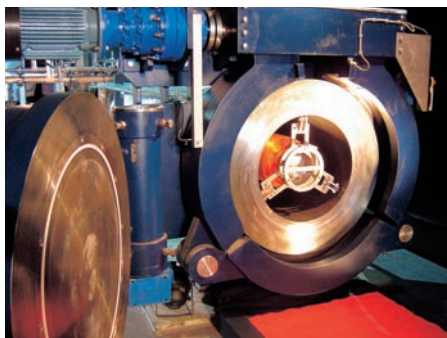


## News

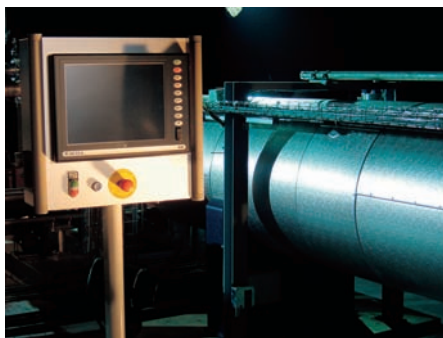
# CO<sub>2</sub> Dyeing Gets Commercial Roll-Out

## Dutch Company Launches Revolutionary System

By John Scrimshaw



A fabric roll in the chamber



Control panel



Pressure storage vessel, pumps and pipework

DUTCH COMPANY DyeCoo Textile Systems BV has unveiled what is believed to be the first commercial dyeing machine to use supercritical carbon dioxide (scCO<sub>2</sub>) as a replacement for water.

The machine has been 11 years in development, initially at DyeCoo's parent company, FeyeCon Development & Implementation BV, which has previously designed scCO<sub>2</sub> systems for other industrial applications, such as chemical extraction in pharmaceutical manufacture. Technical and engineering expertise has been provided by partners Stork Prints and the University of

Delft, while disperse dyes were specially developed by Triade and the control system is by Setex.

At present the process is limited to dyeing scoured polyester fabric, but DyeCoo is working on a version that will dye unscoured fabric and expects reactive dyes for celluloses to be available in less than three years.

The first production machine will start operation later this year at Thailand's Tong Siang Co Ltd, part of the Yeh Group, which has branded the process as DryDye. It will dye batches of between 100 and 125kg of fabric in an open width of 60 or 80 inches. DyeCoo,

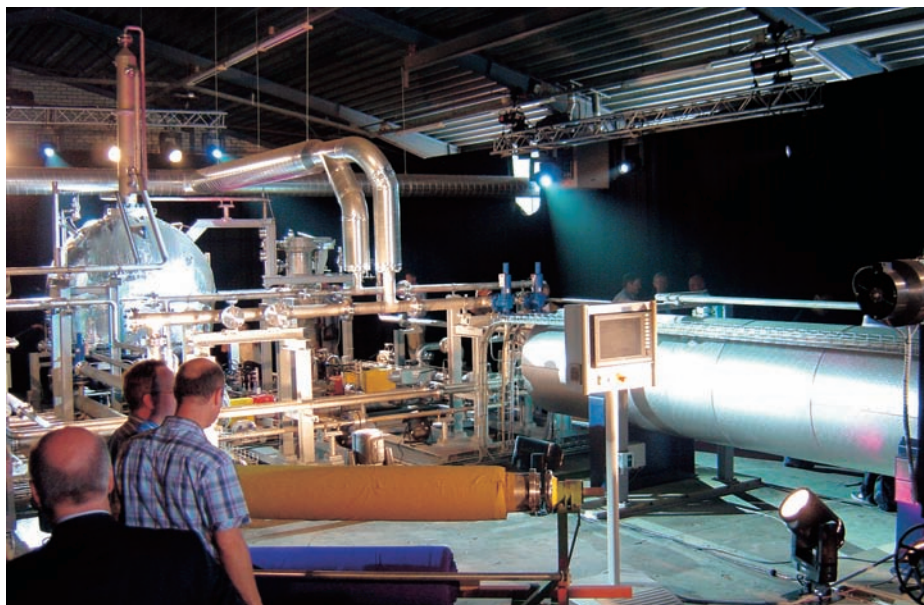
which was founded in 2007, also plans a larger version, which will take batches up to 200kg.

### Principles

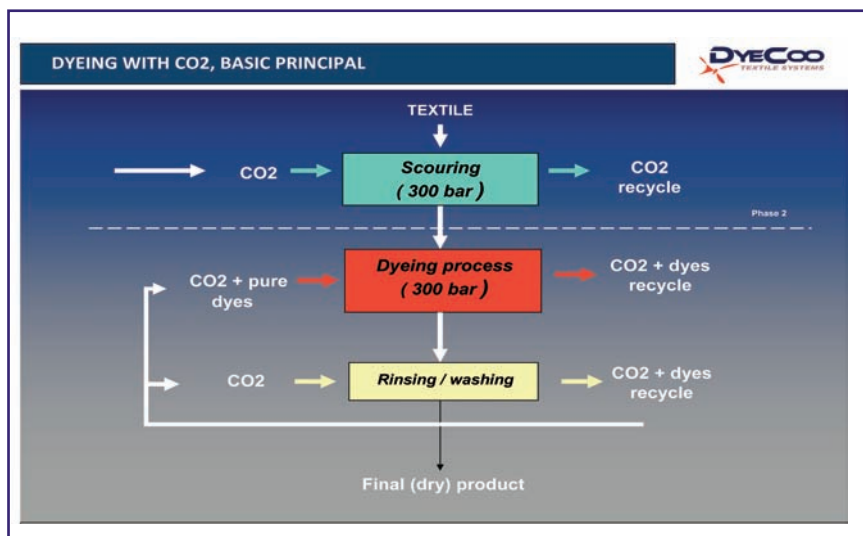
Supercritical fluids are highly compressed gases that have properties of both a liquid and gas, and this offers advantages for textile processing. Supercritical CO<sub>2</sub> may act as both a solvent and a solute. Supercritical fluids have higher diffusion coefficients and lower viscosities than liquids, as well as the absence of surface tension, allowing better penetration into materials.

Replacing water with scCO<sub>2</sub> is considered to offer major environmental advantages for the dyeing industry. Water supply is a problem in many parts of the world, and wastewater and its treatment are both an environmental and an economic burden. The system could also shorten the dyeing process and reduce overall CO<sub>2</sub> emissions. Several other research projects have studied the possibilities of dyeing with scCO<sub>2</sub> but none is thought to have brought a system to commercial reality.

DyeCoo says investment costs for CO<sub>2</sub> dyeing have previously been substantially higher than for water dyeing. However, with cost-effective engineering, its own machine developments and buying components at the world market, it has managed to reduce machine production prices to 'acceptable levels'. Although the investment costs are higher, lower operational costs and faster processing should facilitate market introduction, adds DyeCoo.



DyeCoo system



### Dyeing Process

A roll of fabric is inserted into the cylindrical dyeing chamber on a retractable carriage.

DyeCoo says that when carbon dioxide is heated to above 31°C and pressurised to above 74 bar, it becomes 'supercritical', a state of matter that can be seen as an expanded liquid, or a heavily compressed gas. One characteristic of a supercritical fluid is a high (liquid-like) density that enables dissolution of compounds. In dyeing, scCO<sub>2</sub> is heated to 120°C and pressurised to 250 bar.

The CO<sub>2</sub> penetrates synthetic fibres, thereby acting as a swelling agent during dyeing and enhancing the diffusion of dyes into the fibres. In other words, says DyeCoo, the glass-transition temperature of the fibres is lowered by the penetration of the CO<sub>2</sub> molecules into the polymer. This accelerates the process for polyester by a factor of two. Finally, the CO<sub>2</sub> is able to transport the necessary heat from a heat exchanger to the fibres.

During the dyeing of polymer fibres, CO<sub>2</sub> loaded with dyestuff penetrates deep into the pore and capillary structure of fibres. This deep penetration provides effective coloration of these materials, which are intrinsically hydrophobic. The process of dyeing and the act of removing the excess dye can be carried out in the same plant (the dye can be easily separated from CO<sub>2</sub>).

During the dyeing, the CO<sub>2</sub> is circulated through a heat exchanger, through a vessel where the dye is dissolved and through a vessel where the dye is delivered to the textile. After the dyeing cycle the CO<sub>2</sub> is gasified, so that the dye precipitates and the clean CO<sub>2</sub> can be recycled by pumping it back to the dyeing vessel.

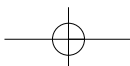
### Auxiliary Free

DyeCoo says current disperse dyes contain 40% detergents and salts to enable the solubilisation of the hydrophobic dyes in the water. When applying carbon dioxide none of these additives are required and pure dyestuff can be used. Another advantage, specifically for polyester, is that under supercritical conditions the CO<sub>2</sub> molecules penetrate and swell the polymer. This plasticises the fibres and increases diffusion coefficients of dyes inside the polyester by one order of magnitude, relative to aqueous dyeing.

In the case of cotton dyed with water-soluble reactive dyes, DyeCoo points out that side reactions currently cause serious wastewater problems and that the availability of a cotton process would greatly increase the market opportunities for CO<sub>2</sub> dyeing. In general, it says, the technical feasibility has been demonstrated but the full dyestuff range has yet to be developed.

In experiments on cotton, silk and wool, using DyeCoo's own synthesised reactive dyes, fixation of 99-100% was achieved in CO<sub>2</sub> dyeing, in comparison to what DyeCoo says is a typical 50-80% in water dyeing – meaning a more-effective use of dyes and no waste. The company has secured three patents for cotton dyeing.

DyeCoo adds that the developed reactive dyes are also suitable for dyeing synthetic fibres, enabling dyehouses to dye blends such as cotton-polyester with a single dyestuff in a single run – reducing process time by a factor five and achieving 'tremendous' savings on energy and water. ID



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