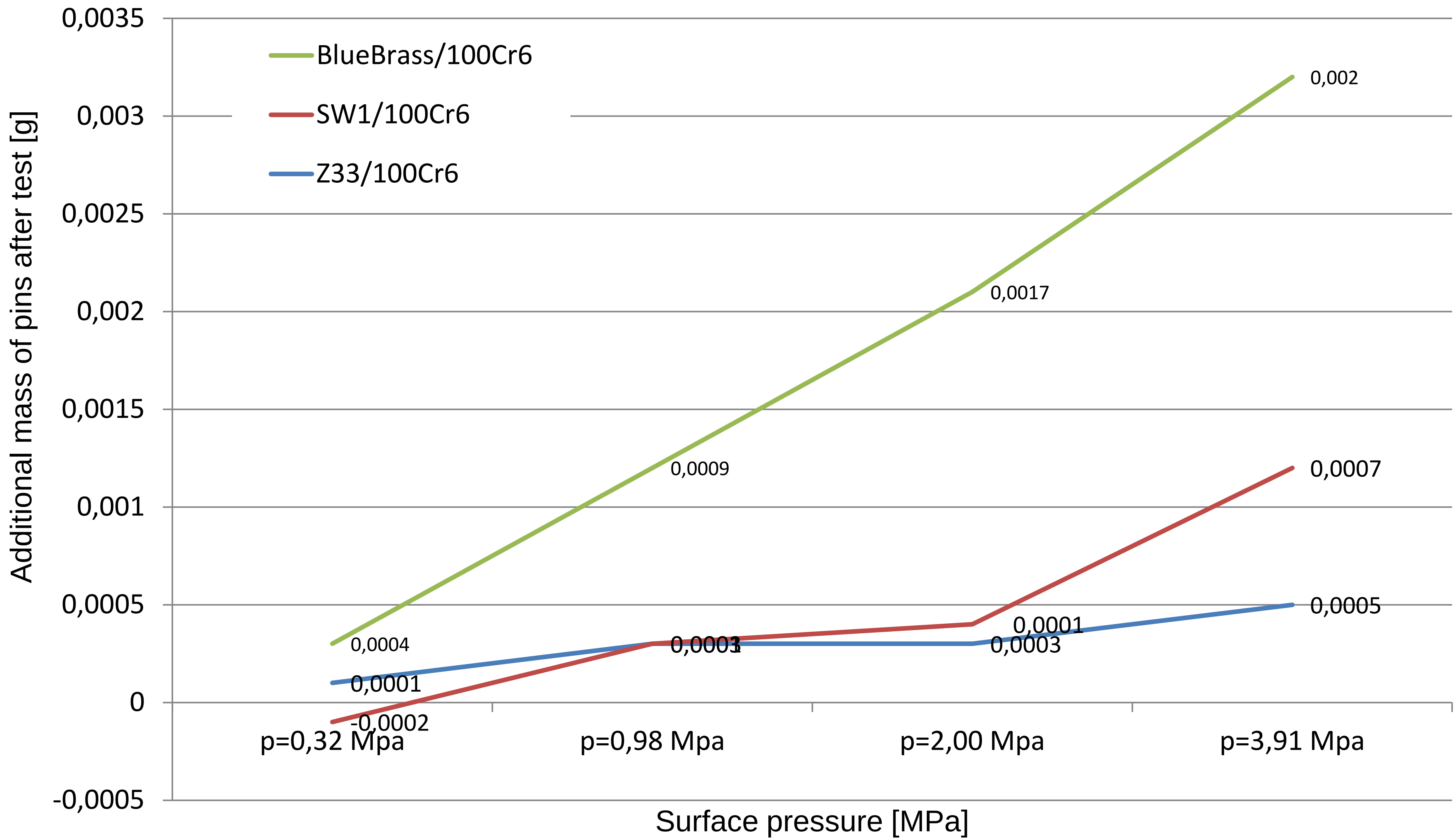
Z33

SW1

Blue Bras



Additional mass of pins after test

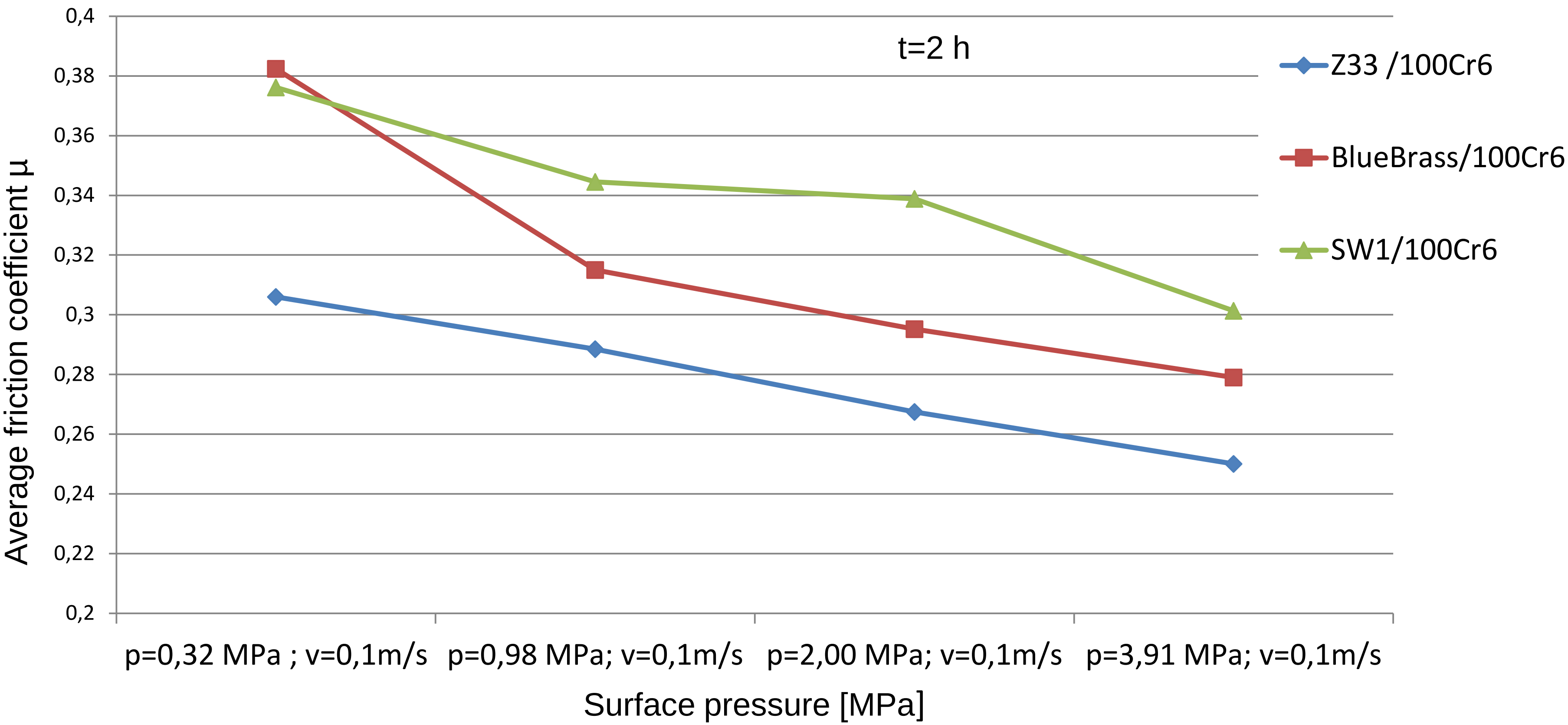


Additional mass of pins after test – Discussion of results

- BlueBrass reveals the highest amount of products on the pin, which can be connected to adhesive wear and be seen at the micrographs. The most reasonable explanation can be found in the bcc lattice structure of the β-phase. This structure is the same of the matrix of the 100Cr6 pin material, which enhances the possibility of micro welding

- SW1 and Z33 have a much lower material transfer to the pin, because of their fcc matrix. It can be proposed, that the lead content of the Z33 hinders to a certain amount the micro welding effect compared to the lead free SW1

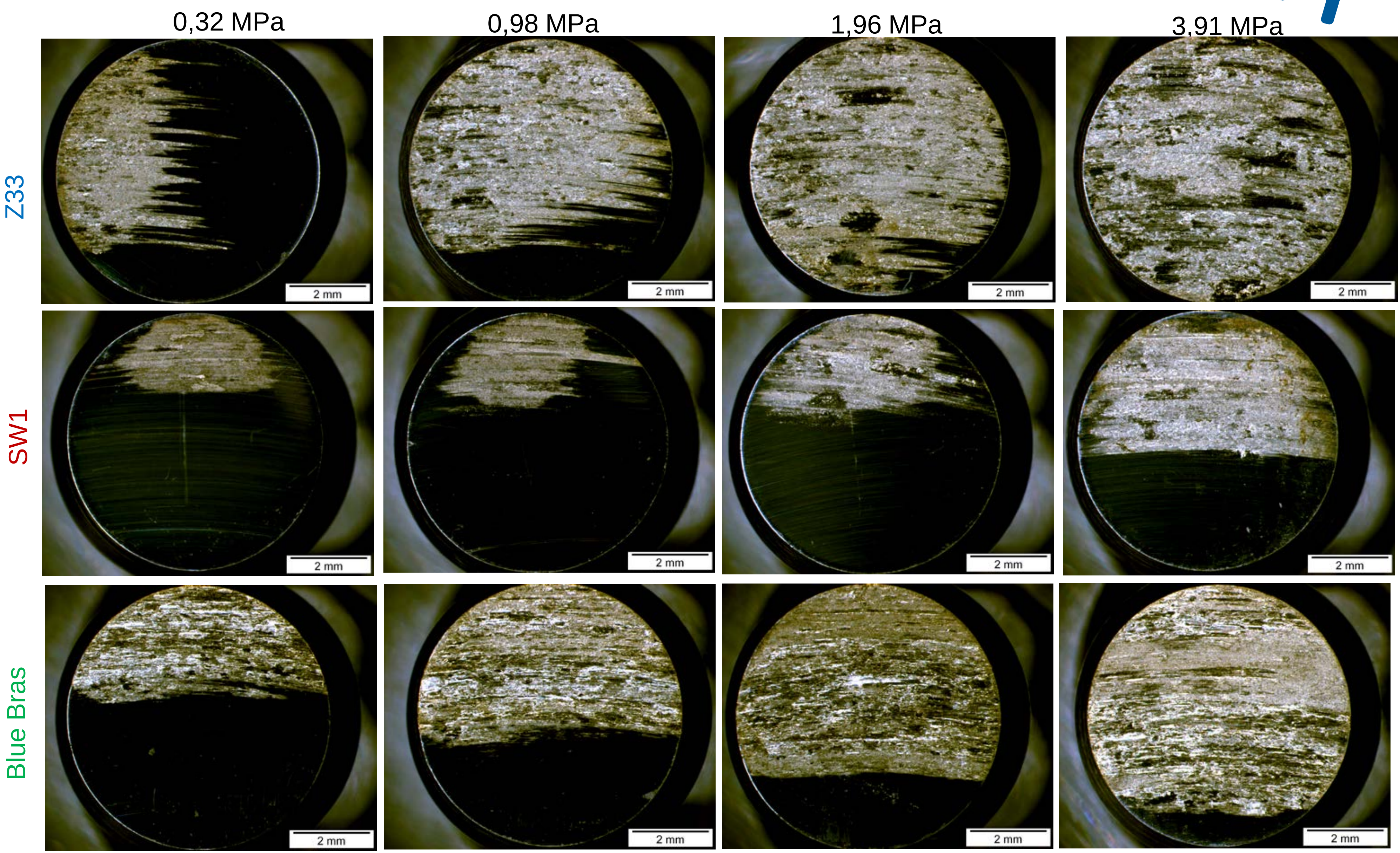
Average friction coefficient



Average friction coefficient - Discussion

- the lead phases of the Z33 material offers the lowest friction coefficient because lead can be considered as a lubricant
- the difference of the specimen SW1 and BlueBrass can be attributed to different E-modules and probably to the missing Cu_4ZnSi- or Cu_8Zn_2Si-Phases

Macroscopical comparison of the pins after test



Results and Conclusion

Results:

- The friction coefficient can be lowered by alloying lead to the basic brass material. Thus lead can be classified in most conditions as a beneficial alloying element reducing the friction in tribological stressed systems and reduces therefore consequently the energy consumption. This result correlates with the literature and the authors observations, that lead moves under pressure and temperature conditions from the grain boundaries to the surface to build a thin film with low friction properties between the tribological stressed components.

- The Si-containing lead free brass alloy SW1 offered a lower wear than the lead containing brass alloy Z33. This result can be explained by the lower hardness resulting in a lower wear resistance of the lead free alloy SW1. The friction coefficient is higher compared to the lead containing Z33.

- Using a α/β-alloy (BlueBrass) lowers the friction coefficient compared to the alloy Si-Containing SW1. The wear resistance can be highly enhanced to Z33 and slightly enanced compared to SW1. The adhasive transfer to the pin is the highest of the three tested alloys.

Conclusion:

The existing tribological systems for lead containing brass can not be simply adapted to lead free brasses (e.g. Ecobrass, BlueBrass). Friction and wear behaviour are vastly different for same contact partners under same conditions. Thus the possibility of a change from a lead containing to a lead free alloy within a tribological system can only be assessed after extensive trialling under real conditions

Literature

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