

Paper and plastic waste composite boards for furniture

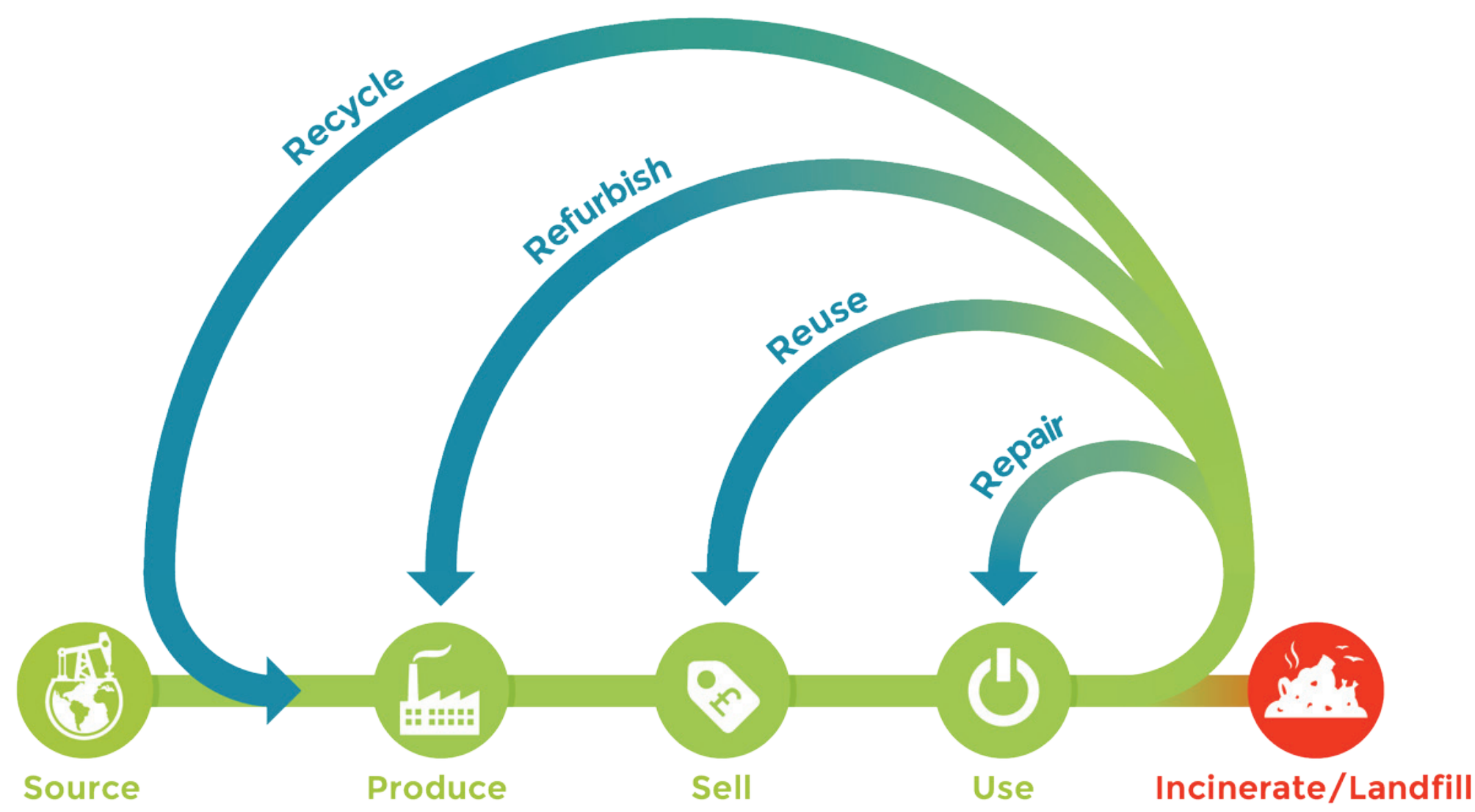
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Abstract

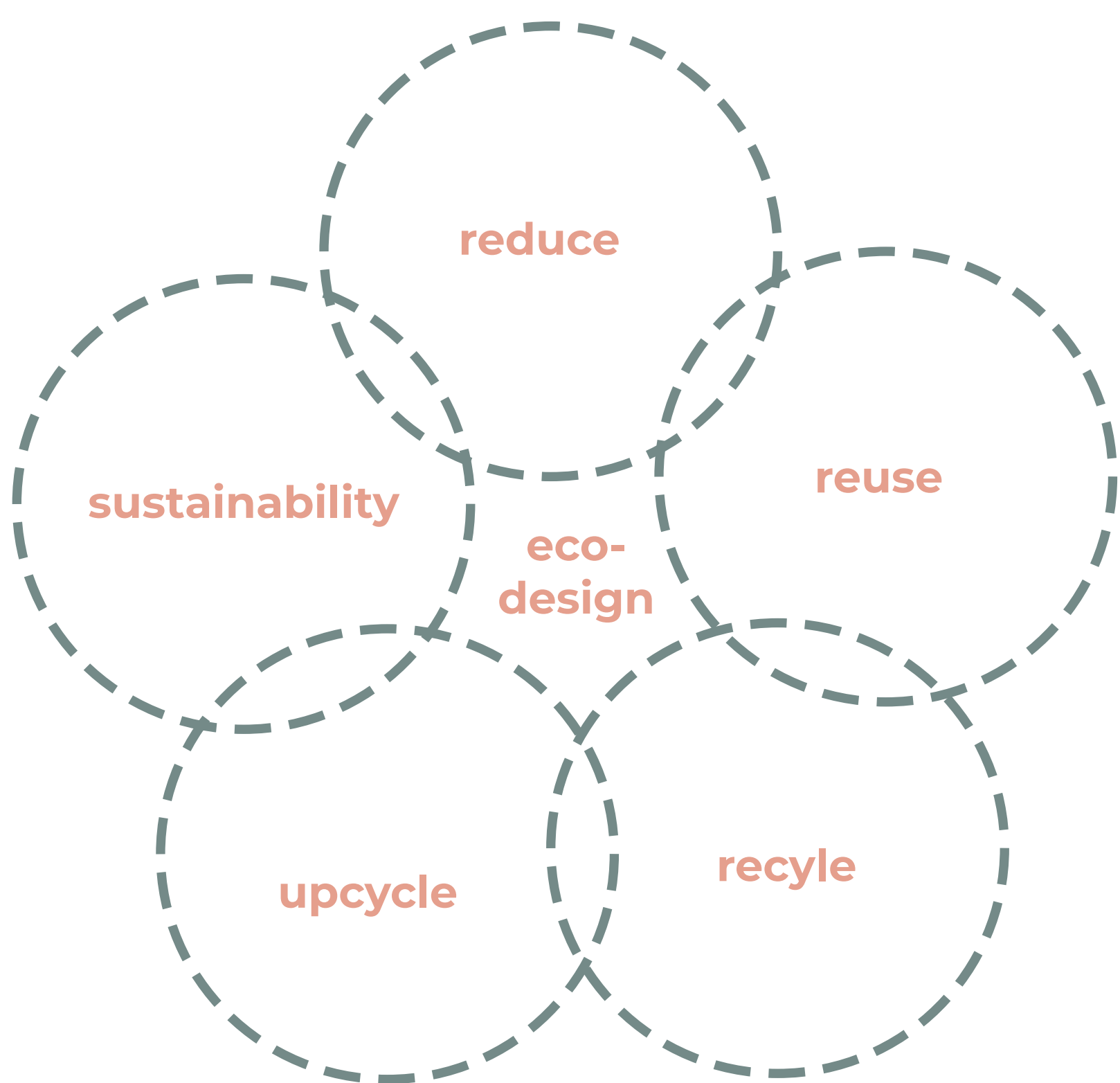
This article focuses on the use of wastepaper and plastic material which is used for creating composite material – paper-plastic boards. The idea of using cardboard as a material for furniture is valuable because of its sustainability. There is a lot of wastepaper which would no longer have other use. There are companies which are using cardboard for 100 % sustainable furniture. The paper which is used is packaging material or other cardboard taken from recycling companies. Second material which works as a binder for paper boards is re-used plastic material from a company production. Different types of postfactory a postconsumer plastic is used for creating the boards.

The goal of this project is to create boards which are made with high temperature and pressed by single opening hydraulic press. After the pressing the boards are climatized and their physical and mechanical properties are tested and compared with industrially manufactured boards and with another composite boards made from waste material. The testing is done according to the European standards. The most important tests for the use as furniture parts are bending strength and modulus of elasticity, internal bond, screw withdrawal resistance, swelling in thickness and water absorption.

After the testing and comparison with other materials, the results are used for design of furniture which is used in interior. Mostly the material can be used as a desk for table or storage furniture.



Circular economy



INTRODUCTION

We live in a time of big changes which should be coming in following years. Our homeland - Earth is being polluted each year more and more because of the manufacture of many products with short lifetime. That is why scientists are looking for new options of the use of materials and products. Also every designer should have sustainability in his mind before creating another product. These products are created in the idea of "Design for design" many times. Americans are taking 5 % of population on the whole planet but they are using 25 % of the world's energy. Their production belongs to one of the biggest in the world. In ideal world the products would be manufactured with long lifetime which is lowering environmental impact (Holman, 2015). Consumption of materials in USA is exceeding 10 tonnes per person per year. The resources of materials on Earth are not infinite but mankind have not realize that until some years ago (Ashby, 2009).



MATERIALS

Paper

The forerunner of paper is papyrus, which was made from the flower stem of the reed. It has been known and used for over 5000 years, native to Egypt. On the other hand, paper is a Chinese invention (105 AD) (Ashby, 2009). Paper is material which is manufactured worldwide. It is a cellulose-based material It starts from sheets of office paper, packages, newspaper but also photography, money, and stamps. Basic component of waste are fibers derived from plants where the main source is wood. Secondary fiber is derived from wastepaper and the recycled paper is made (Kirwan, 2013). Paper is formed from paper pulp fibers which are drained in a fluid through a filter screen to form a sheet of fibers. From the filtering mesh the paper sheet is then pressed through cylindrical roller for higher density and squeeze out the water (Xia, 2002).

Plastic

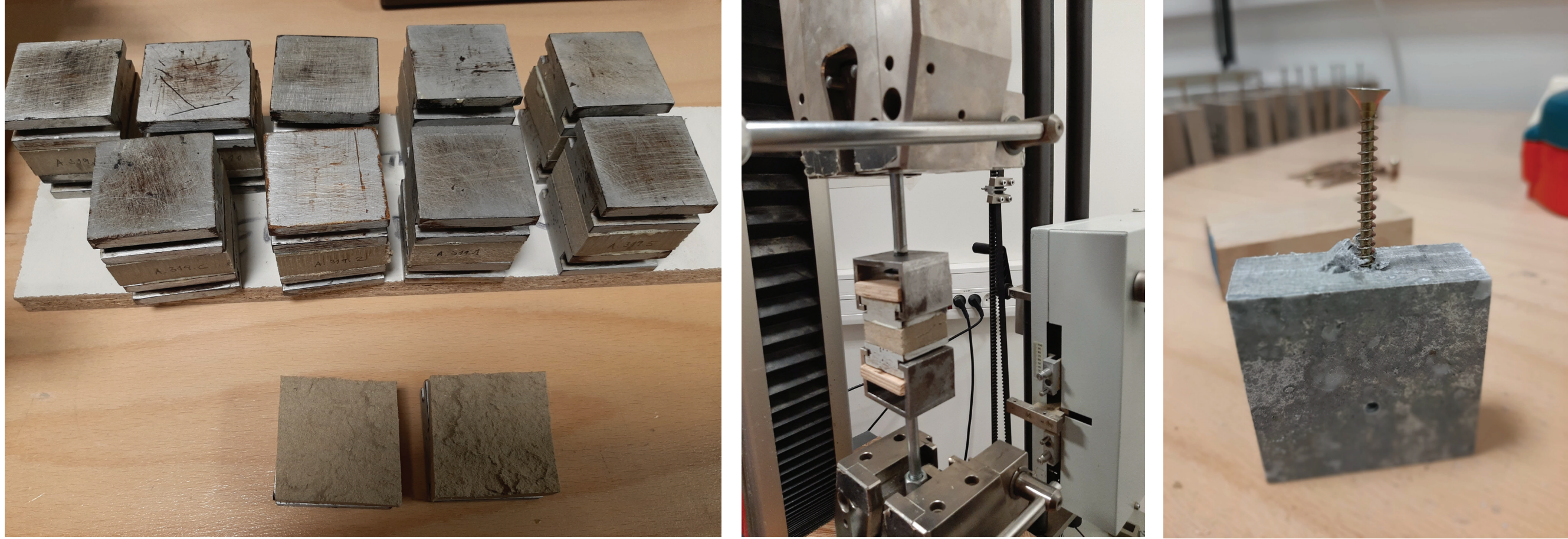
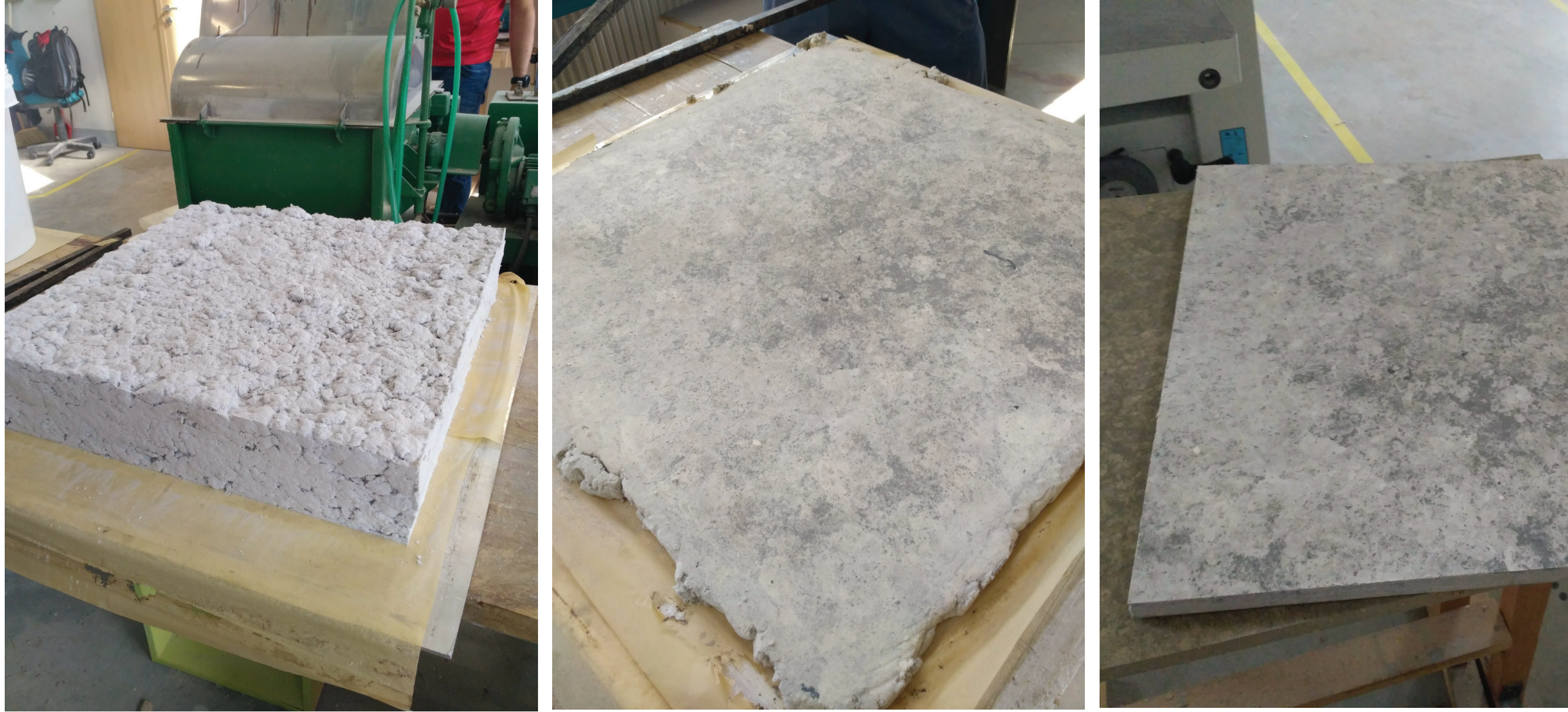
Plastic are used widely for several different products. Also in case of plastic, its recycling is very important. In this project, first trials of combination of paper with plastic was PLA and it continued with use of post-factory and post-consumer plastic.

Poly lactide (PLA)

Biodegradable plastic became very popular material, since it was found out how petroleum-based plastics are affecting our environment. PLA was developed from natural materials to replace plastic based on petroleum for the environment protection. Polylactic acid (PLA) is an polyester produced from maize, wheat, sugar beets or agricultural waste. PLA is often used in biomedicine and food packaging. (Panaitescu, et al., 2017). It is a thermoplastic and it can be processed like most thermoplastics into fibers, films or injection molded (Ashby, 2009).

Post-factory & Post-consumer

The next trials of boards supposed to be high density polyethylene, polyethylene, poplypropylene and polystyrene. The main goal was to use post-factory and post-consumer plastic, which comes from a company Plastia. Post-factory is a recycled plastic from damaged products during the manufacture. Post-consumer is plastic material from already used products after they have been used by customers. It is broken into smaller pieces and later into granulate. Used types of plastic are high-density polyethylene, polyethylene and polypropylene.



RESULTS

In the table below there are the results of first trials with paper pulp (deinked pulp = DIP and old corrugated cardboards = OCC) mixed with starch glue and urea-formaldehyde glue. Another results belongs to the boards from cardboard mixed with plastic (CP) and office paper mixed with plastic (OP).

Due to the pandemic of Covid-19 it was not possible to finish planned testing of the boards. That is why there are presented results from previous research only and further development continues.

TESTING METHOD	Pressing temperature	Thickness	Pressing time	Swelling in thickness EN 317	MOR EN 310	MOE EN 310	Internal Bond EN 319
material/units	[°C]	[mm]	[min]	[%]	[N/mm ²]	[N/mm ²]	[N/mm ²]
S DIP	180	20	10	22,52	-	-	0,37
UF DIP	180	20	10	29,50	6,13	1189,07	0,39
S OCC	180	20	10	19,97	-	-	0,33
UF OCC	180	20	10	21,03	5,89	750,83	0,51
CP	200	18	15	3,73	8,44	1931,32	7,70
OP	200	18	15	7,64	4,90	1529,22	3,50
HDPE	-	-	-	-	-	-	-
PE	-	-	-	-	-	-	-
PP	-	-	-	-	-	-	-

METHODS

The main technology which was used is pressing with single opening press (Höffer HLOP 280) at Salzburg University of Applied Sciences and hydraulic press Stroztach at Mendel University in Brno over high temperature and a pressure of 3.5 N/mm2. There was different temperature during the process od testing. It started with temperature of 60°C, 120 °C and 180 °C without any glues at first. After that there were made samples with glues and temperature of 180 °C. When the PLA was added, the temperature was 200 °C because of the properties of plastic.

Different boards were manufactured and its physical and mechanical properties were tested according to European standards. The boards with the best results were used for design of coffe tables, which should be placed in interior.



CONCLUSION

One of the main goals of this research was to develop and test physical and mechanical properties of paper based composite boards which can be used for wood-based products This research was dealing with upcycling of materials which could be used for wood-based products. The main goal was to find the best solution of the use of recycled paper. Thanks to this research there were obtained very valuable results for the use of this type of composite material. The manufactured material was used for design of coffee-tables. Cooperation with different companies started. Also working at the university abroad brought completely different view over this problematic.

Even though people are recycling and sorting out their household waste, it is not possible to re-use it all. That is why it is important to look for other ways of reusing materials. Paper together with plastic can create sustainable materials which will extend its lifetime. Paper can be recycled about seven times but it is using its strength each time. In this use of paper it can be evenpaper with the almost powder like paper fibers. Also post-consumer and post-factory plastic can be used in this process.

During this project the paper based boards were manufactured, tested and used for design of furniture - coffee tables. There are several different options of used paper and plastic, which gives the boards different look every time. The main contribution of this research is upcycled material which can be used for furniture placed in interior.

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