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FORMALDEHYDE EMISSIONS, DETERMINED BY MODIFIED WKI - METHOD, VS. PARTICLE BOARD THICKNESS AND THE KIND OF COATING

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Abstract

It was found that formaldehyde emissions are decreasing with an increasing particleboard thickness. Formaldehyde emissions from the side areas are aproximately by two times higher than the respective emissions from the surface layer. The highest formaldehyde emissions were found in uncoated particleboards, a bit lower in surface coated particleboards and the lowest in side coated particleboards.

Key words: particleboard, formaldehyde, layer, emission

ODVISNOST EMISIJE FORMALDEHIDA, UGOTOVLJENE Z MODIFICIRANO WKI METODO, OD DEBELINE IVERNIH PLOŠČ VRSTE OPLEMENITENJA

Izvleček

Ugotovljeno je bilo, da emisija prostega formaldehida pada z naraščajočo debelino. Emisija formaldehida iz robnih površin je približno dvakrat višja kot iz površine zunanjega sloja. Najvišja emisija formaldehida je bila ugotovljena pri neoplemenitenih ploščah, nekoliko nižja pri površinsko oplemenitenih in najnižja pri robno oplemenitenih ivernih ploščah.

Ključne besede: iverna plošča, formaldehid, sloj, emisija

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1 INTRODUCTION

The production and the use of particle boards have risen by almost 36 % in Europe over the past decade.

The majority of particle boards are of type V20 (according to the DIN 68 763 standard). They are used for the manufacture of furniture, interior furnishings and in civil engineering. Formaldehyde - based glue, obtained by the synthesis of urea and formaldehyde, has been mainly used in the manufacture of particle boards of type V20. The disadvantage of these particle boards lies in formaldehyde emissions which are hazardous to health. This problem has been therefore given great attention in Europe during the past decade. An increasing number of European countries has decided to make particle boards of class E_1 since then.

2 FUNDAMENTALS

Three - layer particle boards of type V20 (12 mm, 18 mm and 22 mm thick) have been chosen and tested for correlation between the formaldehyde emissions and the varying share of core and the varying gluing factors and the kinds of gluing. The share of single layers depends on the thickness of particle board. The gluing factor depends on the specific particle surface respectively. Particle boards can be either coated, surface and / or side coated or uncoated.

In brief, we wanted to find out how the thickness of particle board and the respective kind of gluing depending again on the particle board thickness (uncoated, surface coated, side coated) affect the formaldehyde emissions.

3 SOME METHODS OF FORMALDEHYDE DETERMINATION

3.1 Perforator method

This is probably the most widely used method which has been applied for more than 20 years and standardized as a European standard EN 120.

According to this method, formaldehyde is extracted with hot toluene and transformed into distilled water. The share of formaldehyde in the aqueous solution is determined by iodometry and / or spectrophotometry and given in mg / 100 g a. d. by particle board. The disadvantage of this method presented for many years the dependence of formaldehyde share on the moisture content in the particle board. This method has been mainly used to determine the share of formaldehyde in uncoated particle boards and fiber boards.

3. 2 WKI flask method

The WKI flask method is quite a simple method. Sample pieces with dimensions of 25 mm x 25 mm x thickness are suspended on a rubber strip over a 50 ml distilled water in 500 ml PE bottle and left for 24 hours or longer at temperatures of 40 ^{o}C. This is the so - called diffusion method. The disadvantage of this method presents an unfavourable relationship between the side and surface area. Here also, the share of formaldehyde in the solution is determined by iodometry or spectrophotometry.

3. 3 Modified WKI method

The modified WKI method, as developed by Roffael, differ from the simple WKI method in both a larger size of test samples (40 mm x 50 mm x thickness) and a bottle content. Furthermore, saturated sodium chloride solution is used instead of distilled water.

3. 4 Gas analysis

This method is known as a DIN standard 52 368. It is based on gas extraction of formaldehyde from the particle board. Under given conditions formaldehyde contained in air mixture turns into distilled water. The share of formaldehyde is then determined by spectrophotometry.

3. 5 Chamber analysis

This method allows the testing of larger samples or even of entire furniture pieces. The research parameters (such as, volume, temperature, moisture content, air velocity, air changes and chamber load) are preset. This method again is based on gas extraction of formaldehyde from a particle board. The content of formaldehyde is given in ppm. The results perfectly correlate with the results obtained by other methods.

4 METHODOLOGY AND EXPERIMENTALS

In the investigation under study, a modified WKI flask method has been used for the determination of formaldehyde emissions. This is again a diffusion method. The diffusion takes place according to the first Fick's law:

$$\frac{dn}{dt} = D \times S \times \frac{dc}{dx}$$

where means:

$\frac{dn}{dt}$ number of formaldehyde molecules diffusing from the particle board in a given time unit

D coefficient of diffusion

S a surface through which formaldehyde diffuses

$\frac{dc}{dx}$ coefficient of concentration

The advantage of this method over similar methods is in the fact that it remains unaffected by the moisture content of the particle board. By using sodium chloride it is possible to maintain the relative humidity above the solution more exactly. Larger test pieces (40 mm x 50 mm x thickness) allow for a larger relationship between the surface and side area. A 400 ml bottle, 90 mm high, has a diameter of 85 mm. Here too, the test

pieces are suspended on a rubber strip over the solution. The bottle is airtight closed and subject to temperatures of 40 ^{o}C for 24 hours. The relative humidity above the bottle is 85 % RH. The above mentioned three - layer test pieces (12 mm, 18 mm and 22 mm thick) of type V20 and the emission class E1 have been tested. Urea - formaldehyde glue has been used in the manufacture of particle boards. The gluing factor was 11, 7 % for the surface layer and 7, 5 % for the core respectively. The test pieces to be tested for formaldehyde and moisture content have been cut and shaped according to a drawing. The experiment was carried out in various alternatives. 10 test pieces have been always used in each alternative.

All tree thicknesses of a particle board have been tested in the following three alternatives:

I uncoated particle board
II surface coated particle board
III side coated particle board

The surface was coated with a melamine - resin impregnated foil, with a basis weight of 80 / 200 g / m^2. The sides were coated with a threefold coat of polyurethane varnish.

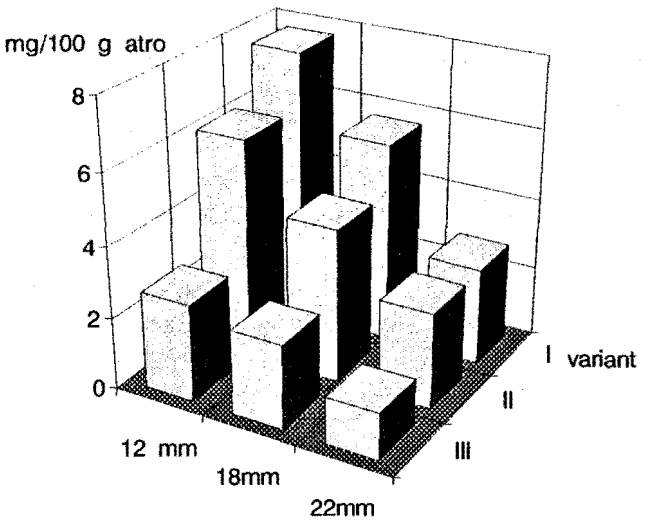
5 RESULTS AND DISCUSSION

The following formaldehyde emissions and their correlations have been found in the investigation under study:

- Formaldehyde emissions vs. board thickness in uncoated particle boards (in mg / 100 a. d.) . A linear correlation with a correlation coefficient R = 0, 96 was determined.
- Formaldehyde emissions vs. board thickness in coated particle boards (in mg / 100 g a. d.) . A linear correlation with a correlation coefficient R = 0, 95 was determined.
- Formaldehyde emissions vs. board thickness in side coated particle boards (in mg / 100 g a. d.) . A linear correlation with a correlation coefficient R = 0, 68 was determined.

- Formaldehyde flux vs. the share of side areas in uncoated particle boards (in mg / m^2 / h) . The correlation takes a shape of a curve. The correlation coefficient is R = 0, 96.
- Formaldehyde flux vs. the share of side areas in coated particle boards (in mg / m^2 / h) . The correlation takes a shape of a curve. The correlation coefficient is R = 0, 91.

Let us now look at the graphs of formaldehyde emissions in all three thicknesses and all three alternatives of surface coating.



As the graph clearly shows, formaldehyde emissions are decreasing with the increasing particle board thickness of uncoated, surface coated and side coated particle boards. The reason lies in the relationship between the number of board layers and the gluing factors. The share of side areas is increasing with the increasing particle board thickness which inhibits the formaldehyde flux. In side coated particle boards, the formaldehyde emissions from the surface layer are decreasing with the increasing board thickness owing to the share of surface layer and a higher gluing factor.

Further, the graphs show that the formaldehyde emissions have been the highest in uncoated particle boards and the lowest in side coated particle boards. This applies to all three board thicknesses. In uncoated particle

boards, the relative share of formaldehyde emissions released from the side area in relation to the total formaldehyde emissions does not depend on the board thickness. The same applies also to the formaldehyde emissions from the surface layer.
The above comparison shows that formaldehyde emissions from side areas reach approximately twice the amount of formaldehyde emissions from the surface layer.

6 CONCLUSIONS

- Reduction of formaldehyde emissions by increasing particle board thickness;
- Formaldehyde emissions are the highest in uncoated boards, and the lowest in side coated particle boards;
- The relative share of formaldehyde emissions from the side areas does not depend on the board thickness;
- The relative share of formaldehyde emissions from the surface layer shows only a light interdependence with the board thickness;
- Formaldehyde emissions from the side areas are approximately by two times higher than those from the surface layer;

POVZETEK

Prispevek govori o rezultatih ugotavljanja emisij formaldehida iz ivernih plošč tipa TP 20 , kjer je bilo uporabljeno urea - formaldehidno lepilo. Pri ivernih ploščah je bila ugotavljana odvisnost med emisijami formaldehida, debelino plošč in vrsto oplemenitenja. Preiskušane so bile tri različice ivernih plošč (neoplemenitene, površinsko in robno oplemenitene) in treh različnih debelin (12 mm, 18 mm in 22 mm) . Emisije formaldehida so bile ugotovljene z modificirano WKI metodo. Ta metoda je zelo praktična in uporabna za vse tri vrste ivernih plošč:neopleme - nitene, površinsko in robno oplemenitene.

Ugotovljeno je bilo, da emisije formaldehida padajo z naraščajočo debelino ivernih plošč. Emisije formaldehida iz površine robov so približno dvakrat

višje kot emisije iz površine zunanjega sloja. Najvišja emisija formaldehida je bila ugotovljena pri neoplemenitenih ivernih ploščah, nekoliko nižja pri površinsko oplemenitenih in najnižja pri robnooplemenitenih ivernih plošćah.

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