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UTILIZATION OF LIGHTWEIGHT MATERIALS IN CERAMIC BODY

Summary. The article describes possibilities of utilization of cement – bonded particleboards CETRIS® and paper-making sludge in a raw material mixture for brick form-piece production. The most important characteristics of the body ware were observed – absorbing capacity, volume weight, the capillarity and solidity.

The effort is to exploit the waste as lightweighting materials.

WYKORZYSTANIE LEKKICH MATERIAŁÓW DO WYTWARZANIA MAS CERAMICZNYCH

Streszczenie: Artykuł opisuje możliwości wykorzystania odpadów płyt wiórowych na spoiwie cementowym CETRIS® oraz osadów przemysłu papierniczego jako dodatków do mieszanin służących do produkcji cegieł budowlanych. Do najważniejszych zaobserwowanych charakterystyk powstałych mas należą: zdolność absorpcyjna, ciężar objętościowy, kapilarność oraz spoistość.

Głównym celem referatu jest przedstawienie możliwości wtórnego wykorzystania odpadów, takich jak materiały lekkie.

1. Introduction

Not only presence, but mainly near future, forces us to recycle waste materials instead of wasting nonrenewable natural sources. The brick industry can demonstrate an ideal instrument for utilizing of this waste, e.g. like the lightweighting materials.

The brick body lightweighting enables decreasing of volume weight and consequently smaller product weight, lower basic material consumption, easier manipulation etc. The brick products can be light-weighted. This means reducing their volume weight, with the following methods:

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- Expansion of body porosity – it means adding lightweighting materials into the production mixture,

- Formation of hollows – it means reducing body share in the of product volume,

- Combination of the preceding methods – as a body – and as a volume – light-weighted product.

Lightweighting of a brick body does not only influence the volume weight of the product. The light-weighting materials used in the brick industry influence also other characteristics.

They decrease e.g. the plasticity of the ceramic concoction, drying shrinkage, the solidity of the dried samples, drying sensitivity, the compressive strength, the heat conductivity.

All together 4 mixtures were made (addition waste is expressed by specific weight %):

- Šlapanice brick clay (100%) – (title S).
- Šlapanice brick clay + paper-making sludge Žilina (20%) – (title SZ).
- Šlapanice brick clay + paper-making sludge Předklášteří (20%) – (title SP).
- Šlapanice brick clay + waste of cement – bonded particleboards (5%) – (title SC).

2. Used raw materials

2.1. Šlapanice brick clay

Individual components were dried in the resistance dryer at temperature 60°C and grinded in ball mill.

Table 1

Structure Šlapanice brick clay in specific weight %

Name	brick clay I	brick clay II	loess	sand
S	31	31	18	20

Brick clay I:

Table 2

Determination sedimentation granularity

fraction < 2 μm [%]	fraction 2 – 20 μm [%]	fraction > 20 μm [%]
32	18	50

Based on the visible values in Winkler diagram the raw material can be classified as falling into the area III – generally perforated bricks.

Table 3

The sieve analysis

The control sieve	[mm]	4	2	1	0,5	0,25	0,125	0,063
screen residue	[%]	3,11	12,83	35,11	66,96	78,25	84,46	100
siftings	[%]	96,89	87,17	64,89	33,04	21,75	15,54	0

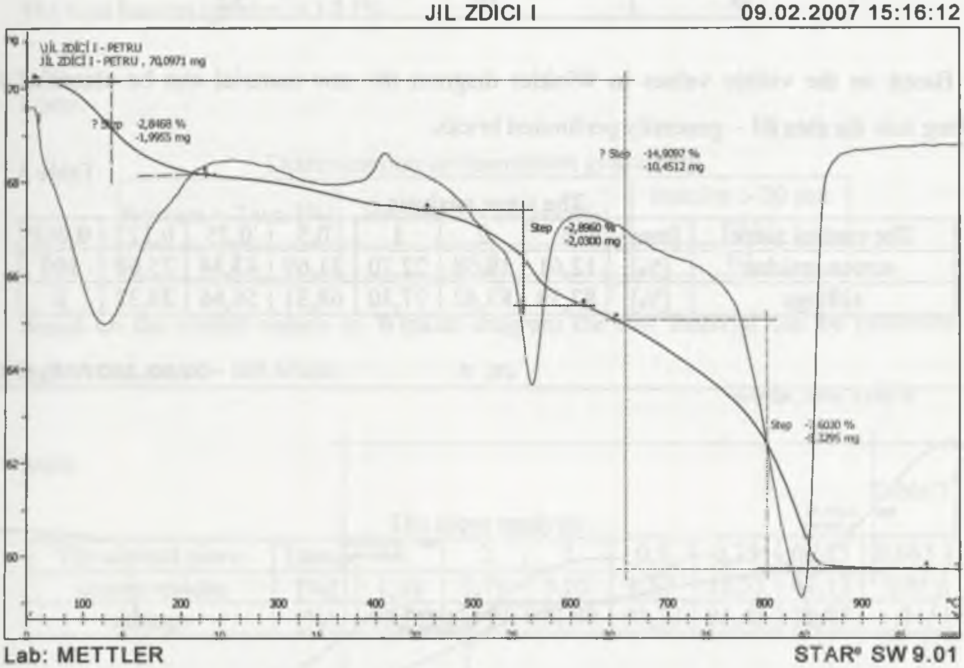

Fig. 1. DTA: proceeding in the material with growing temperature
Rys. 1. DTA: przebieg w materiale przy rosnącej temperaturze

DTA curve:

The endothermic reaction in 230°C belongs to the loss of physically mechanically fixed water, the loss is 3.3%.

The endothermic reaction in the area of 460 - 605°C belongs to dehydroxilation of clay minerals, the loss is 2.9%.

The endothermic reaction in the area of 650 - 900°C – belongs to calcite $CaCO_3$, the loss is 7.6%.

The total loss on ignition is 14.9%.

Brick clay II:

Table 4

Determination sedimentation granularity

fraction < 2 μm [%]	fraction 2 – 20 μm [%]	fraction > 20 μm [%]
38	10	52

Based on the visible values in Winkler diagram the raw material can be classified as falling into the area III – generally perforated bricks.

Table 5

The sieve analysis

The control sieve	[mm]	4	2	1	0,5	0,25	0,125	0,063
screen residue	[%]	12,61	16,58	22,70	31,69	43,34	75,68	100
siftings	[%]	87,39	83,42	77,30	68,31	56,66	24,32	0

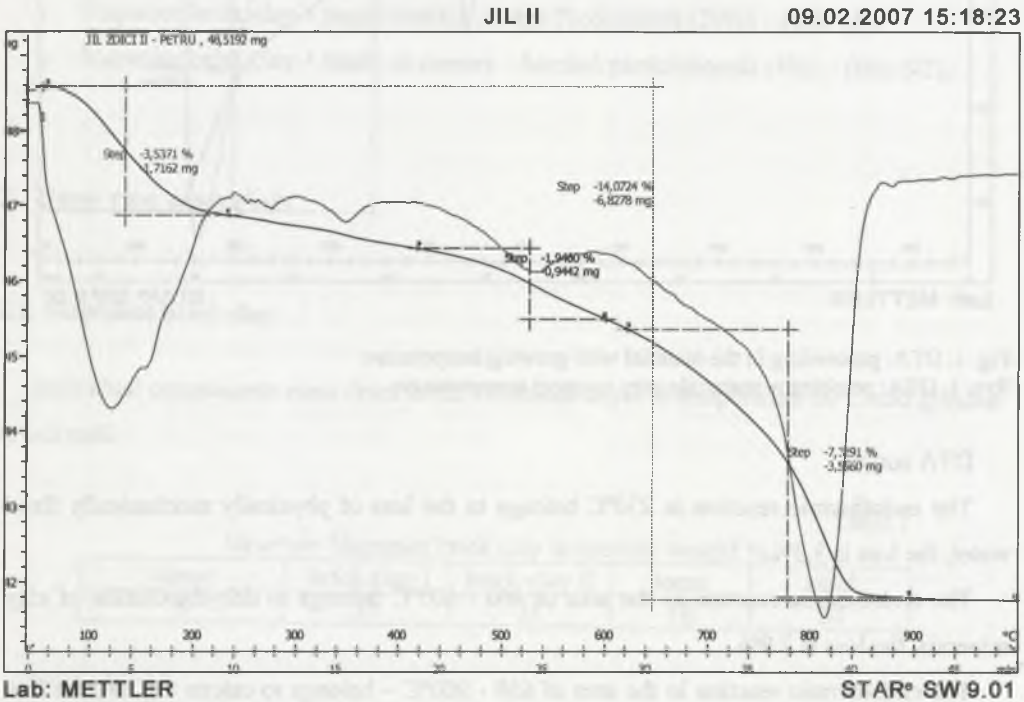

Fig. 2. DTA: proceeding in the material with growing temperature
Rys. 2. DTA: przebieg w materiale przy rosnącej temperaturze

DTA curve:

The endothermic reaction in 230°C belongs to the loss of physically mechanically fixed water, the loss is 3.5%.

The endothermic reaction in the area of 460 - 605°C belongs to dehydroxilation of clay minerals, the loss is 1.9%.

The endothermic reaction in the area of 650 - 900°C – belongs to calcite $CaCO_3$, the loss is 7.3%.

The total loss on ignition is 14.1%.

Loess:

Table 6

Determination sedimentation granularity

fraction < 2 µm [%]	fraction 2 – 20 µm [%]	fraction > 20 µm [%]
18	20	62

Based on the visible values in Winkler diagram the raw material can be classified as falling into the area I – full bricks.

Sand:

Table 7

The sieve analysis

The control sieve	[mm]	4	2	1	0,5	0,25	0,125	0,063
screen residue	[%]	1,33	3,79	5,02	6,67	18,55	67,13	100
siftings	[%]	98,67	96,21	94,98	93,33	81,45	32,87	0

2.2. The cement- bonded particleboards

The waste CETRIS II is sucked of from a saw that carves out boards of a basic format from a raw pressing. Longer offcuts (formatting in linear direction) are treated already during sawing – the saw leaves are equipped with the gradual waferizers that process the cut-off band to granular form during the cutting. It is not possible to process shorter offcuts with this technique with regard to the technological apparatus; hence these offcuts are further processed into smaller segments in a hammer mill, from where the granules are fed into the fractional screen by a box feeder. Raw granules, bigger than 4 mm, are screened out and re-recycled in a board production.

2.3. The paper-making sludge

The used paper-making sludge originates from waste paper processing. Most of this sludge ends up in dumps; it is usually a mixture of fibres, clays, fillers and TiO_2 and is generally regarded as nontoxic. The paper-making sediments have lower effect on reduction of volume weight of the ceramic body than the wooden sawdust.

3. Experimental Methodology

The samples were created by hand-churning into forms, whereby the bricks of 14x50x100 mm (after Czech standards 72 1565 – 4) were formed. The ceramic plastic body conformed to plastic deformation rate 0.6 according to Pfefferkorn apparatus Czech standards 72 1074.

Working moisture, the determination of the critical moisture content Czech standards 72 1565 – 11 (the Bigot's method) and the drying shrinkage (Czech standards 72 1565 – 5) were determined for this ceramic plastic body. Afterwards the samples were placed into the resistance dryer and dried at 110°C. A test of bending strength was performed on the dry samples according to Czech standards 72 1565 – 7.

The firing was performed in a laboratory electric furnace (capacity 5 dm^3).

Used firing curve:

The firing temperature was 950°C, growth was 250°C/hour, and hold time was 1 hour

The samples were always fired by two pieces. They were placed by their second largest planes onto the cordierite plate in the furnace.

The most important characteristics of the burnt-out body were observed - absorbing capacity, volume weight, apparent porosity (Czech standards 72 1565 – 6), predisposition to efflorescence (Czech standards 72 1565 – 13) and bending strength (Czech standards 72 1565 – 7).

4. Result

w_{pr} – optimum moisture,

DS – drying shrinkage,

CSB – drying sensitivity from Bigot's method.

Table 8

The plastic body characteristics

name	w_{pr} [%]	DS [%]	CSB [-]
S	30.41	8.67	2.18
SZ	39.32	8.87	2.98
SP	37.36	10.08	3.71
SC	43.42	8.72	1.37

Table 9

Resulting data of test of burned bodies

	S	SZ	SP	SC
firing temperature [°C] / growth [°C/ hour]	950/250	950/250	950/250	950/250
total shrinkage DC [%]	9.76	10.21	9.41	11.89
volume weight ρ [kg.m^{-3}]	1737	1531	1507	1661
water absorption N [%]	18.38	27.15	27.53	24.20
apparent porosity PZ [%]	31.92	41.56	41.21	40.18
bending strength $\sigma_{po\text{-}v}$ [MPa]	9.13	11.33	8.35	11.35
efflorescences - intensity	no	small	small	no
- color	no	yellow	yellow	no
- locality	no	area	area	no

5. Conclusion

The aim of the research was the examination of the raw material mixtures with addition of cement chip boards waste and paper-making sludge as a lightweight material for brick form-piece production and that from the aspects of the plastic body characteristics and the ceramic body.

In the mixtures with lightweight materials there weren't proved any positive effects on characteristics of plastic body and hence the used lightweight materials, does not meet the grog function.

Comparing the typical kaolinitic clay stone and the mixture with Cetris addition, these mixtures have lower volume weight, which is an advantage for the production of thermal insulation characteristics of brick form-piece production.

Next advantage is higher bending strength. Substantial disadvantage, of the mixture with lightweight materials, is higher water absorption of the ceramic body, than has the basic kaolinitic clay stone. There was proved the efflorescences on samples of mixtures with addition of paper sludge.

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