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Production, additive printing and mechanical testing of PLA/PHB material with different concentrations of TAC emollient

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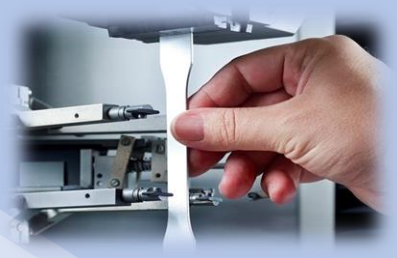
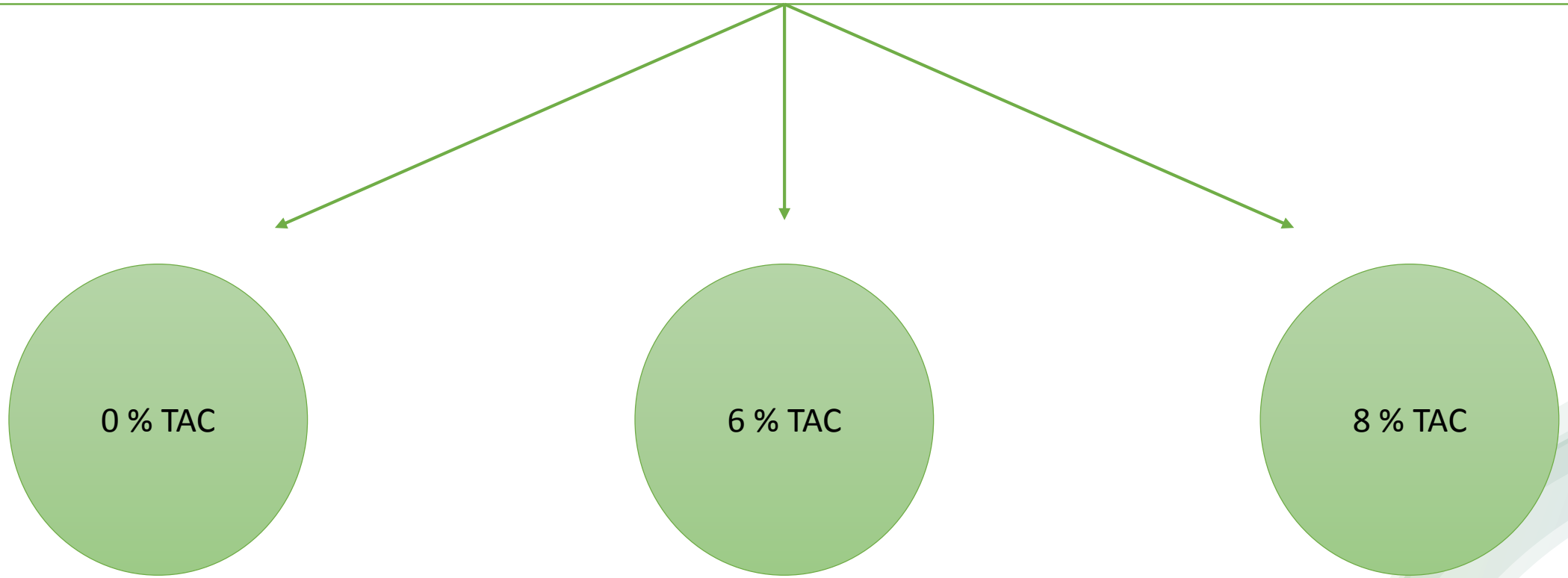


- Aim of the study
- Overview study
- Practical part
- Summary of the practical part

PROCESS OF PRODUCTION AND TESTING OF FILAMENTS

- In order to perform tensile and pressure tests on objects printed using 3D additive technology from PLA/PHB material with three different types of solvents, it is necessary to produce filaments.
- The production of filaments is a difficult process.
- The required filaments should be made of specific materials such as PLA and PHB with different ratios of solvent added.



S.n.	Company name	Specialization of the company	Information available at
1.	3Demon	Several years of work in 3D printing and 3D modeling.	https://3d-mon.com/
2.	Fillamentum	Fillamentum specializes in high quality 3D printing. It is located in the southeastern part of the Czech Republic, in the town of Hulin where it was founded in 2011.	https://fillamentum.com/
3.	MATERIALPRO3D	Slovak company that produces and distributes filaments for additive printing.	
4.	MAKERSLAB	Czech company offering custom 3D printing, modeling and workshops.	https://makerslab.cz/.
5.	3D PRINT	A company based in the Czech Republic offering custom-made filaments.	
6.	NEXEO Plastics	A global company providing distribution services, intelligent solutions in the field of additive production.	https://www.nexeoplastics.com/.
7.	Innofil 3D	One of the largest producers in Europe with an exclusive focus on FFF printing threads.	
8.	FILAMENTS.CA	A global company based in Canada providing a wide range of filaments	
9.	Advanced Biomedical Technology Inc.	Established company based in Taiwan engaged in 3D printing for medical purposes.	

TABLE. COMPANY OVERVIEW STUDY

MODELING AND 3D PRINTING OF SAMPLES

- Dogbone samples are intended for using primarily in tensile tests.
- Type I samples are most widely used with a thickness of 3,2 mm and are usually produced by injection. Type I samples have a total length of 165 mm and a width of 13 mm.

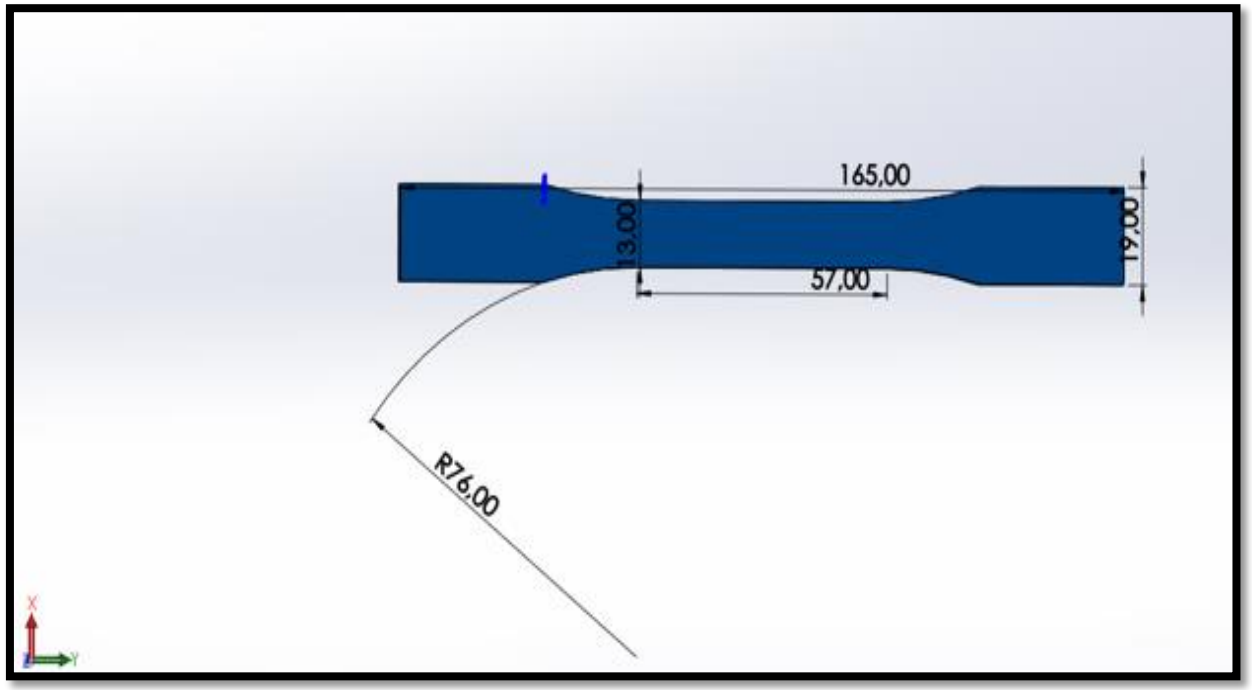


Fig. Dimensions of type I sample for mechanical testing in mm

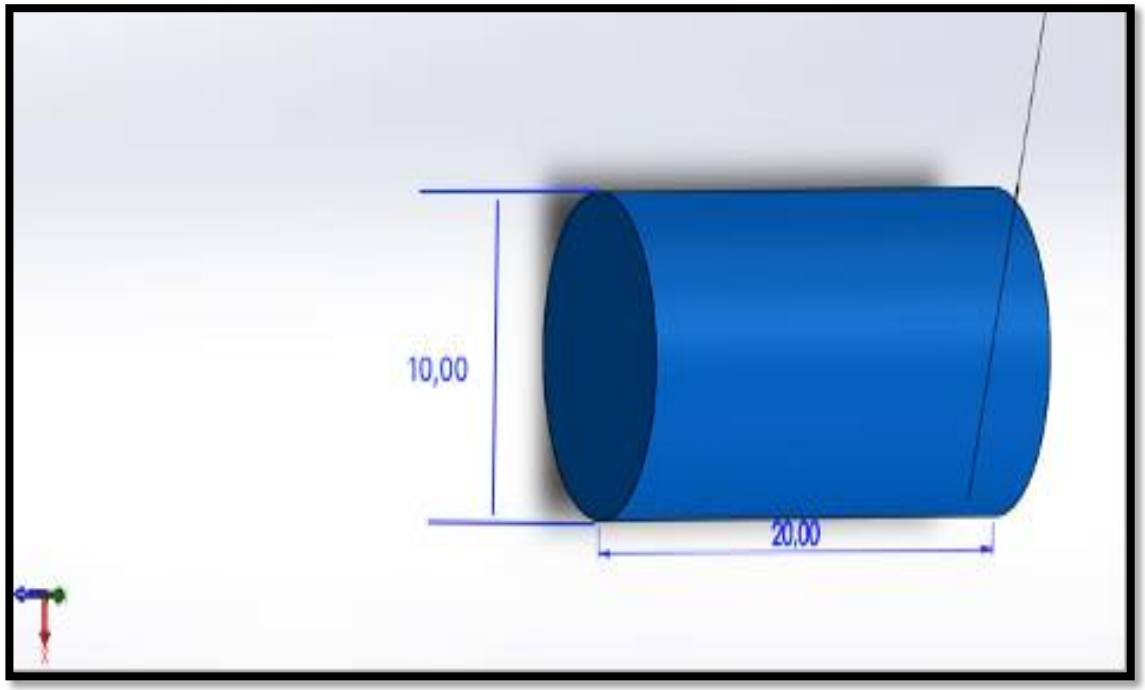


Fig. Dimensions of sample for pressure tests in mm

- A TRILAB printer was used to print objects for subsequent tensile and pressure tests.
- To perform tensile and pressure tests, it was necessary to print 90 rollers and 30 bones.
- The total estimated printing time was 36 hours.
- All rollers made of all three materials were printed in 13.5 hours, 22.5 hours were needed to print the bones.

Printing temperature	210 °C
Plate temperature	55 °C
Printing time for 1 bone	45 min
Printing time for 1 roller	9 min
Total printing time	4:36 p.m.
Materials used	PLA/PHB with 0 % TAC, PLA/PHB with 6 % TAC, PLA/PHB with 8 % TAC

TABLE. PRINT PARAMETERS

- Printing itself led to various problems, stuttering the printer filament.
- Some modifications had to be made.
- The resulting products had good quality without pores.
- After the samples had been printed, preparation for the testing itself began.
- Two types of objects were printed.
- Tensile and pressure tests were carried out according to ASTM D638 on a machine from Hegewald & Peschke.

Fig. Rollers and dogbone

ANALYSIS OF THE PRACTICAL PART OUTPUTS - EVALUATION OF THE PRESSURE TEST

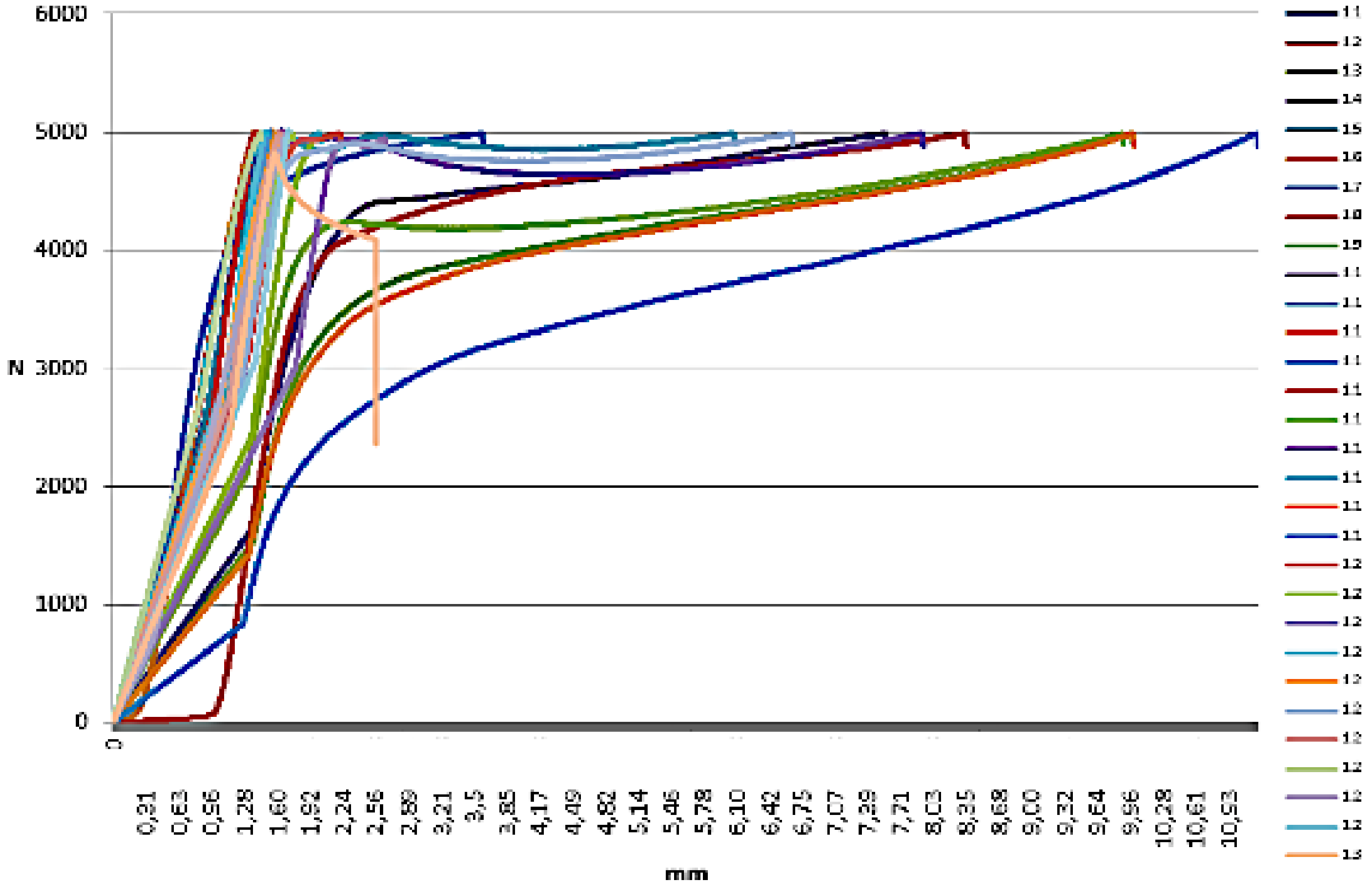


Fig. Graphical representation of the values of test set 1

- On the basis of the pressure test in which 90 rollers from three different materials were tested.
- The data recorded in the graphs and tables were obtained.
- Sets 1, 2 and 3 were tested, there were 30 rollers in each set.
- The graphs record the force data in N and the displacement in mm, where the graph shows the tension curve at which the roller has deformed.

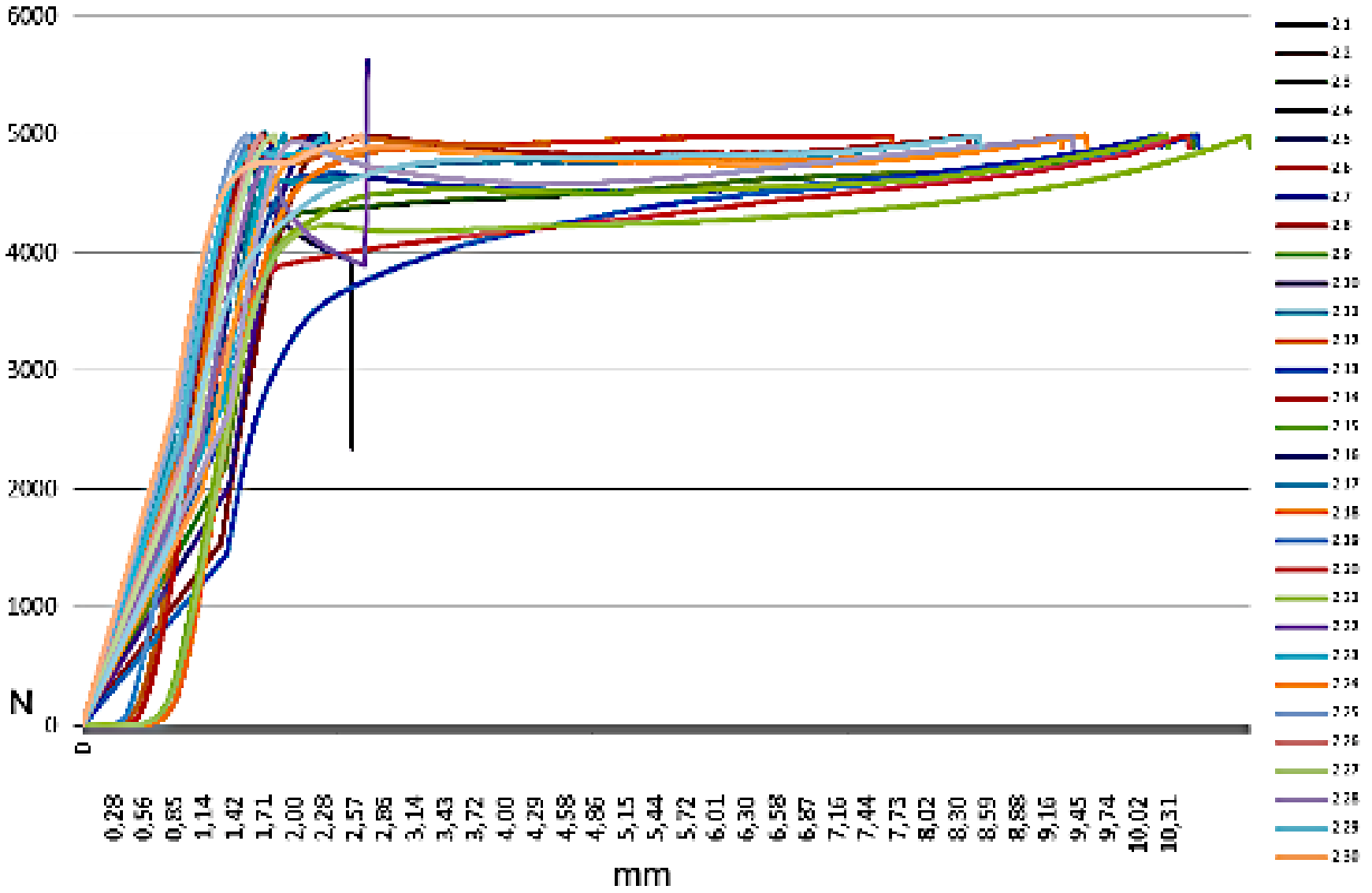


Fig. Graphical representation of the values of test set 2

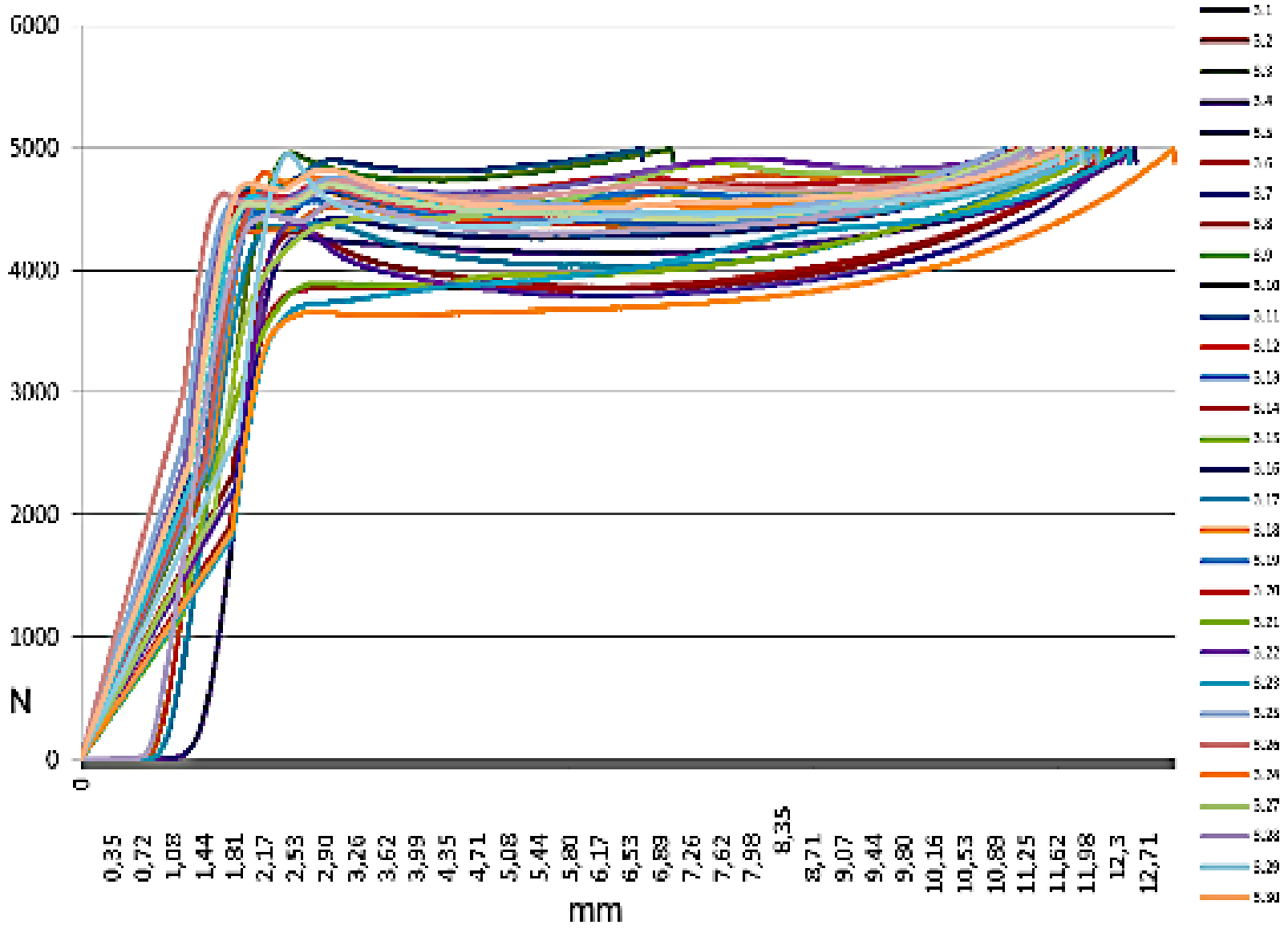
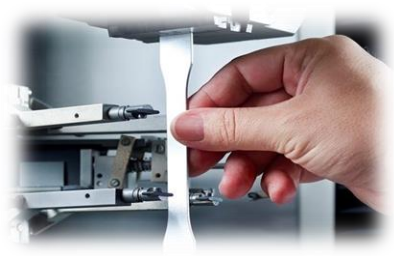


Fig. Graphical representation of the values of test set 3



ANALYSIS OF THE PRACTICAL PART OUTPUTS - EVALUATION OF THE TENSILE TEST/MODULUS OF ELASTICITY

- The evaluation of carried out tensile test consists of the evaluation of the *modulus of elasticity* E and the tension $\sigma_{MAX.}$
- During the tensile test, the tensile machine software recorded the cross-sectional *value* S_O, the value of the module elasticity in tensile *E*, the maximum $\sigma_{tension\ MAX}$ value, or the tension value between the $\sigma_{slip\ Y}$.
- The auxiliary extensometer device recorded the initial measured length L_O, proportional elongation, and percentage elongation.
- In total, 30 samples were tested in three sets of 10 samples.
- Colored graphical evaluation with appropriate tables serves as the best interpretation of obtained results.

	Modulus of elasticity [MPa]		
Test sample	Set 1	Set 2	Set 3
1	1065,523	1025,238	1066,986
2	677,3	569,497	963,873
3	1144,988	472,724	1103,005
4	975,5	1058,407	823,571
5	1319,02	1321,501	711,621
6	911,393	1433,128	1283,201
7	988,572	954,864	938,795
8	871,41	830,077	1360,67
9	378,99	1040,054	1058,021
10	1303,15	904,446	1169,553
Average	963,5846	960,9936	1047,9296

TABLE. THE VALUE OF THE MODULUS OF ELASTICITY

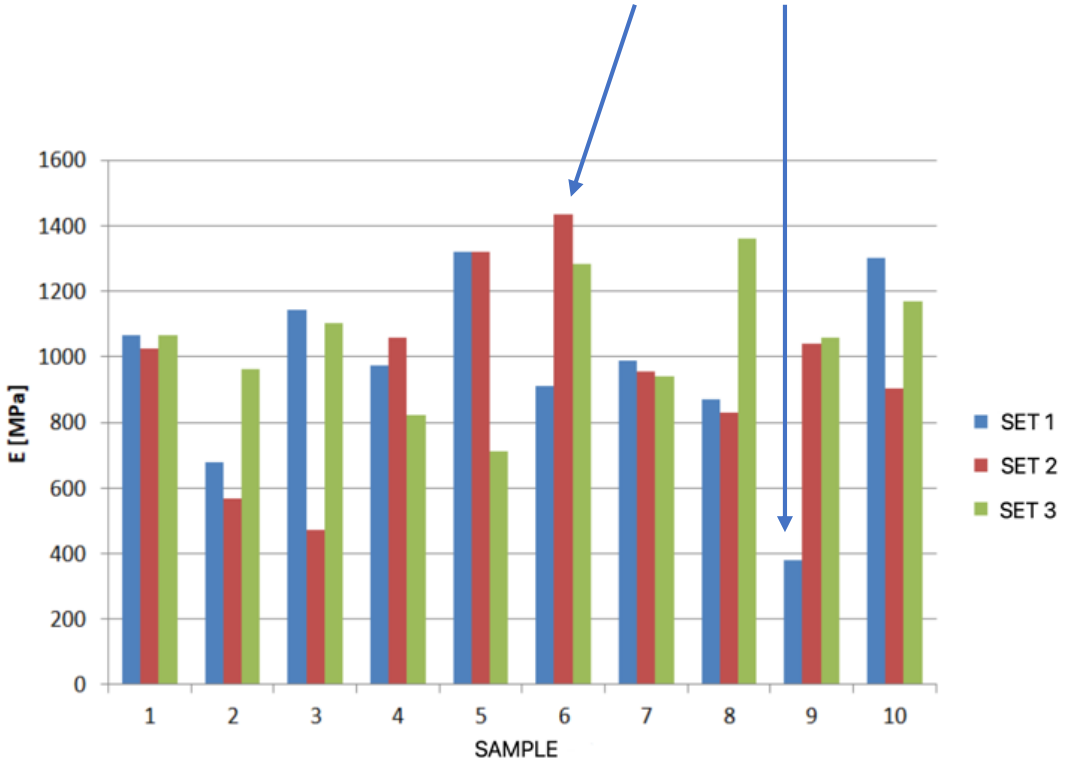


Fig. Graphical representation of the tensile modulus of elasticity

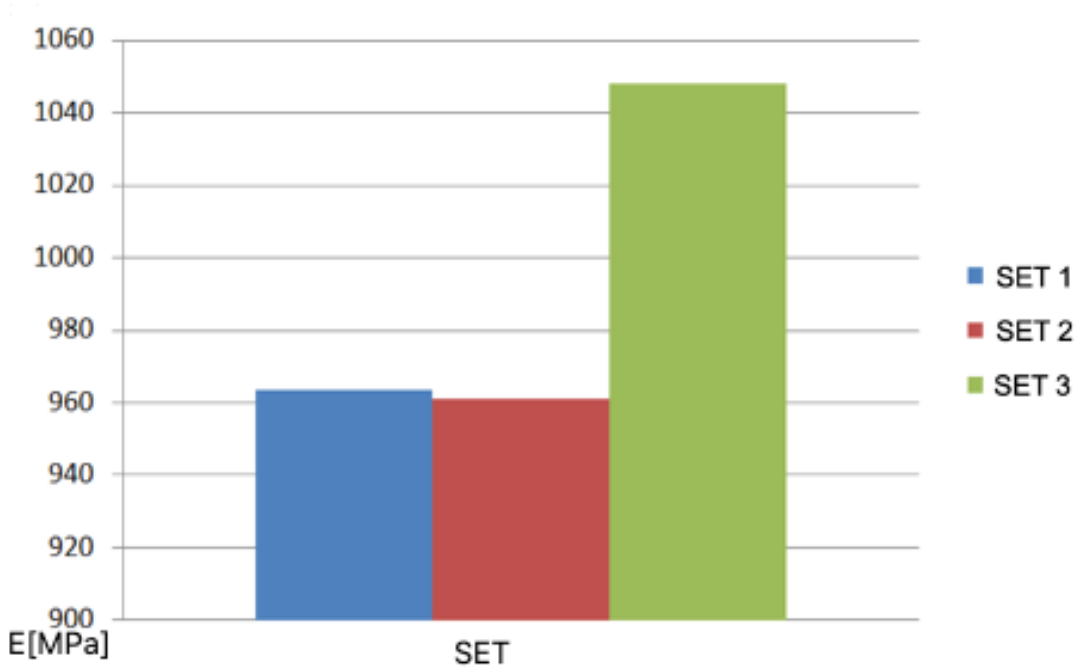


Fig. Average values of tensile flexibility set

ANALYSIS OF THE PRACTICAL PART OUTPUTS - EVALUATION OF THE TENSILE TEST/ TENSION EVALUATION

	Tension [MPa]		
Test sample	Set 1	Set 2	Set 3
1	40,786	32,511	37,908
2	36,327	21,969	21,566
3	29,485	39,924	35,885
4	38,961	33,745	18,689
5	45,204	38,62	15,109
6	20,498	37,115	33,494
7	40,741	36,489	17,431
8	18,173	16,175	27,8
9	31,235	23,946	37,894
10	46,591	27,348	23,107
Average	34,8001	30,7842	26,8883

TABLE. TENSION VALUES

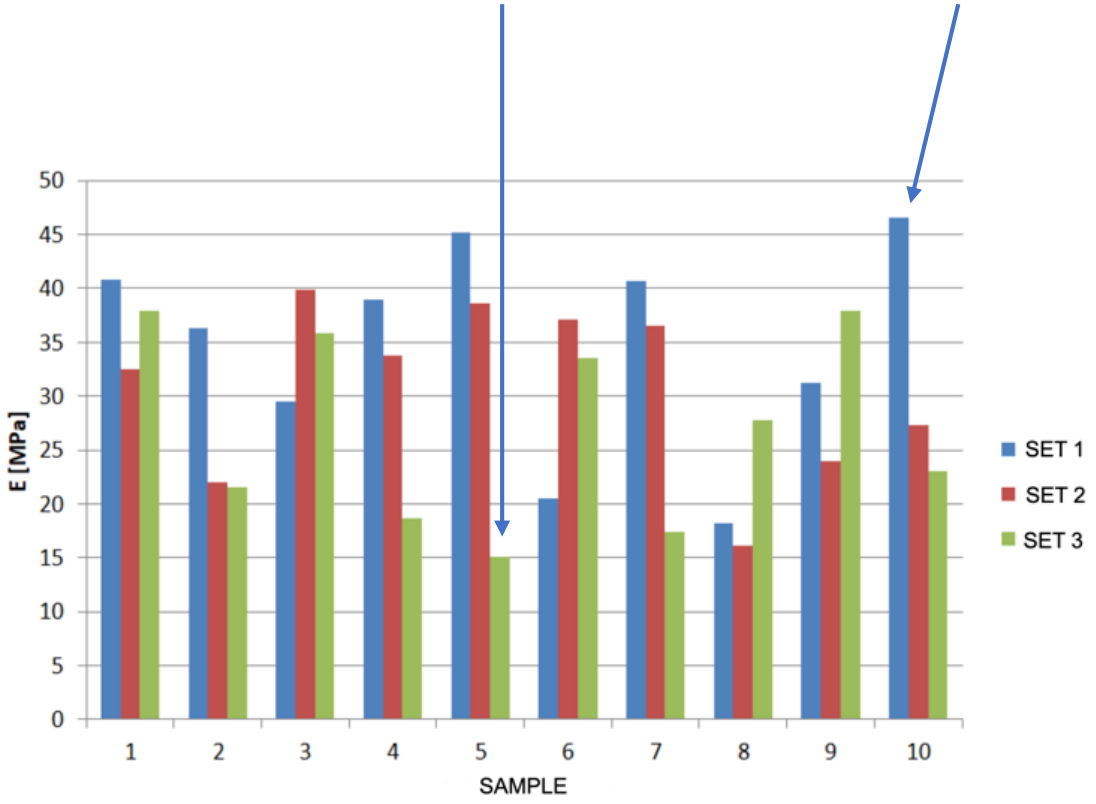


Fig. Graphical representation of tension

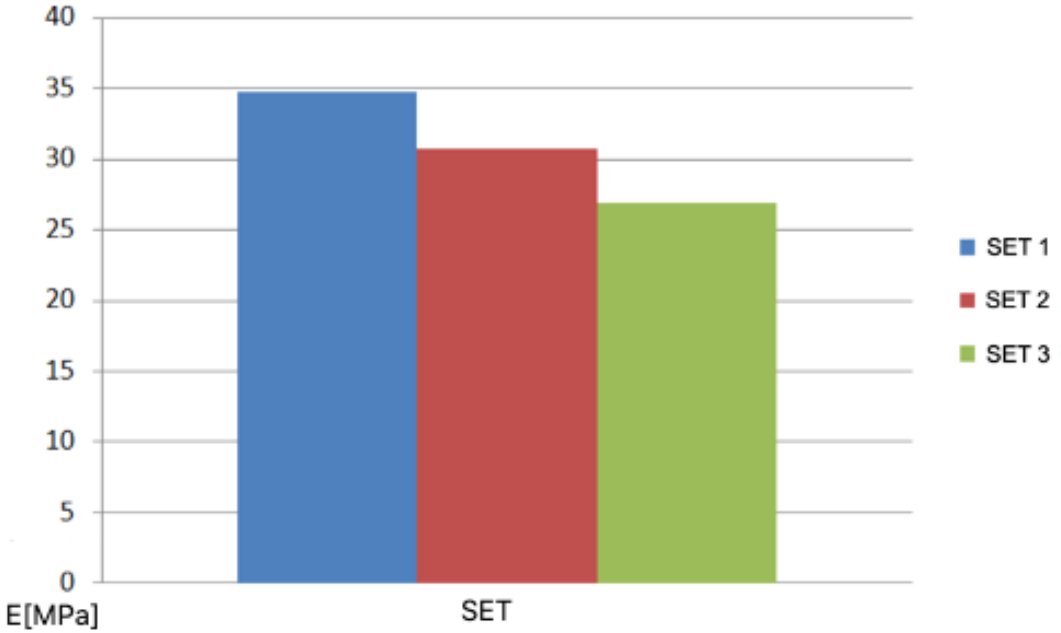


Fig. Average tension set values

CONCLUSION AND OVERALL RESULTS

- In the pressure tests, samples with the highest addition of the TAC solvent showed lower compressive strength and greater plasticity.
- The Less solvent added, the better the tensile strength.
- Prepared theoretical part and its possible application in practice represent a benefit for the area of mechanical testing of materials.
- The study aims to provide new knowledge and bring it to the practical sphere.

	Modulus of elasticity [MPa]	Tension [MPa]
Set 1	963,5846	34,8001
Set 2	960,9936	30,7842
Set 3	1047,9296	26,883

TABLE. OVERALL RESULTS

Thank you for your attention

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