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SMART LIQUOR®

Dyebath Analysis

General Description

SMART LIQUOR® is a state-of-the-art system for the analysis and optimisation of exhaust and continuous dyeing processes. It consists of a fully-fledged spectrophotometer with several accessories for continuous, on-line as well as individual, off-line measurements and of a powerful software package featuring the option of monitoring up to six dyes simultaneously. The system can be connected, in principal, to any dyeing machine in laboratory and production.
SmartLiquor was introduced in 2003 at the ITMA in Birmingham and is being used in many dyehouses, research laboratories and at dye and chemical manufacturers all over the world. In combination with unique software, available as accessory, it is possible to automate process optimisation, i.e. to automatically generate recommendations for optimised dyeing processes based on a SmartLiquor measurement. The result is more efficient processes: higher productivity in combination with lower dye, chemical, energy and water consumption.

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Application Areas

Suitable for all major dyestuff classes (e.g. reactive, direct, acid, disperse etc.).

- On-line measurement of dye exhaustion values during a dyeing process carried out, for example, on a MATHIS COLORSTAR «CJ» or MATHIS TURBY «T» laboratory dyeing machine or on a bulk dyeing machine
- Off-line measurement of dyestuff concentrations in solutions, e.g. samples from a beaker laboratory dyeing machine of the type MATHIS LABOMAT «BFA»
- Measurement and control of dye concentration changes in padding troughs «Tailing» in semi-continuous and continuous dyeing (e.g. Cold Pad Batch and E-Control)
- Quality control of dyestuff batches
- Analysis of washing off characteristics of bulk production machines
- Scientific analysis of dye-fibre systems (e.g. characterisation of the effect of Plasma treatment)

Features

- Spectrophotometer with USB-port for full spectral analysis 400 to 700 nm (no filtered spectrum)
- Up to 6 dyes measured simultaneously
- Compensation of lamp drift for high accuracy and reproducibility
- Concentration range: 0.01 to approx. 10 g/l (100 g/l for continuous dyeing)
- Two calibration modes: relative and absolute
- Data export to spreadsheets (e.g. MS Excel)
- Calculation of average exhaustion speed of each individual dye
- Calculation of dye compatibility
- Calculation of the dye fixation values
- Automated recording and display of process variables temperature, flow, pH, differential pressure etc.

Optional Accessories

Integrated measurement system for pH and conductivity
Dual-channel instrument for pH and conductivity with integrated multi-point calibration method. Automatic buffer recognition and electrode test. Linear and non-linear temperature correction.

SmartMachine
Software with algorithms for process optimisation. SmartMachine analyses the SmartLiquor measurement data and the performance of bulk production machines. Based on this analysis. SmartMachine calculates for each machine and recipe the optimum temperature- and dosing gradients as well as holding times.

Dye Solubility Coefficient
Software module that is integrated in SmartLiquor calculating the ratio of insoluble dye pigment to dissolved dye on-line under dyeing conditions. It is recommended for the dyeing of polyester with disperse dyes permitting a detailed analysis of dyestuff and auxiliary properties.

SmartRinse
Software for the optimisation of the washing off after exhaust dyeing of cellulosics (cotton, viscose) with reactive dyes. SmartRinse uses a physico-chemical model for the calculation and incorporates an optimisation method that selects the cheapest recipe-specific process.

SmartPad-Liquor
Software module that is integrated in SmartLiquor eliminating tailing effects with reactive dyes, particularly suitable for Cold Pad Batch (CPB) and E-Control. Using a simple laboratory test, this module calculates tailing correction factors.

SmartManager
Software designed to help dyehouse management to organise all the information related to process optimisations with Smart-Liquor, SmartMachine and SmartRinse. It allows the user to document and prioritise different optimisation steps and incorporates a feature to generate reports using pre-defined templates.

Application Example

1 Analysis of Exhaustion

Substrate:	100% polyester
Process:	Disperse dye trichromie (yellow, red, blue) 130 °C
Main Variable:	Exhaustion (in % of total dye amount)
Recorded PLC Variables (2nd y-axis):	Target temperature (light red) Actual temperature (dark red)
Calculated Parameters:	Average exhaustion speed yellow: 1.9% per min Average exhaustion speed red: 1.7% per min Average exhaustion speed blue: 1.8% per min Dye compatibility index: 94 (out of 100)

Dyebath analysis polyester dyeing

2 Analysis of Exhaustion

Substrate:	100% cotton
Process:	Reactive hot dye trichromie 80 °C (isothermal)
Main Variable:	Exhaustion (in % of total dye amount)
Recorded PLC Variables (2nd y-axis):	Target temperature (light red) Actual temperature (dark red) Dosed alkali (green)
Calculated Parameters:	Average exhaustion speed yellow: 2.7% per min Average exhaustion speed red: 3.2% per min Average exhaustion speed blue: 5.5% per min Dye compatibility index: 92 (out of 100)

Dyebath analysis cotton dyeing

Application Example

3 Analysis of Rinsing

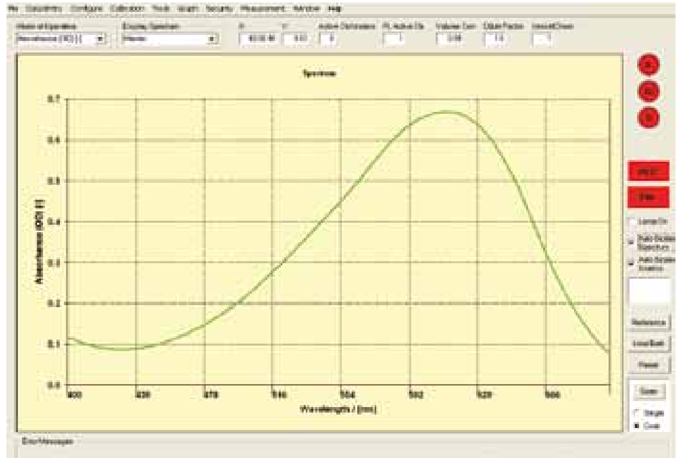
Substrate:	100% cotton
Process:	5 rinses of reactive warm dye trichromie (yellow, red, blue)
Main Variable:	Concentration (in % of total dye amount)
Recorded PLC Variables (2nd y-axis):	Target temperature (light red) Actual temperature (dark red)

Analysis rinsing cotton dyeing

4 Analysis of Dye Spectrum (QC)

Substrate:	N/A
Process:	Reactive dye (yellow) in solution
Main Variable:	Absorbance (dimensionless)
Recorded PLC Variables (2nd y-axis):	N/A

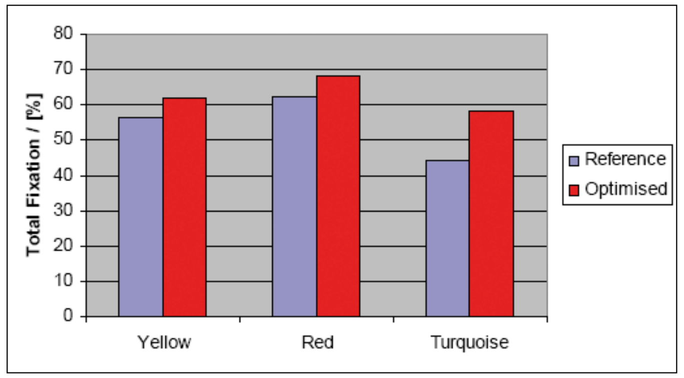
Spectral analysis of a dyestuff



1 Dyestuff Fixation

Substrate:	100% cotton knit goods	
Dyes:	Reactive dye trichromie (yellow, red, turquoise), hetero-bifunctional	
Problems:	1.	Poor batch-to-batch reproducibility in bulk production
	2.	High percentage of «blotchy» fabric requiring additional washes
	3.	Irreversible unlevelness when higher salt concentrations are employed

Total fixation before and after SMART LIQUOR® optimisation



Analysis

1. SMART LIQUOR® analysis showed that poor reproducibility was caused by low fixation values, particularly of the turquoise dye. The turquoise dye fixed to only 44%. Total fixation values for the yellow and the red dye were 56% and 62% respectively.
2. SMART LIQUOR® analysis showed that the «blotchy» fabric was caused by hydrolysed turquoise dye which was not entirely removed during the washing-off cycle. The problem had its origin in the low fixation value of the turquoise dye. The dye exhausted to 84% in the neutral exhaustion phase. Since the fixation value was only 44%, 40% dye would have had to be washed off, too much for the programmed rinsing cycles.
3. SMART LIQUOR® analysis showed that unlevelness at higher salt concentration was due to the fact that 65% of total dye exhaustion occurred during the first 15 minutes of salt addition and another 25% during the addition of soda ash. Therefore these two phases required particular attention and a revised dosing profile.

Solutions

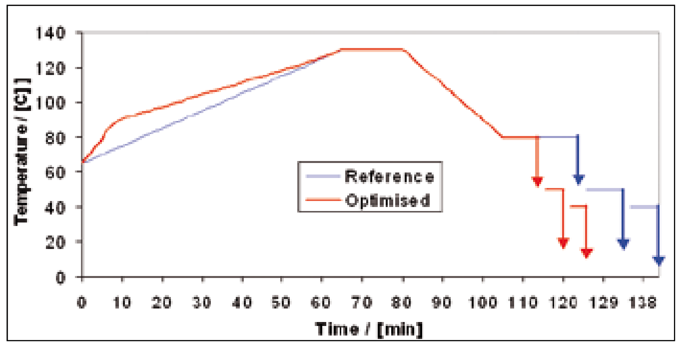
1. From the analysis followed that increasing the fixation, particularly of the turquoise dye, would solve the problems of reproducibility and «blotchy» fabric. Best results were obtained by increasing the salt concentration from 50 g/l to 80 g/l and a modified temperature profile (60 °C/80 °C instead of isothermal 60 °C). These changes increased the fixation of the turquoise dye from 44% to 58%, an increase of 30%. Fixation of the yellow and the red dye was increased by around 10% each.
2. Based on the analysis the time period for the dosing of salt was extended and the time period for the addition of caustic soda, which was added after the soda ash, was reduced by an equal amount. This solved the problem of unlevelness without increasing total processing time.

2 Process Optimisation

Substrate:	100% polyester knit goods
Dyes:	Disperse dye trichromie (yellow, red, blue), medium energy dyes
Problem:	Unlevelness, especially in pale shades ($\Delta E_{(CMC,\ 2:1)}$-value of 1.1 within one and the same piece of fabric)

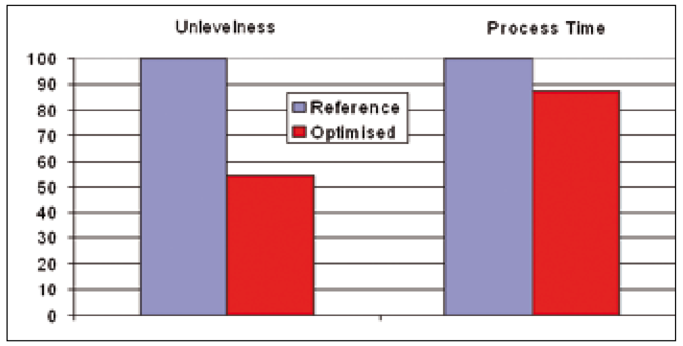
Process profile before and after SMART LIQUOR® optimisation

SMART LIQUOR® analysis showed that around 80% of the dyes exhausted in the critical temperature range between 90 °C and 125 °C.
It also showed that times for reduction clearing and washing off could be cut in half without affecting quality.



Process improvements due to SMART LIQUOR® analysis

A new process profile was introduced which increased the temperature faster than previously until 90 °C and then more slowly until 125 °C. Times for reduction clearing and washing off were reduced by 50%.
As a result unlevelness was reduced by 45% from a ΔE-value of 1.1 to a value of 0.6 while processing time was reduced by 13%.



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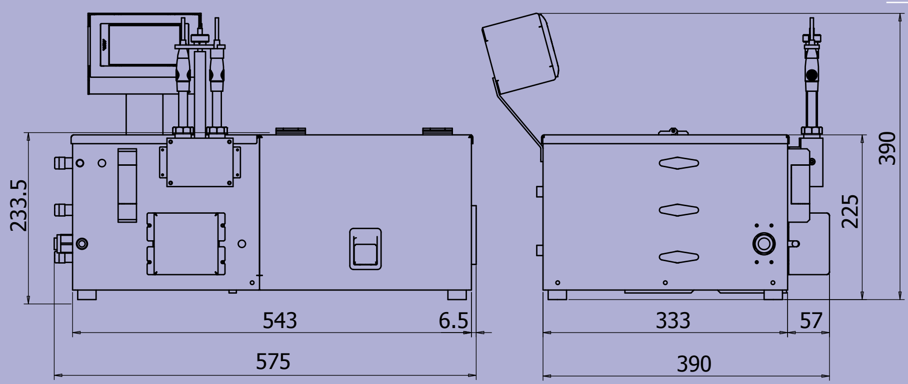
Jointly developed with Smart Lab Limited and University of Leeds

Technical Data



Net weight 19 Kg
(spectrophotometer without accessories)

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