THERMAL CHARACTERIZATION OF COATED FABRICS

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REZUMAT. Capacitatea de sudare a tesăturilor este o proprietate complexă, de care depinde posibilitatea acestora de a fi de asamblate folosind o procedură de sudare anume. De obicei, pentru a aprecia capacitatea de sudare, două grupuri de caracteristici sunt vizate: caracteristicile termice – pentru orice procedură de sudare; caracteristicile electrice speciale - pentru procedurile de sudare endo-termice (de exemplu, caracteristicile dielectrice în caz de sudare în curent electric de înaltă frecvență). Pentru procesul de sudare exo-termică, căldura reprezintă un factor de risc major din cauza acțiunii sale directe pe suprafața țesută. Stabilirea comportamentului termic al țesăturilor se referă la: determinarea temperaturii de topire a polimerului de acoperire; caracterizarea comportamentului termic al materialului; stabilirea răspândirii căldurii pe suprafața tesaturii. Lucrarea prezintă metodele de caracterizare a comportamentului termic pentru un grup reprezentativ de țesături acoperite.

Cuvinte cheie: sudare, caracterizare termică, polimer de acoperire.

ABSTRACT. The fabric welding capacity is a complex propriety that defines its possibility to be assembly using a certain welding proceeding. Usually, to appreciate the welding capacity two groups of characteristics are concerned: the thermal characteristics - for any welding proceeding; the special electric characteristics - for the endo-thermal welding proceedings (e.g. the dielectric characteristics in case of the welding by High Frequency Electrical Current). For the exo-thermal welding process, the heat represents the major risk factor because of its direct action on the coated surface of the fabric. The thermal behavior of the coated fabrics refers to: determining the melting temperature of the coating polymer; characterizing the thermal behavior of the coated fabric; determining the heat spreading on the fabric surface. The paper presents the characterizing methods of the thermal behavior for a representative group of coated fabrics.

Keywords: welding, thermal characterization, coating polymer.

1. INTRODUCTION

A fabric welding capacity is a complex propriety that defines its possibility to be assembly using a certain welding proceeding. Usually, to appreciate the welding capacity two groups of characteristics are aiming:

1) the thermal characteristics needed to be determinate for every welding proceeding;

2) the special characteristics necessary to be known for the exothermic welding proceedings (e.g. the dielectric characteristics in case of the welding by High Frequency Electrical Current).

The basic condition for welding process development is the presence in the assembly zone of a thermoplastic polymer that, in interaction with the thermal field, becomes fluid-viscous and this fact facilitates the internal mobility, respectively the macromolecular chains shifting and diffusion with the remaking of new links.

The welding process involves three phases, with simultaneous or successive development, with implications over the phases transformations of the polymer (Table 1).

2. MATERIALS AND METHODS

The specific character of the phenomena governing the welding process is a decisive argument to investigate the thermal behavior of the coated fabrics.

In the exo-thermal process, the temperature is the principal risk factor because of the heat intensity action to the fabric. The thermal behavior of the composite fabrics refers to:

- determining the melting temperature of the coating polymer;
- characterizing the thermal behavior of the coated fabric;
- determining the heat spreading on the fabric surface.

The paper presents the characterization of the thermal behavior for a representative group of coated fabrics presented in Table 2.

Table 1. **The welding process phases**

1-st PHASE	***HEATING***	Over heat action the phase transformations are produced and the polymer reach the limit between the high elastic state and the fluid-viscous, interval named "diffuse transition zone". That is a result of the progressive crossing from the molecular segments movement to the entire chain movement, making possible the relative shifting of the macromolecules.
2-nd PHASE	***PRESSING***	Here phase characteristic is the macromolecular chain diffusion amidst the fabric layers. At those interference it is putting in evidence two elementary stages: – the superficial adherence stage that is conditioned by the intermolecular interacting forces on the contact surface, depended on the chemical nature of the fabric. – the diffusion stage that produce a polymer block in the assembly zone. This stage is specific to the welding of the chemical nature fabrics.
3-rd PHASE	***COOLING***	Because of the stopping of the thermal field action it is produce a consolidation of the new chain position due to the pressure. The cohesive links in the polymer mass are remade and the effect is the assembly geometrical stabilization.

Table 2. **Characteristics of coated fabrics**

Cod.	Commercial category	Fabric composition	Coating polymer		
			Chemical nature	Coating method	Orientation
F1	Gore-tex tape	-	PUR + Hot melt	Laminated	-
F2	Cissarel	100%PA	PUR	Indirect stratification	Exterior
F3	-	100%PES	PUR	Impregnation	Exterior
F4	-	-	PCV	Single layer	-
F5	Tyvek PRO-TECH "F"	100%PE	PE	Laminated	Exterior

To characterizing the thermal behavior of the mentioned coated fabrics and to put in evidence the melting intervals it is used the thermogravimetric analyze in un-isothermal conditions. The MOM derivatographic type PAULIK-PAULIK-ERDEY has been used. There are applied the following analyze methods:

- the thermogravimetry (TG);
- the derivative thermogravimetry (DTG);
- the differential thermal analyze (DTA).

DTA is a dynamic technique that permits to record the temperature difference between the sample and the reference substance depending on time or temperature. The same substances are placed in the same enclosure and in programmed heating conditions.

TG permits the mass measurement of a heating or cooling sample depending on time or temperature. The complex processes are took place in successive serial stages.

DTG is the technique with that it is possible to deduce the differential of a thermo gravimetrical curve depending on time or temperature, giving information about the kinetics of the thermal decomposition processes.

The thermograms (presented as superimposed curves, figure 1 and 2) were been recorded in the same conditions to avoid the dates modifications and to permits their comparing:

- sample mass - 50 mg;
- heating speed - 12 ^{o}C/min;
- DTG, DTA sensibility - 1/10;
- the maximal temperature - 900 ^{o}C;
- reference substance - Al_2O_3;
- normal environment.

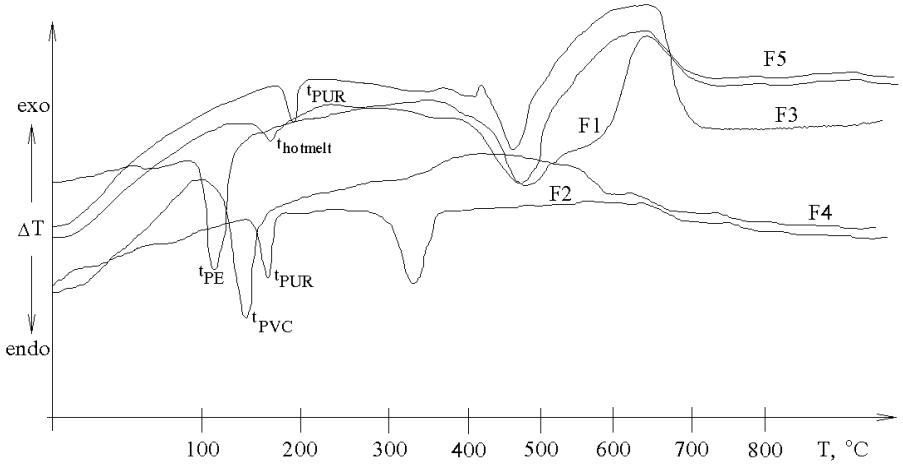

Fig. 1. DTA cumulative curves .

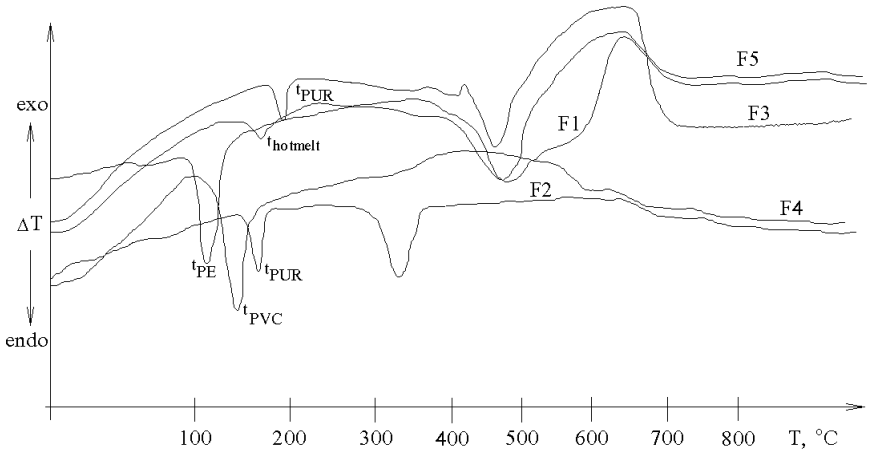

Fig. 2. DTG cumulative curves .

3. RESULTS AND DISCUSSION

In conformity with the usual methodology to establish the stages of thermal solicitation, the characteristic thermal values were been determinate (Tables 3 and 4).

The notation significance is:

T_i – the initial temperature of the thermal solicitation interval;

T_m – the temperature that the degradation is developing with maximum speed (for DTA, $T_m = T_t$);

T_f – the final temperature of the thermal solicitation interval;

W_∞ – the weight loosing;

ΔT – the thermal domain, $\Delta T = T_f - T_i$.

Table 3. **DTG results**

Cod.	I-st STAGE				
	T_{iI} (°C)	T_{mI} (°C)	T_{fI} (°C)	ΔT_I (°C)	$W_{\infty I}$ (%)
F1	179	195	243	64	9,69
F2	191	240	268	77	13,90
F3	183	257	291	108	15,84
F4	150	284	410	260	63.77
F5	124	181	260	136	19,53
Cod.	II-nd STAGE				
	T_{iII} (°C)	T_{mII} (°C)	T_{fII} (°C)	ΔT_{II} (°C)	$W_{\infty II}$ (%)
F1	263	368	542	279	63,46
F2	300	354	461	161	57,30
F3	328	453	501	173	66,15
F4	518	650	683	33	23,84
F5	297	473	520	223	59,99
Cod.	III-rd STAGE				
	T_{iII} (°C)	T_{mII} (°C)	T_{fII} (°C)	ΔT_{II} (°C)	$W_{\infty II}$ (%)
F1	603	681	703	100	17,30
F2	550	628	683	133	27,69
F3	553	609	705	152	11,23
F4	-	-	-	-	-
F5	570	639	690	120	16,69

Table 4. **DTA results**

Cod.	I-st STAGE			
	T_{iI} (°C)	T_{mI} (°C)	T_{fI} (°C)	ΔT_I (°C)
F1	150	163	185	35
F2	132	150	198	66
F3	150	176	240	90
F4	126	152	181	55
F5	105	120	163	43
Cod.	II-nd STAGE			
	T_{iII} (°C)	T_{mII} (°C)	T_{fII} (°C)	ΔT_{II} (°C)
F1	330	400	460	130
F2	250	284	304	54
F3	410	460	503	93
F4	295	420	590	295
F5	373	480	550	177
Cod.	III-rd STAGE			
	T_{iIII} (°C)	T_{mIII} (°C)	T_{fIII} (°C)	ΔT_{III} (°C)
F1	590	646	705	115
F2	-	-	-	-
F3	503	650	700	197
F4	-	-	-	-
F5	550	643	682	132

The general characteristic of the thermal behavior is the complexity of coated fabrics destruction, being putted in evidence at least three stages differentiated by the thermal domain specific to each component. For the F4 variant (PCV single layer) the degradation has take place in two stages. Generally, the analyzed polymers have small or null hygroscopicity (PCV, PE) and the first stage hasn't the significance of the physical humidity elimination, this phenomenon being met at the usual hygroscopic polymers.

The thermostability is appreciated through the temperature when a decomposition of the fabric in elementary compounds is starting and through the kinetic of the thermal degradation process. Experimentally the thermostability is evaluating by the

temperature T_{iI} value or by the weight loosing $W_{\infty I\ I}$ recorded on the TG, DTG and DTA curves.

It is considering that first stage refers to the coating polymer termostability. In figure 3 it is presented the thermostability variation for the analyzed coated fabrics. The results confirm the specialty literature values and forms.

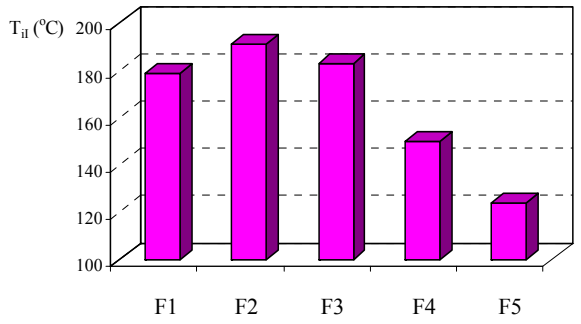

Fig. 3. Thermostability T_{iI} variation.

The smallest values are obtained for F5 (PE) and F4 (PCV) variants, comparable from the thermostability point of view and the maximum is recorded for F2 and F3 (PUR) variants.

The thermal behavior of the coated fabrics depends of the physical and chemical structure of the polymers. It is observing that the diagrams for the coated fabrics present at least two peaks what demonstrates the staidly degradation depending on the components thermostability, beginning with the coating layer degradation.

On the DTA diagrams it's observed that in the first stage endothermic peaks appear, without weight loosing (in correspondence with the DTG diagrams). That appoints the melting of a component (figure 1). Theoretically, the melting temperature is situated between the temperature corresponded to the peak end and the maximum point. Or that temperature can't be precisely determinate and usually it is accepted as melting temperature the value corresponding to the peak.

Analyzing the values from Tables 3 and 4, in order to the phenomena that governing the welding process it is possible to delimitate as normal thermal domain the interval $(T_{iI\text{-}TG} - T_{mI\text{-}DTA})$. For the temperature values placed outside of this domain the welding isn't acceptable. For less value the welding isn't possible, for greater values the thermostability limit is passed and the decomposition in elementary components is realized. The melting temperature $T_{mI\text{-}DTA}$ enforces restrictions over the polymers heating during the welding process.

Another important observation is that in first stage the maximum weight loosing is recorded for F4 variant (PCV single layer), dues in a great measure to the emitting of volatile, toxic compounds. It is a supplementary confirmation that the PCV processing is non-ecological, from this point of view the PUR coated fabrics being superiors.

4. CONCLUSIONS

1. The thermal characteristics' knowing is a premise of the welding technological parameters establish.

2. The thermal behavior study is the only that permits to establish the useful thermal domain.

3. For the temperature values placed outside of this domain the welding isn't acceptable. For less value the welding isn't possible, for greater values the thermostability limit is passed and the decomposition in elementary components is realized. The melting temperature $T_{mI\text{-}DTA}$ enforces restrictions over the polymers heating during the welding process.

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