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ALTERNATIVE WAYS OF TEXTILE MATERIALS MOUNTING WHILE USING MICROWAVE FIELD

Abstract:
This work analyses possibility of using microwave energy for small textile parts mounting. Existing ways of textile materials mounting are dependent on temperature, pressure and humidity, whereas energy intensity of this process is very high. Using of microwave field can decrease energy intensity, but it is necessary to find optimal values of parameters for particular material types – it means temperature, humidity, mounting time and apparatus power. At these conditions should be reached high quality of bonded joint

Keywords:
microwave field, mounting, textile, damp-heat processing

INTRODUCTION

Using of microwave energy is in industry generally growing. In textile industry is microwave field being used for drying, cleaning or pigment fixing. Inside the microwave apparatus energy is being transformed into heat, whereas heating up of inserted material is in whole volume, in contrast to conventional heating up, where heat is spreading from surface into material center. It is basic characteristic of microwave field incidence. Regarding these properties it is possible to think over the alternative way of mounting by using of microwave field.

At microwave mouting process, appeared heat induces melting of backing inset and inset is consequently bonded with base material. This process is generally dependent on temperature, humidity, microwave device power, microwave length and physical properties of backing and base material. It is necessary to analyze these parameters, to explore extent of their influence and to find their optimal value, so that the final effect can be as good as possible, from both quantitative and qualitative point of view. Using of this technology can bring energy savings in contrast to conventional technology (using mounting presser).

MICROWAVE MOUNTING

For microwave mounting was used microwave apparatus with frequency of 2450 MHz, which correspondes to wave length approximately 12,2 cm. Energy absorbed by volume unit [2] is equal to:

$$P = 2\pi \cdot f \cdot \varepsilon' \cdot \varepsilon'' \cdot E^2 \qquad (1)$$

P ... energy absorbed by volume unit $[W.m^{-3}]$
f ... microwave field frequency $[Hz]$

ε' ... *permitivity* $[F \cdot m^{-1}]$
ε'' ... *dielectric loss-factor of material*
E ... *intensity of electric field inside material*

Microwave energy is being transformed into heat, which induces melting of backing inset (based on polyamide 6), heating up of base material and finally bonding of both parts. Temperature inside the apparatus should be approx. 225°C, which is polyamide 6 melting temperature. This temperature should be modified according to used base material and its ironing temperature, so that base material is not destructed.
Amount of absorbed energy and consequently mounting quality is strongly dependent on physical qualities of textile material – permittivity, electrical conductibility and humidity receiving ability. Added humidity is an important factor, because material is absorbing microwave energy better if it is containing more water rate (or other polar dissolution reagent).
It is possible to suppose, that joint quality can be improved by load pressure inside the apparatus. It is appropriate to achieve of pressure using ballast weight made of such material, that is transparent toward microwave field, for example glass or teflon.

EXPERIMENT

For experimental part of this work was composed set of samples encompassing various types of base material with various physical qualities. Backing inset was based on polyamide, which is most common backing material.

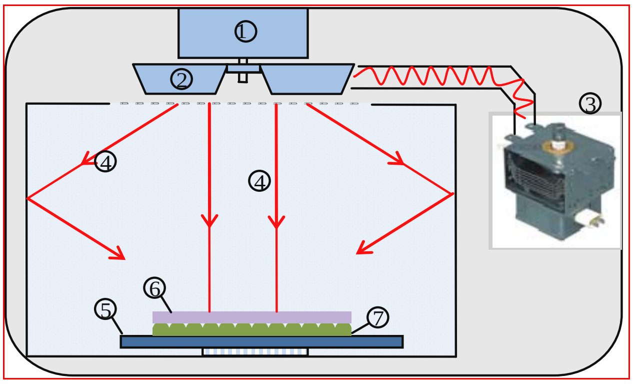


Figure 1: Microwave system
1…motor,2…apparatus for microwave field (energy) dissipation, 3… magnetron, 4… microwaves, 5… rotating plate , 6… base material, 7… backing material

Base material: ***1. 100% polyester***
2. 100% linen
3. 40% polyester+60% wool
Mounting backing inset: ***polyamide point application*** *– melting temperature 220°C*
Constant values: ***microwave system power*** *– 750W,*
microwave frequency *– 2450MHz,*
pressure *– 1kPa*
Variable values: ***operating time*** *– 120-180s*
humidity *– 0,15-0,60g of added water to 1cm²*
For better condition specification would be good to have chance to measure inside temperature and to change power of microwave device. Unfortunately at this experiment was not possible to adjust mentioned parameters, because experiment was performed using standard microwave device (microwave oven).

Tab. 1: Measured strength at three type of base material

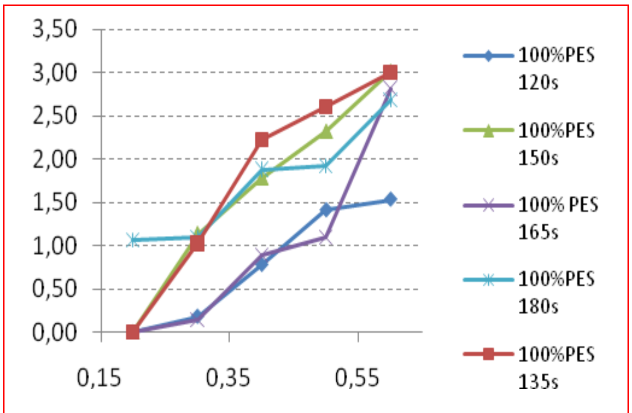
		100% polyester	100% linen	40% polyester 60%wool
Time $[s]$	Added water $[g \cdot cm^{-1}]$	Strength $[N]$	Strength $[N]$	Strength $[N]$
120	0,2	0,000	0,000	0,000
120	0,3	0,181	0,008	0,370
120	0,4	0,779	0,018	0,449
120	0,5	1,410	0,307	0,500
120	0,6	1,533	0,317	0,598
135	0,2	0,000	0,000	0,097
135	0,3	1,028	0,105	0,203
135	0,4	2,227	0,962	0,418
135	0,5	2,605	1,099	0,424
135	0,6	3,005	3,317	0,494
150	0,2	0,000	0,067	0,000
150	0,3	1,137	0,132	0,014
150	0,4	1,781	0,390	0,124
150	0,5	2,319	2,791	0,416
150	0,6	3,011	3,092	0,736
165	0,2	0,000	0,000	0,000
165	0,3	0,147	0,282	0,122
165	0,4	0,894	0,590	0,176
165	0,5	1,097	0,627	0,285
165	0,6	2,818	3,727	0,305
180	0,2	1,070	0,000	0,000
180	0,3	1,097	0,210	0,066
180	0,4	1,881	1,185	0,079
180	0,5	1,920	2,253	0,398
180	0,6	2,682	3,006	0,502

Above mentioned samples were inserted into microwave field at specified variable values (operating time and added water). Consequently *were measured values of strength of bonded joint using dynamometer. Results are stated in tab. 1. The aim was to find optimal input parameters values for reaching of the highest strength of bonded joint without destruction of base material.*

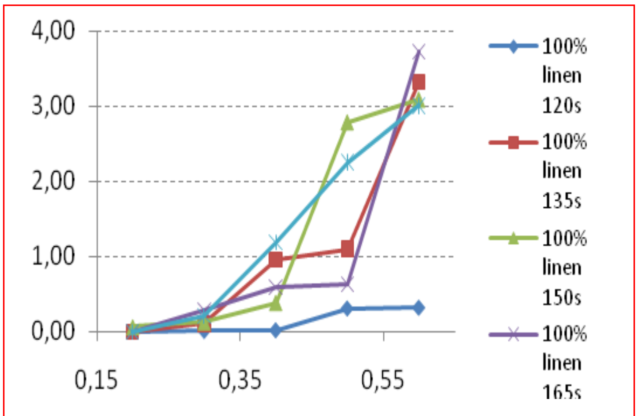
Problems of standard microwave device as we were using: inhomogeneity of microwave field (in connection with measurement reproducibility), protection of microwave system against radiation excess and measurement of actual temperature inside the microwave system. On this account presented dependencies is not possible to considerate as exact. They should only show off basic tendencies and trends.

RESULTS

For each textile material as described above was prepared 25 samples. And at each sample joint strength was measured using dynamometer. The following graphs describe dependence time – humidity – strength.

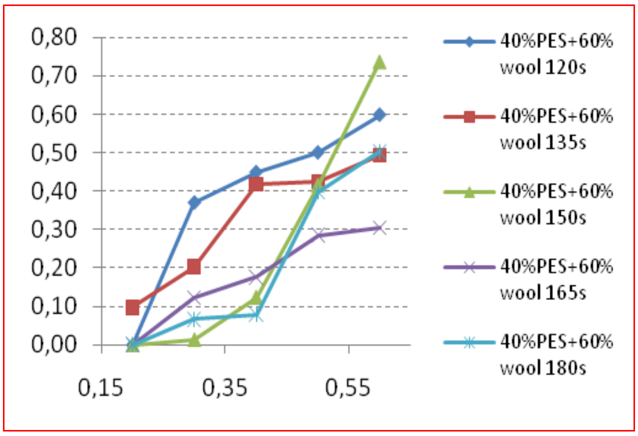


Graph 1: Dependence of strength (y axe) on amount of added water (x axe) for 100% polyester

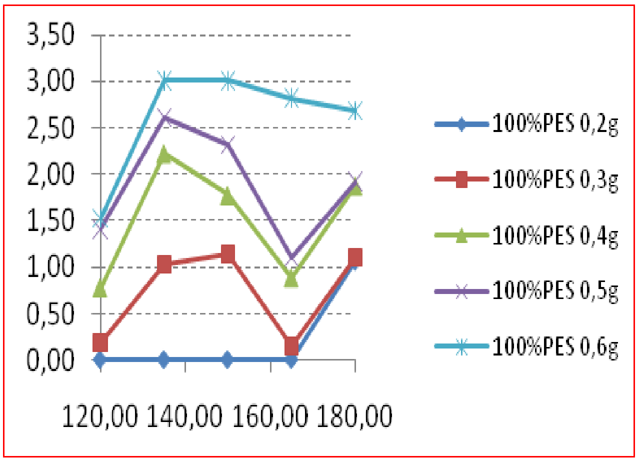


Graph 2: Dependence of strength (y axe) on amount of added water (x axe) for 100% linen

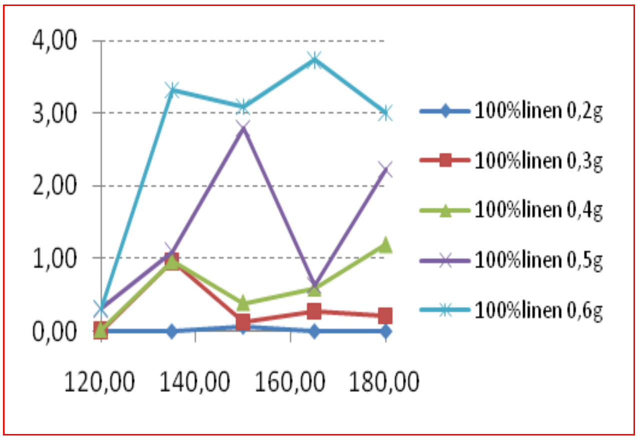
From graphical interpretation it is possible to assume that with increasing time and humidity, strength of bonded joint is increasing as well, whereas increasing intensity is in relation with physical qualities of used material.



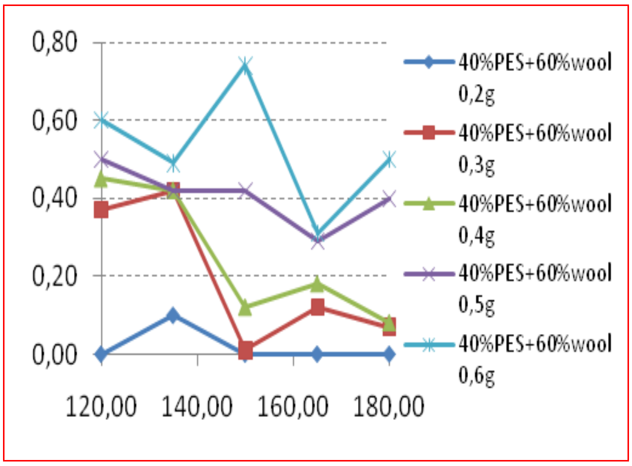
Graph 3: Dependence of strength (y axe) on amount of added water (x axe) for 40%polyester+60%wool



Graph 4: Dependence of strength (y axe) on time (x axe) for 100% polyester



Graph 5: Dependence of strength (y axe) on time (x axe) for 100% linen



Graph 6: Dependence of strength (y axe) on time (x axe) for 40%polyester+60%wool

CONCLUSION

For textile parts we realized mounting process in microwave field. Technology of inserting textile parts into microwave device is from its principle primarily determinated for mounting of small textile parts.

For larger parts would be possible to use device at present used for microwave drying. Quality of the joint strength depends on material parameters, humidity, temperature, pressure, operating time and system power. In this moment we are able to affect only some of them, so the joint strength is less than joint strength at using conventional presser. From results analysis it is evident, that optimal value of time when samples are under influence of microwave field is in this case 150s. Strength of bonded joint is strongly dependent on amount of added water. The more water is added, the better is the result of mounting process. It is possible to assume that optimal value of added water is close to maximal amount of water that is material and its structure able to absorb. Next experiments for determination of optimal parameters are subject of following research.

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