

Can Industry 4.0 Technologies Be Used to Improve the Effectiveness of Printing on Wet Cellulose Tubing?

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Introduction

This report investigates potential alternative printing methods to the current azo-base printing method. This is because the colour range is limited and the process has many hazards linked to it. By doing this, Viscose Closures will be able to expand the range of print options. This includes more colours and ease of multiple colour designs. Industry 4.0 has been used to regulate the process conditions, allowing different chemicals to be used.

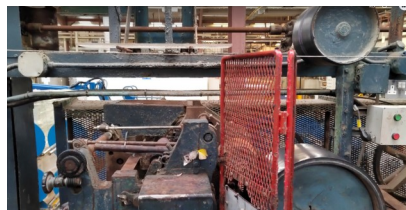


Figure 1: Viscose Closures current printing tooling

Project Aims

The primary aim is to determine an alternative more effective printing process. The effectiveness was measured by the ease of obtaining the chemicals, the quality of the print, the colour range and the ability to change the print patterns.

Ink Selection

Out of acid dyes, solvent inks, reactive dyes, pigment dispersions and dye dispersions, reactive dyes were the most suitable. This is because they react with cellulose in alkali conditions, therefore having a high colour fastness.

Table 1: 5 Classes of reactive dyes for applications on cellulose fibres (Smigiel-Kaminska, et al., 2020)

Name of group	Primary use of dye
MCT/VS bi-functional dyes	Dyeing of cellulose fibres
VS dyes	Dyeing of cellulose fibres
MCT/MCT bi-functional dyes	High fixation in polyester/cotton blends
MCT Dyes	High Temperature Cellulose Dyeing
DCT Dyes	Low Temperature Cellulose Dyeing

VS dyes are the most stable of the reactive dyes, but require the tightening of process controls.

Process Optimisation

The areas being investigated for the print quality are :

- Exhaustion Rate
- Fixation Rate
- Print Clarity

These are controlled by the following variables:

- Temperature of the soaking solution at 60°C
- Temperature of the washing solution at 80°C
- Concentration of Sodium Carbonate in Soaking Solution at 8wt%
- Concentration of Sodium Chloride in Soaking Solution at 16wt%
- Ink Amount Transferred, Spread using 2 rollers

The black print worked well, with good colour depth, with only smudging from excess ink on the band.



Figure 2: Black ink print example after the washing process

Colours had high exhaustion rates, but lower fixation rates, causing the colour to be light.



Figure 3: Scarlet ink print example after the washing process

However proper control of the temperatures and chemicals ensured a higher fixation rate. There was also a greater range of colours achieved with VS dyes than the legacy dyes.



Figure 4: Blue ink print example after the washing process containing sodium chloride and sodium carbonate

Conclusions

Industry 4.0 allows more relevant dyes to be implemented on wet cellulose tubing for printing, as process control over a process has greatly improved. While vinyl sulfone requires precise conditions, it enables a full range of colours to be printed, as well as different colours on the same tubing.

Recommendations

The final figure shows that by adding sodium carbonate and sodium chloride to the washing solution, a greater colour depth can be achieved. This means that these variables need to be optimised.

Furthermore an automated continuous trial should be conducted, which would remove the smudging as the ink amount would become more exact.

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