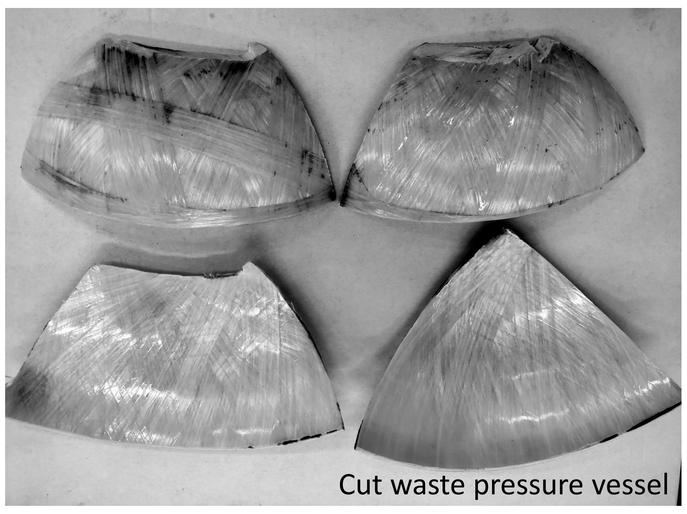
Utilization of FRP recyclate in the production of chipboards for construction industry

Martina Drdlová*, P. Böhm*, M. Šperl**

***Research institute for building materials, Brno, 61700, Czech Republic**
****The Institute of Theoretical and Applied Mechanics, Prague, 19000, Czech Republic**

INTRODUCTION

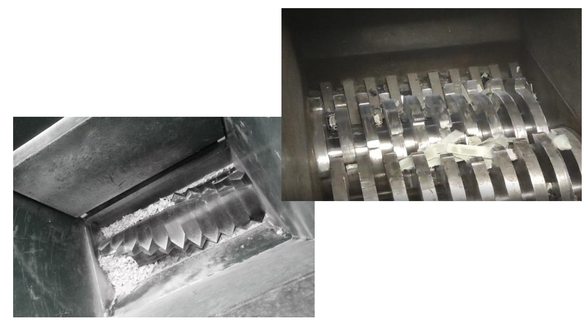
- The research deals with the possibilities of using recyclate, prepared by shredding waste fibre reinforced polymer (FRP), in production of chipboards for building and furniture industry.
- FRP composites are widely used in many industrial sectors, such as automotive, aircraft and renewable energy industries - being so spread, these materials generate significant amounts of waste at the end of their life cycle.
- As the first step, the influence of disintegration parameters on the properties of the output product of FRP recycling was investigated.
- The outputs in the form of chips of suitable granulometry and shape parameters were further verified for use in chipboard for structural purposes. The effect of chip size and binder content on the physico-mechanical parameters of the chipboard was evaluated.
- Functionally graded specimens with variable chip lengths were also prepared and the effect of gradation on the mechanical parameters of the chipboard was assessed.
- The results were compared with commercial particleboard and wood chip-based materials, and the competitiveness of the developed new FRP recyclate-based materials was confirmed.


Cut waste pressure vessel

MATERIALS

The source material for the preparation of FRP recyclate was discarded fibreglass pressure vessels for gas storage, i.e., vessels at the end of the life cycle and those that did not pass the output inspection in production. The container composition was 82% glass fibre and 18% thermoset resin (epoxy). The vessels were cut into four pieces and further disintegrated using different variants of shredders:

- single-shaft knife crusher DRJ44 (with sieve 6 mm and 12 mm)
- double-shaft shredder DRK500 (width of crushing disc 18.36 mm, without sieve)
- double-shaft shredder DR120 (width of crushing disc 5.5 mm, without sieve)
- hammer shredder RTZ (width of hammer segment 10 mm, grate 10 mm)
- shear mill CM 2500 (sieve 10 mm)



MIXTURES

- The crushing outputs of the single-shaft knife crusher DRJ44 (designation ST) and the hammer shredder RTZ (designation V) were selected as suitable for preparing chipboard test samples. Two types of chipboards were prepared – dense and cavern (open structure).
- The chips ST were used to prepare the dense chipboard samples. To evaluate the effect of the chip size and resin content on the flexural strength, 10 formulations were prepared, with binder content ranged from 16% to 24% in increments of 2%. (mix proportions are summarized in Table 1)
- 3-layered functionally graded samples have been prepared from ST chips to achieve higher flexural strength and to evaluate the influence of the fine/coarse chip ratio on the physico-mechanical properties of the panel.
- Chips designated as “V” obtained from processing the laminate waste by the hammer shredder RTZ were used to prepare the cavern chipboard samples with low bulk density, similar to the product of Velox, Durisol, etc.
- In all cases, the recyclate was mixed with the resin for 5 min. in a laboratory mixer, after which the mixture was manually layered into a mould and pressed at elevated temperature.


Recyclate from single-shaft knife crusher (designated ST)


Recyclate from hammer shreder (designated V)

RESULTS

- The physico-mechanical properties of the dense specimens with chips designated ST (length of 0-6 and 0-12 mm) are summarized in Table 1. With increasing amount of binder, flexural strength and impact toughness increases as well. Higher flexural strength of the specimens can be noted compared to the wood chip-based reference specimen, with better results in the case of samples based on the chips with a size of 2-6 mm.
- The results of physico-mechanical properties of functionally graded specimens are summarized in Table 2.
- The physico-mechanical properties of open structure samples prepared from „V“ chips are summarized and compared with the reference sample (commercial Velox slab) in Table 3.


Dense slabs


Open structure slabs

Table 1. Physico-mechanical properties of the ST chipboard samples

Designation	Amount of epoxy % wt.	Chip size (mm)	Bulk density (kg/m^3)	Flexural strength (MPa)	Impact toughness (kJ/m^2)
Ref - wood	NA	NA	741.8	17.86	6.2
ST 1	16 %	2-6	1047.5	17.02	7.9
ST 2	18 %	2-6	1074.3	17.96	8.6
ST 3	20 %	2-6	1105.3	24.32	9.4
ST 4	22 %	2-6	1138.9	29.41	13.1
ST 5	24 %	2-6	1159.4	34.88	12.6
ST 6	16 %	2-12	1002.4	11.59	6.2
ST 7	18 %	2-12	1046.5	14.63	10.3
ST 8	20 %	2-12	1083.6	22.24	11.2
ST 9	22 %	2-12	1120.8	27.15	15.4
ST 10	24 %	2-12	1157.0	25.66	17.5

Table 2. Mix proportions and physico-mechanical properties of the functionally graded chipboard samples

Designation	Fine (2-6 mm)/coarse (2-12 mm) chip ratio	Bulk density (kg/m^3)	Flexural strength (MPa)	Impact toughness (kJ/m^2)
ST3-0.4	0.4	1077.7	23.81	10.8
ST3-0.75	0.75	1116.7	24.42	11.1
ST3-1	1	1093.3	23.67	11.3

Table 3 Mix proportions and physico-mechanical properties of the “V” based chipboard samples

Designation	Amount of epoxy % wt	Chip size (mm)	Bulk density (kg/m^3)	Flexural strength (MPa)	Impact toughness (kJ/m^2)
REF (Velox)	-	-	502	0.28	3.2
V-1	20	2-30	497	5.29	8.4
V-2	16	2-30	471	3.81	6.1
V-3	14	2-30	430	2.72	4.2

CONCLUSIONS

- By mixing and subsequent hot pressing of recycled FRP chips with appropriately dosed organic binder (14-20% by weight) it is possible to prepare boards with good mechanical parameters, potentially suitable for using in the construction or furniture industry (partitions, lost formwork, building cladding, floor boards, anti-noise wall panels). The mechanical properties are comparable with commercial particleboard available on the market. In the case of cavern chipboards, the achieved physico-mechanical parameters outperform the values of commercial reference specimens.
- The overall character, shape and size parameters of FRP recyclate can be highly influenced by the device used for shredding, parameters of milling unit, used sieve and the parameters of the shredding process itself. Therefore, it is possible to design the processing line so that the output material corresponds with the planned application.
- Regarding the dense particleboards, test specimens consisting of shorter chips (2-6 mm) show higher flexural strength values compared to those produced from longer chips (2-12 mm). Gradation and changing the fine/coarse chip ratio does not significantly affect the mechanical parameters of the chipboards
- Further work will be focused on the preparation of large-scale (1200x700 mm) test bodies and the evaluation of dimensional stability, impact resistance, long-term durability and acoustic parameters to fully verify the suitability of the proposed boards for structural purposes.

VÚSH
Research Institute for Building materials,
Hněvkovského 30/65, Brno, Czech Republic,
www.vustah.cz, +420 513 036 090,
+420 730 519 707

ITAM ARCCHIP
Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, Prosecká 809/76
190 00 Prague 9, Czech Republic

T A
Č R

The authors wish to express their gratitude and sincere appreciation to the authority of The Technology Agency of the Czech Republic, project No. FW01010355, for financial support