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RADIO-FREQUENCY HEATING AS AN EFFICIENT OPTION FOR PVC-P COATINGS

INTRODUCTION

Energy, its production and use is one of the most important factors of modern civilizations. Moreover, many industrial processes highly depend on the use of energy. The coating industry is a large consumer of huge amounts of energy for processes such as heating, curing, drying etc. A major disadvantage of heating up polymers is heating up good thermal insulators and therefore the efficiency of common heating processes using hot air or IR radiation is highly limited. An interesting option for increasing the energetic efficiency is the use of volumetric heating processes as they are offered by the use of dielectric heating.

In the framework of a research project of FILK the possibility of heating up a polyvinylchloride (PVC) plastisol using radio-frequency was evaluated.

METHODS

For the experimental work, a radio-frequency 50Ω solid state generator of 4 kW at 27.12 MHz was designed by Sairem SAS [1] and installed at FILK's Laboratory Coating Machine as shown in Fig. 1.

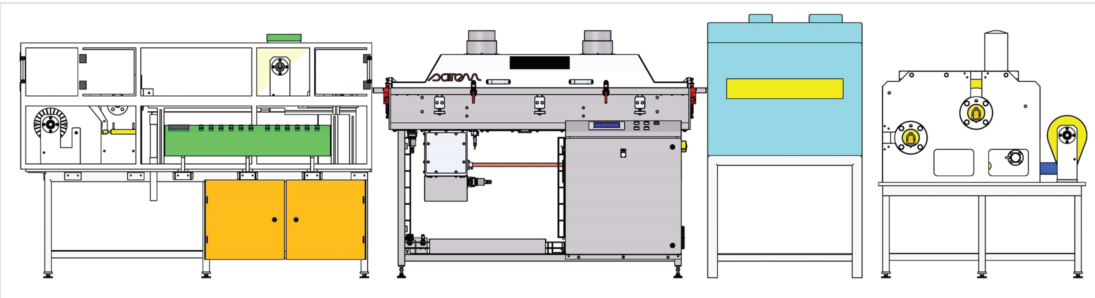

Fig. 1. Scheme of the modular FILK lab coating unit with unwinding and application unit (left), convertible process units (RF tunnel and hot air oven) and cooling and winding-up unit (right).

The polyvinylchloride (PVC) is dispersed by mixing all components (PVC powder, plasticizer, stabilizer and additives) together, give them through a three-roll-mill and evacuate the plastisol for approx. 1 hour. After that, the plastisol can be applied by doctor blade on a substrate, mainly paper for transfer coating or textile for direct coating processes.

The coating enters the applicator:

- stray field applicator [2]
- aluminium electrodes set in an angle of 45° under the substrate
- process length: 1.2 m
- process width: 0.3 m
- machine velocity between 0.4 and 2.8 m/min.

During the heating process the PVC is set in the electric field for 2 min maximum.

The generator power could be varied between 0 and 4000 W, the automated matching box is run mainly in automatic mode to identify optimal conditions for the fusing process.

The reason for the good affinity of PVC to high frequency excitation is the relatively high polarity, provided by the chlorine atoms in the PVC molecule. The polarization effect caused by the plasticizer is much lower as shown in some tests with PVC dry blends. The polarization mechanism for the considered plastisols is the same as for microwave heating: orientation polarization.

RESULTS

There were many tests done to compare the RF-based fusing technology to conventional hot air processes. One test was to investigate the difference of product's behaviour after multiple heating processes as shown in Fig. 2. After multiple heating processes, an extraction was done to quantify the mass loss during heating. Another test shows the careful heating during RF process by working without thermal stabilizer or extender (Fig. 3 and Fig. 4). The production of coated textiles using RF was shown in a further investigation by compare the mechanical properties of hot air and RF fused samples (Table 1). Last but not least the power demand was regarded in Fig. 5. There it could be shown that the RF heating process is an efficient and energy saving technological alternative to common hot air processes.

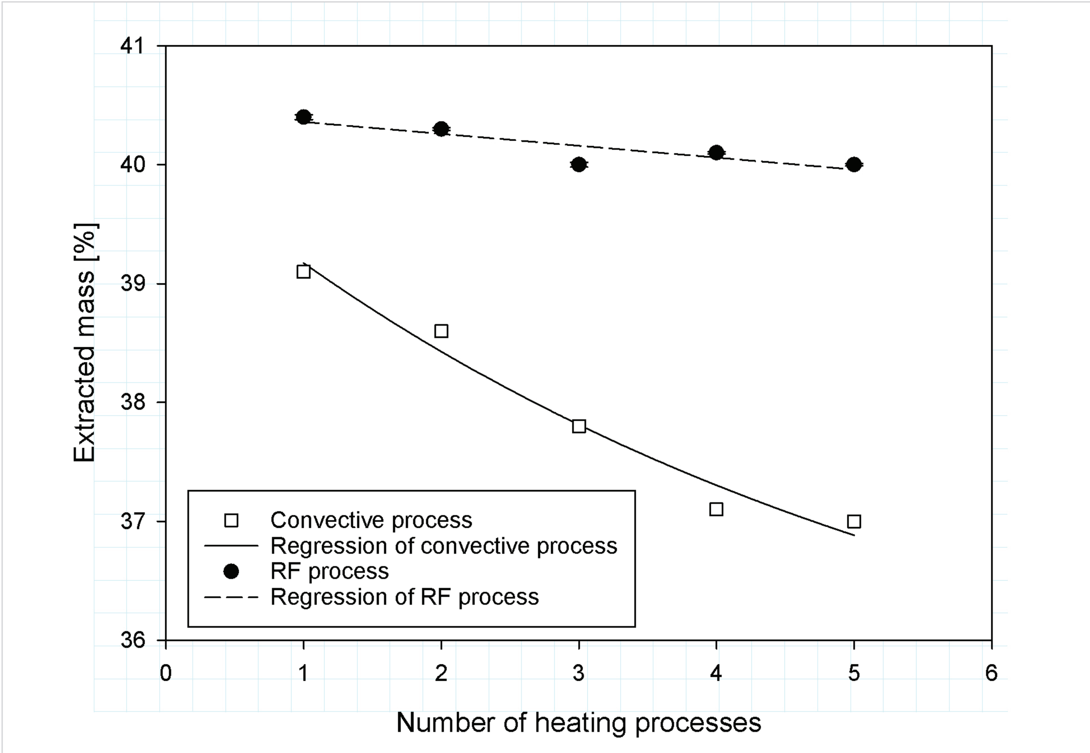

Fig. 2. Extracted mass (by diethylether) of RF and convective heating processes according to DIN EN ISO 6427

Fig. 3. Fused top coat without extender and thermal stabilizer using hot air.

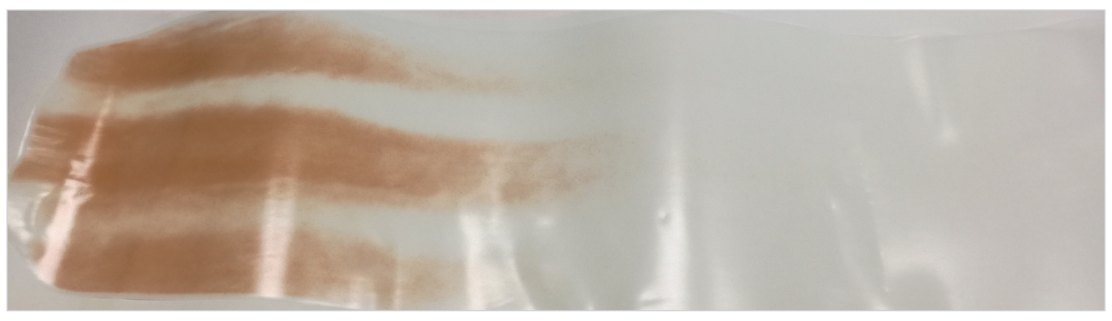

Fig. 4. Start of the fused top coat without extender and thermal stabilizer using RF.

Table 1. Results of the mechanical tests of tensile force and strain at fracture according to DIN EN ISO 1421 to compare convective and radio-frequency fused samples.

Sample	Convective process Max. tensile force [N] / Strain at fracture [%]	RF process Max. tensile force [N] / Strain at fracture [%]
Top coat – 0.35 mm, semi fused (135 °C)	42 ± 1 / 46 ± 1	-
Top coat - 0.35 mm, fused	152 ± 5 / 257 ± 8	142 ± 10 / 232 ± 19
Foam – 0.5 mm, semi fused (0-expansion)	71 ± 2 / 28 ± 1	228 ± 6 / 179 ± 9
Foam – 0.5 mm, fused/foamed	196 ± 8 / 177 ± 13	214 ± 2 / 197 ± 7
Foamed coated textile	406 ± 19 / 70 ± 2	464 ± 20 / 61 ± 4

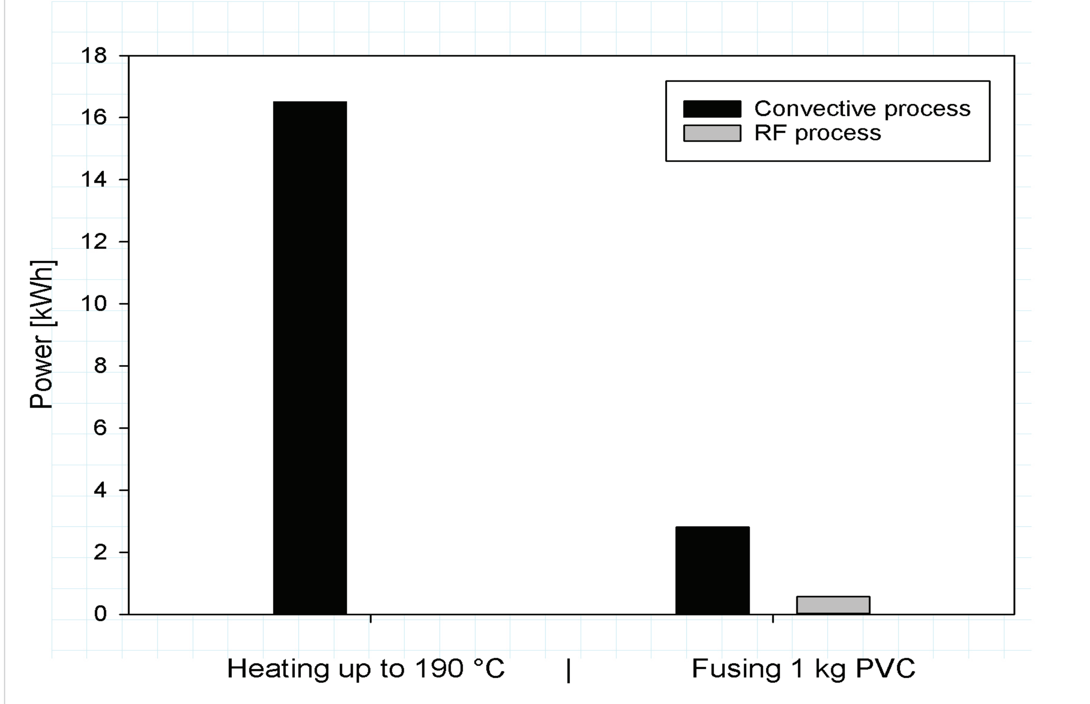

Fig. 5. Power demand of RF and convective process (with electrical heating).

CONCLUSION

As yet, radio-frequency heating has not been used in PVC-P coating industries. The project results show, that it offers a wide range of advantages in comparison to the state of the art convective heating process using hot air. These advantages are:

- Reduction of the warm up times after product change or maintenance
- Less process and installation space for process unit
- Faster processing times
- Reduction of recipe components (e.g. plasticizer due to less emission during heating process and thermal stabilizer due to a more careful heating of the plastisol)
- Energy saving potential

Although there are some more fields of interest such as the exact behaviour of the plastisol in the electric field and the influence of the used PVC-plasticizer ratio, the advantages are obvious and already draw interest of numerous PVC manufacturers.

Consequently, there are many possibilities to study the behaviour of different PVC-P materials at different process conditions. The focus in this project was on plastisols, but it could be shown that the technique also works with PVC dry blend and waterborne dispersions of polyurethane. The project's target was succeeded.

REFERENCES

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2. Jones, P. I., High Frequency Heating in Paper Making. Drying Technology: An International Journal, 1986, 2, 217–244.

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