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Investigations of properties of solidified layers from HM adhesives applied in veneering operation. Part I. Hardness and chemoresistance

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Abstract: *Investigations of properties of solidified layers from HM adhesives applied in veneering operation. Part I. Hardness and chemoresistance*. Measurements of the hardness of the solidified layers from HM adhesives have been made. This parameter is expressed as the width of cracks at different loadings of graver. Examined the impact of resistance to lacquer solvents. Presented visualization the behavior of a drop of water in contact with the surface of adhesive layers and registered a values of the contact angle. Based on the results carried out of studies it was stated among others, that tested HM adhesives in terms of hardness values differ significantly from each other, are characterized by a varying resistance to lacquer solvents and the obtained contact angle values corresponded to the hydrophobic materials.

Keywords: hot melt, solidify layer, hardness, resistance to lacquer solvent, wettability

INTRODUCTION

There has been continuous progress in the field of binding agents, allowing multiple applications at the same time, i.a. in the furniture industry. Due to the automation of technological processes in particular the numerically controlled machine tools, an appropriate choice of the hot melt adhesives (HM), assortment from all sides justified (Tout 2000, Kajaks et al. 2009). HM adhesives are mainly used for veneering the surface of plate elements in the standard layout and softforming and also wrapping method (Erb & Brückner 1999). Solidified in adhesive-bonded joints layers of adhesives should be characterized by proper adhesion or cohesion. Based on assumptions for example adsorption theory of adhesion and Young-Dupre'a equation can be designate specific adhesion relationships based on values interaction surface energy contacting materials (Zielecka 2004, Proszyk, Krystofiak & Lis 2006, Jinzhen & Kamdem 2007). However, based on the results of hardness measurements solidified layers can be concluded about the progress and hardening processes of different binders which describe the forces of cohesion, deciding on their resistance to mechanical and chemical factors (Krzoska-Adamczak 1996, Żenkiewicz 2007). During the technological processes surface finishing with lacquer products, adhesive bonds are exposed to solvents contained in them, which may cause the hardening phenomenon, dissolution and also diffusion. In the case of a limited adhesives resistance on lacquer solvents, listed processes can reduce parameters of adhesive bonds. The analysis of the literature data has shown lack of scientific elaborations. Have been taken researches, whose aim was to evaluation the properties of layers HM adhesives by specifying their hardness and resistance to the effects of lacquer solvents and also determination on the basis of contact angle measurements susceptibility the surface layers to the impact of water.

METHODS

To the implementation of the study three HM adhesives were selected of JOWAT-Poland company under the trade names Jowatherm: 291.60 (EVA without filler), 288.50 (EVA with filler) and 236.50 (based on polyolefine-PO). Adhesive layers with a thickness of 5 mm were prepared by liquefaction of adhesives in melters with surfaces lined with PTFE. All measurements were carried out on the surfaces obtained in contact with the PTFE.

Specified hardness of the layers acc. to PN-EN ISO 1518-2 using Clemen's tool doing scratch by sapphire graver with different loadings. The width of obtained cracks were measured by caliper (± 0.1 μm).

Research of chemoresistance layers were carried out acc. to EN 12720. To the experiments used the following solvents:

- RLR to polyurethane products (R1)
- Chlororubber to polyvinyl and chlororubber products (R2)
- Nitrocellulose for general use products (R3)
- RF-04 for alkyd and carbamide products (R4).

Resistance of solidified adhesive layers to lacquer solvents determined after the time of 1, 2, 10, 60 min. Surface changes were evaluated by five-point scale acc. to PN-EN 12720.

Measurements of the contact angle (Θ) of the surface layers of dimensions 15x50 mm, were carried out by goniometer PG-3 using distilled water as a wetting liquid. The test was performed under dynamic conditions, leading measurements after the time 0, 75, 150, 300 s. After the the tests reports have been generated in the form the value of the Θ angle, height and a base diameter of drop.

RESULTS

Results of the hardness of the layers of HM adhesives are summarized in Table 1.

Tab. 1 The course of the hardness of the layers of HM adhesives expressed the width of scratches at different loadings of graver

Loading of graver [g]	**Kind of Jowatherm adhesive**		
	291.60	288.50	236.50
	The width of scratch [μm]		
50	46.2	57.8	95.7
100	95.7	138.6	198.0
150	174.9	336.6	287.1
200	203.0	358.1	379.5

Analyzing the obtained data it has been found that included in experiments HM adhesives were characterized by varying hardness, on which exert the influence their chemical composition, in relation to both the thermoplastic and the other components, including filler. Not without significance is the molecular weight of the base polymer and the degree of polydispersity. Tested adhesives in terms of hardness expressed in values of the width of scratches independent of the loadings graver, can be sorted as follows (from highest to lowest): Jowatherm 291.60 (EVA without filler) > Jowatherm 288.50 (EVA with filler) > Jowatherm 236.50 (based on PO).

Table 2 shows the results of the resistance of the adhesive layers to lacquer solvents. Tested HM adhesive layers in nature of expense method showed varying resistance to their action, which was related with both the time of their impact, and chemical composition. General analysis of the data contained in Table 2 proves that the effect of solvents on the surface of the layers at the time of 1 min did not cause any changes. Similar results were obtained for the R1 and R3 solvent after 2 min on all products and after 10 min for the adhesives layer of 291.60 and 288.50. The lowest chemoresistance showed solidified

adhesives after 60 min interaction, with the largest changes was observed for the binding agent Jowatherm 291.60 (2 and 3 degree of change). In other cases, the solvents caused lowered resistance of 1 degree with the exception of R4, which contributed to a reduction of tested property of two and three degrees.

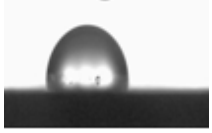
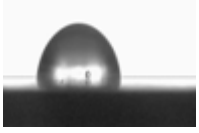
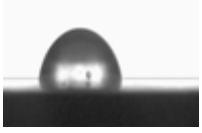
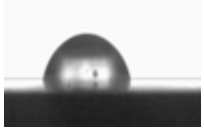
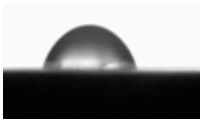
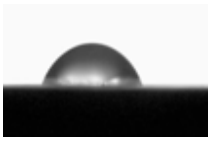
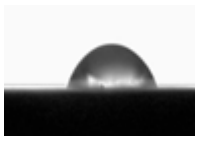
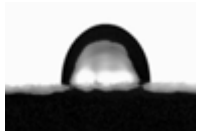
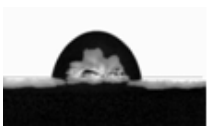
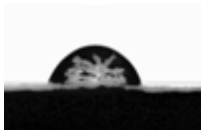
Tab. 2 Results of researches of resistance the HM adhesives layers to lacquer solvents at different times of their impact

Kind of solvent	Time of impact [min]	Kind of Jowatherm adhesive		
		291.60	288.50	236.50
		Evaluation (acc. to PN-EN 12720*)		
R1	1	5	5	5
	2	5	5	5
	10	5	5	5
	60	2	4	4
R2	1	5	5	5
	2	4	4	4
	10	4	4	4
	60	2	4	4
R3	1	5	5	5
	2	5	5	5
	10	5	5	4
	60	3	4	4
R4	1	5	5	5
	2	4	5	4
	10	3	4	3
	60	2	3	2

* 5-no visible change, 4-slight change of appearance of the surface of the adhesive layers, 3-small trace, seen at different viewing directions eg full puck or ring, 2-strong track but the surface structure is largely unchanged, 1-strong track surface structure is largely changed

Table 3 presents the visualization of surface wetting of the adhesive layers at a various time.

Tab. 3 The behavior of a drop of distilled water in contact with the layers of HM adhesives at the function of time

Kind of Jowatherm adhesive	Time [s]			
	0	75	150	300
291.60				
288.50				
236.50				

As is apparent from the data presented in Table 3, the behavior of a drop of water in an individual surfaces was varied. It has been found that as time passes, value of the Θ angle fell continuously and base diameter of drop increased. Generally, registered value of the Θ angle for the studied systems correspond to materials with reduced wettability, exhibiting

hydrophobic properties. The greatest values of this parameter were recorded for the layers of the adhesive Jowatherm 236.50, while the lowest for 288.50.

CONCLUSIONS

1. Tested adhesives in terms of hardness expressed by values of the width of scratches can be sorted as follows (from highest to lowest): Jowatherm 291.60 (EVA without filler) > Jowatherm 288.50 (EVA with filler) > Jowatherm 236.50 (based on PO).
2. Adhesive layers were characterized by varying resistance to solvents. The largest changes was observed for the adhesive Jowatherm 291.60 after 60 min. The most intense effect on the tested surfaces showed RF-04 solvent for alkyd and carbamide products.
3. Layers showed different hydrophobicity, with the highest values of this parameter was recorded for the adhesive Jowatherm 236.50, the lowest for Jowatherm 288.50.

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Streszczenie: *Badania właściwości zestalonych warstw z klejów HM stosowanych w procesach okleinowania. Cz. I. Twardość i chemoodporność*. Przedstawiono wyniki badań, których celem była ocena wybranych właściwości klejów topliwych (HM) poprzez określenie twardości w próbie odporności na zarysowanie oraz badań na oddziaływanie rozpuszczalników, a także zaprezentowanie wizualizacji zwilżania wodą destylowana powierzchni warstw klejowych w czasie. Na podstawie wyników przeprowadzonych badań stwierdzono, że testowane kleje pod względem twardości wyrażonej wartościami szerokości rysy można uszeregować następująco (od największej do najmniejszej): Jowatherm 291.60 (EVA bez wypełniacza) > Jowatherm 288.50 (EVA z wypełniaczem) > Jowatherm 236.50 (PO). Warstwy klejowe charakteryzowały się zróżnicowaną odpornością na działanie rozpuszczalników. Największe zmiany odnotowano dla kleju Jowatherm 291.60 po 60 min. Najbardziej intensywne działanie wykazał rozpuszczalnik RF-04 do wyrobów alkidowych (ftalowych) i karbamidowych.

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