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Tribological properties of Poly(lactide acid) composites

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INTRODUCTION

The dominant agricultural wastes used for tribological materials are natural fibres of plant origin. Another group of post-agricultural fillers for polymer-based composites are seeds and stones.
In the presented work the agricultural wastes like cherry and plum seeds were combined with two types of poly(lactide acid) (PLA) and the composites has been tested in terms of tribological properties without additional lubrication.

MATERIALS, ORGANIC FILLERS PREPARATION

To prepare the cherry and plum seeds (from local plants) for the mixing with polymer pellets the seeds were pulverized to a powder state. At the beginning, seeds were dried in an air-circulating oven at 80°C for 72 h. In the next step, dried seeds were fed into the low speed screenless granulator. As a result of low speed and blade design, there is less dust produced in the cutting process.

Initial: Dried raw organic fillers

plum seeds

S1 plant 1, S2 plant 2

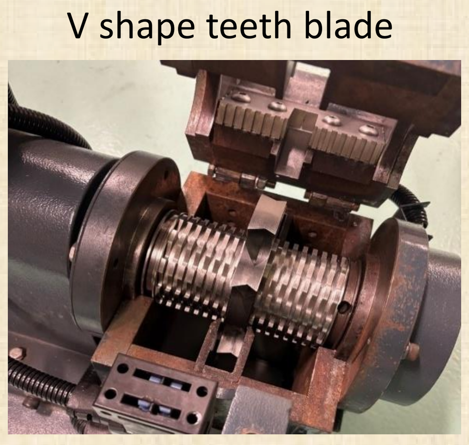
cherry seeds

W1

1st step Shell crushing initial cutting to reduce size, single teeth cutter Shini granulator

Shini SC-1411

Cutting chamber
V shape teeth blade



The teeth blades produce less dust and even distribution of regrind size

2nd step Shell pulverising with high-speed grinder

Capacity 2 kg

6 blades
operated at 30000 rpm's

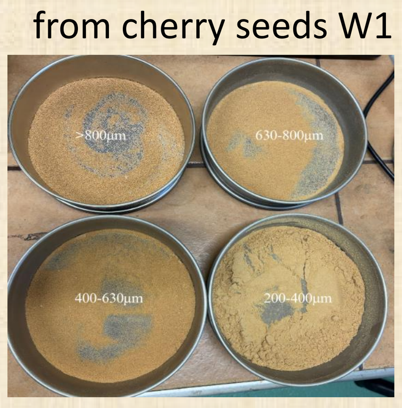
Interval cycles 30 s

3rd step Separation into different grades fractions by using vibratory sieve shaker

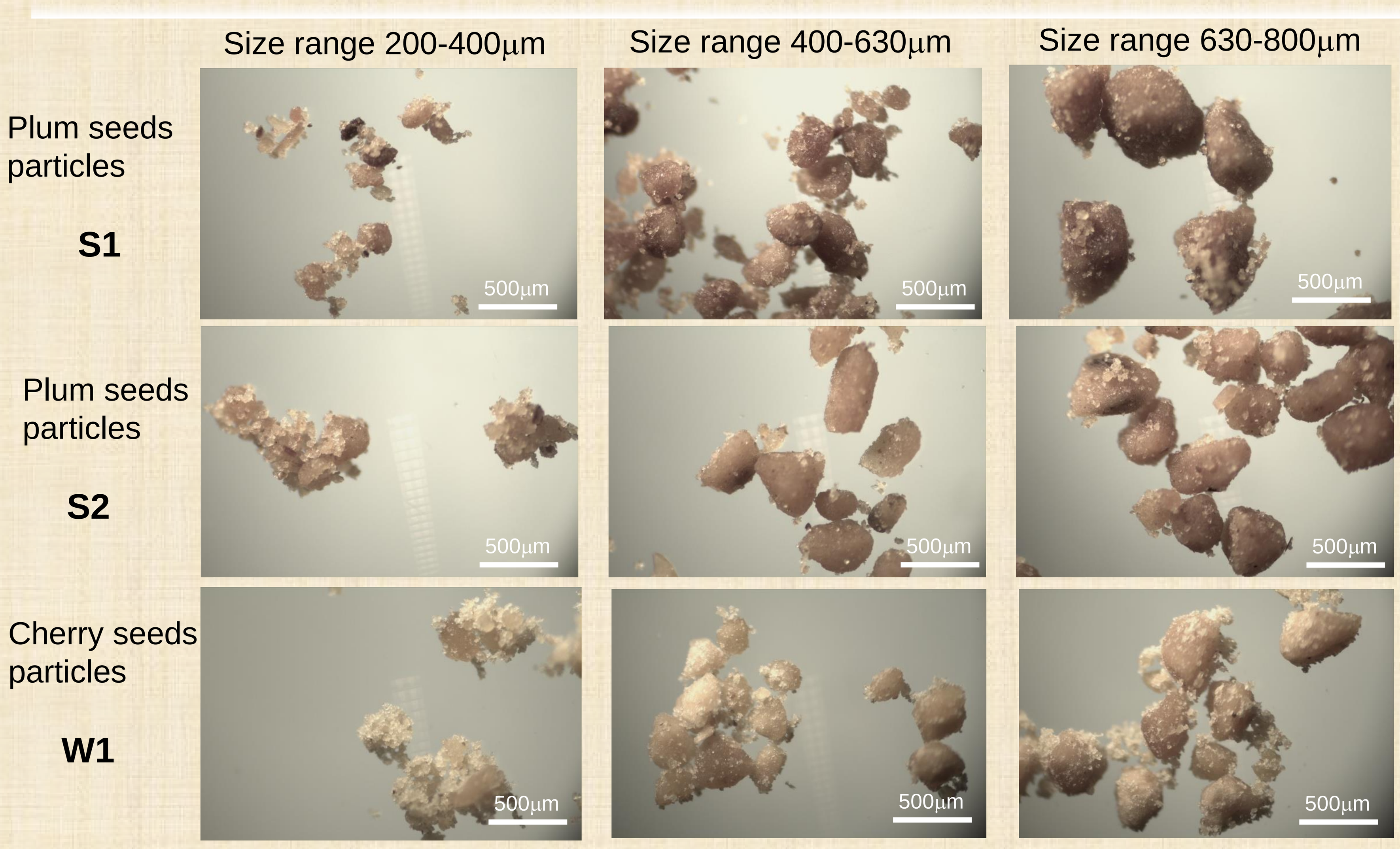
Time 5 min
Amplitude 1 mm

Separated powders
from plum seeds S1

Separated powders
from cherry seeds W1



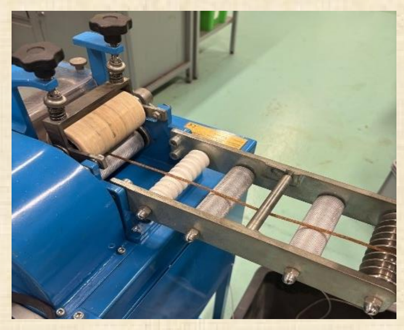
OPTICAL MICROSCOPY

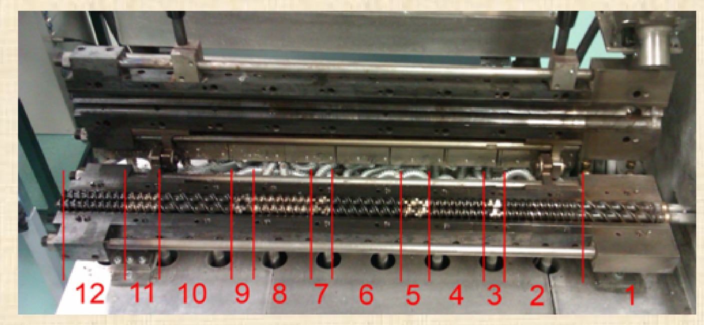


EXTRUSION AND INJECTION MOLDING

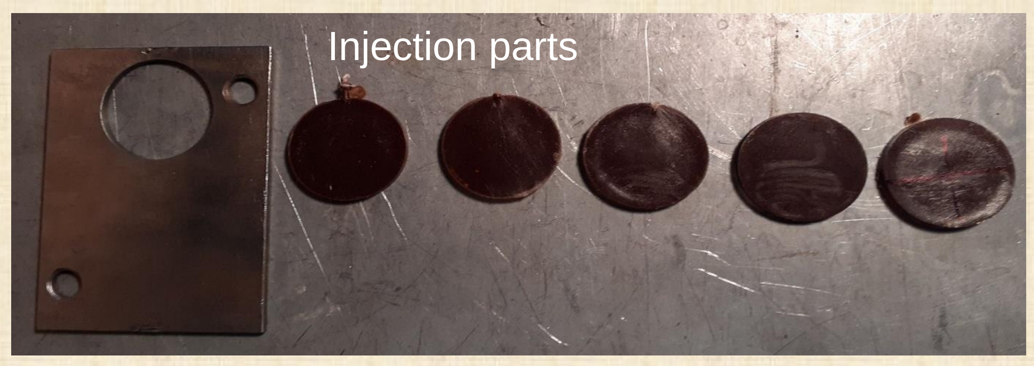
Composites with 15% by weight of plum/cherry fractioned powders and two grades of crystalline PLA 2500 HP (MFR 8 g/10 min) and 3100 HP (MFR 24 g/10 min).

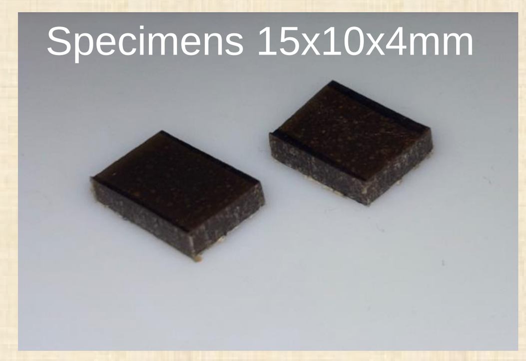
Twin screw extruder 16/40 (16 mm screws diameter L/D 40),
co-rotating mode, barrel temperature 160-205°C, extrudates cooled with air funs





Injection molding (injection temp. 205°C, mould temp. 30°C)





TRIBOLOGICAL TESTS

Tribological tests to determine the COF were conducted in the 'block-on-ring' system under dry friction conditions. Rings with an external diameter of 45mm and width of 12mm were manufactured from AISI 1045 steel and then ground, consequently offering anisotropic surface morphology (Sa =approx. 0.5µm). The frictional behaviour was analysed on the basis of the measured values for the friction torque and the COF calculated from it and the applied load (Eq. 1).

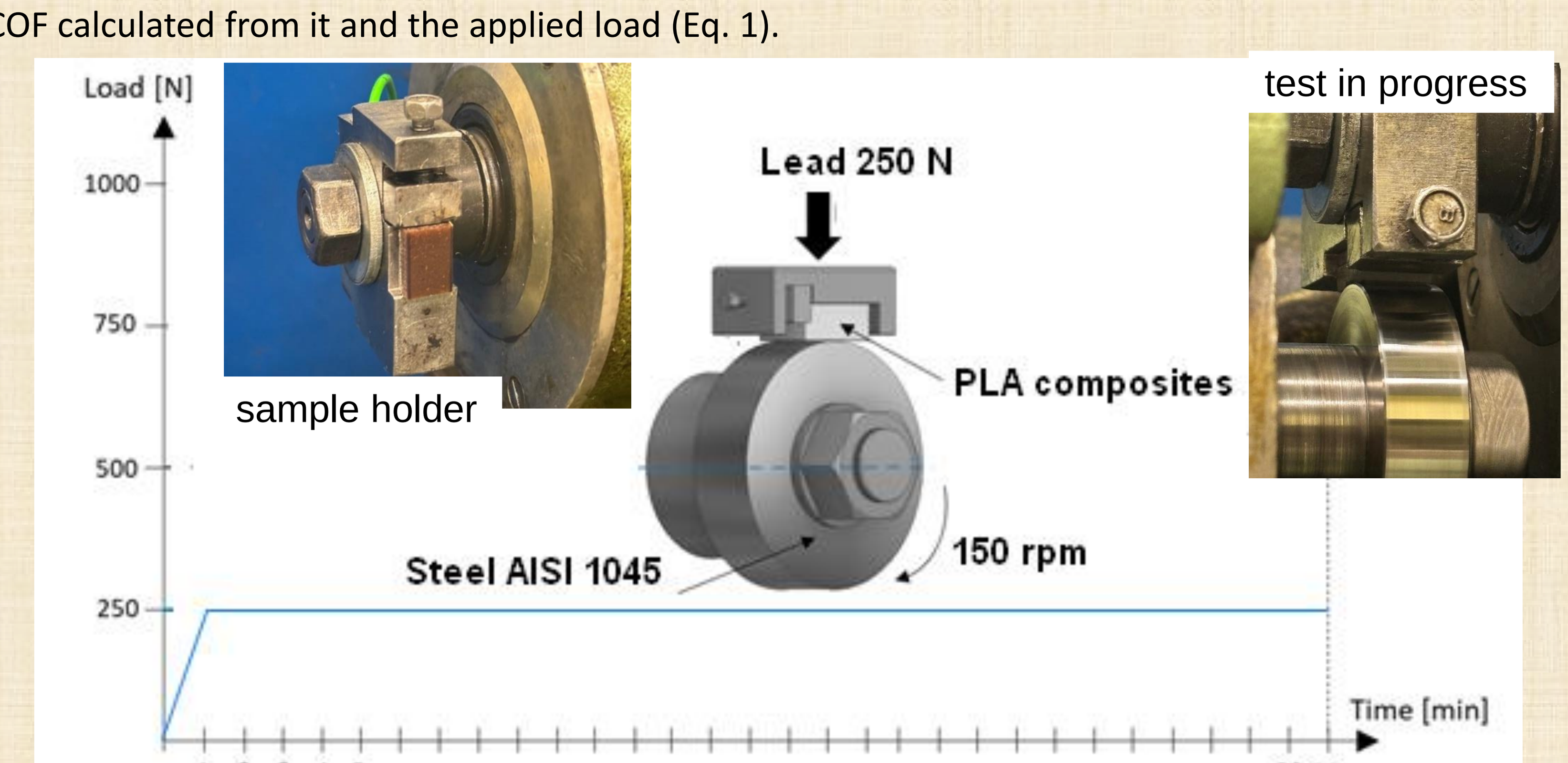
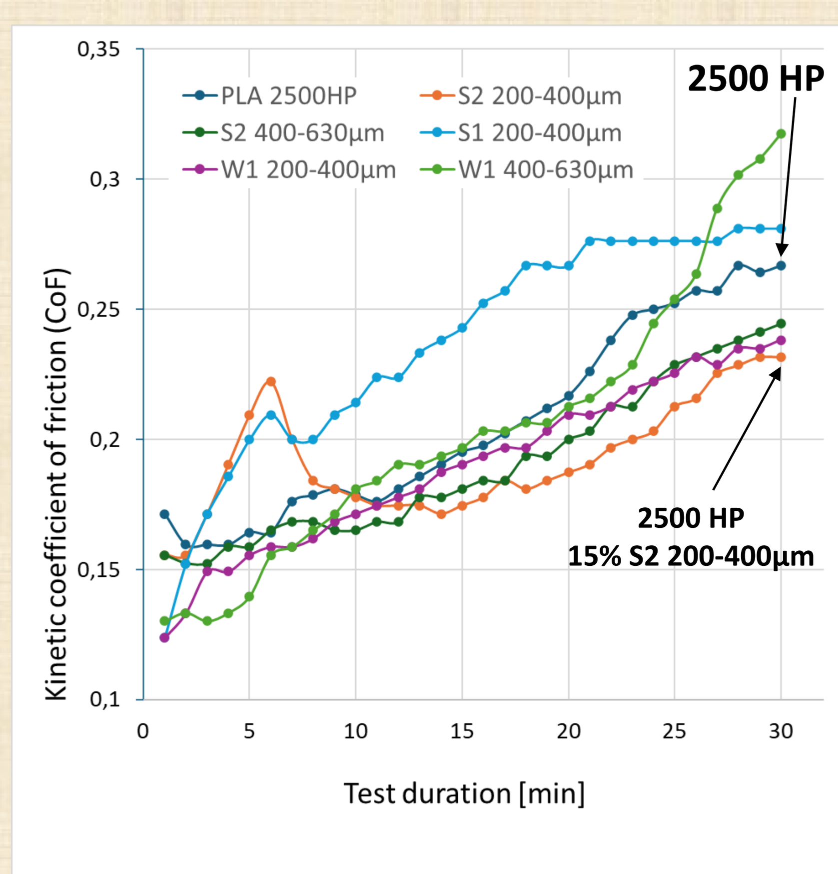


Diagram of the tribological test parameters

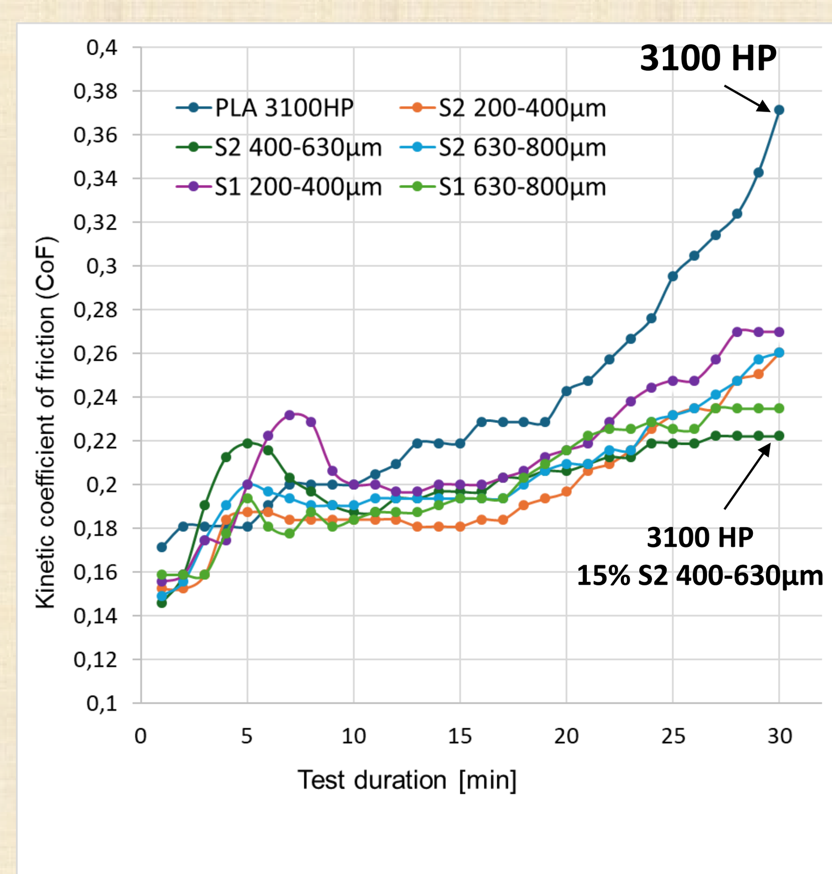
Calculation of CoF $\mu = \frac{M_t}{F_n \cdot r}$

Mt – friction torque [Nm]
Fn – applied force
r – radius of the counter sample

PLA 2500 HP composites
CoF variability during the 30 min. test



PLA 3100 HP composites
CoF variability during the 30 min. test



CONCLUSIONS

The most signifficant improoved kinetic CoF was noted for composites of PLA 3100 HP/15 % plum seeds grade S2 400-630µm, the reduction of CoF was over 40%.
Composites of plum seeds with PLA crystalline polymers are promissing materials for environmentally friendly, lubricants free linear bearings, made partly from waste materials that are locally available.

Acknowledgments
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