BEST TECHNOLOGY: LOW LIQUOR DYEING MACHINES

BACKGROUND AND EXPLANATION

Industrial dyehouses were traditionally sited in areas of the world where water was plentiful and free of charge. Over the last 50 years there has been a growing trend to for the authorities in developed nations to impose strict rules on effluent discharge and to impose significant charges for water consumption.

Over the past 50 years there has also been a change in the economics of dyeing. Originally a dyer that could meet the stringent colour fastness requirements of retail brands would be able to set the price but, as more good quality dyeing capacity came on stream, they had to become more competitive – with water, and associated costs being a significant factor.

The trend over the past 30 years has been for dyehouses to be sited closer to garment manufacture and this has lead to many dyehouses being situated in areas of the world where water is more scarce and - where pollution legislation is not a strict.

There is also a growing awareness that the energy consumption associated with heating water to conduct dyeing processes contributes to emission of greenhouse gases.

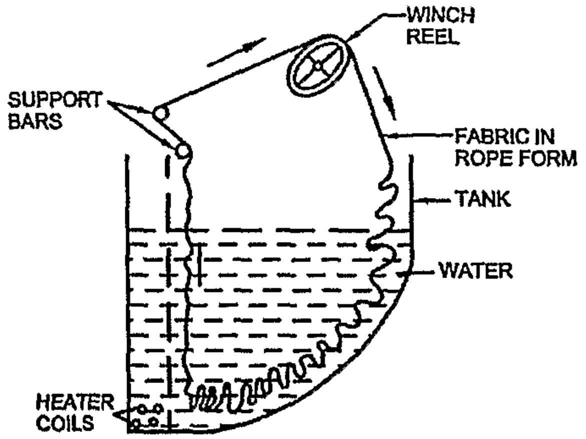
Therefore there has been a drive to develop machines that use less water in each process bath and to develop processing protocols that use fewer baths.

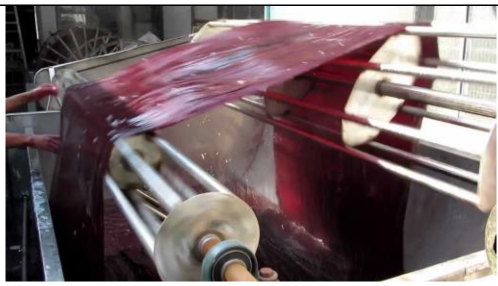
OLD TECHNOLOGY - WINCH DYEING

In order to get dyes to fix on a substrate dye liquor has to make contact with the substrate - and in order for the dyeing to be uniform (i.e. not unlevel) either the substrate has to be moved through the dye liquor and/or the dye liquor moved through the substrate. This is referred to as fabric/liquor interchange.

Historically fabric, yarns, fibres or garments were dyed in large vats that were stirred by hand. Once machines could be powered, automated 'stirring' was introduced and different types of machine were developed that were best suited to garments, fibres, yarns or fabrics –with different methods of fabric/liquor interchange employed.

Fabric dyeing is the most popular form of dyeing and the most common type of machine was the winch dyeing machine. Fabric is sewn in long continuous ropes that sit in a large volume of *static* dye liquor in the bottom of a vat. The fabric rope is moved around the machine by the action of a rotating winch reel that hauls fabric out of the front of the dye vat and then places it in the back of the dye vat (see schematic diagram and photograph below – note the winch reel is often elliptical to get greater pull)





The overall speed of fabric movement is slow and it may take several minutes for the rope to complete a full circuit of the machine. The only significant fabric/liquor interchange to assist with level dyeing is as the fabric moves out of the front of the machine and as it enters the back of the machine so, in order to get good, level dyeing it is necessary to use quite dilute dye liquor (i.e. lots of water) and long process times.

Winch machines typically operate at 20 to 40:1 liquor ratio. That means for each process bath (e.g. scouring, dyeing, washing etc) there are 20 to 40 litres of water present for every kg of fabric.

Most chemicals used in dyeing processes are added on a g/l basis so high water usage results in high chemical consumption during processing that must subsequently be remediated before discharging into the environment.

Also, since most processes are hot, each litre of water requires heating – with heat energy proportional to temperature rise and volume of water.

The reason winches were popular is because originally there were no other options - and they have remained popular to some extent because they are cheap, they are simple to operate, they operate at low tension (limited undesirable stretching), they require little maintenance and in many areas of the world water and energy remains very cheap.

If you tried to operate a winch machine at very low liquor ratio you would almost certainly get an unlevel dyeing and fabric ropes can sometimes tangle.

It is incredibly rare to find a winch machine that can be pressurised so the temperature can never be raised above boiling point – it is therefore impossible to dye polyester on winch machines without the use of so-called *carriers*, some of which are known to be harmful chemicals.

JET DYEING MACHINES

The need to reduce water consumption in dyeing processes was so evident that machinery manufacturers created machines that could operate at lower liquor ratios whilst delivering high levels of fabric/liquor interchange to provide the opportunity for uniform dyeing.

The basic concept is similar to the winch machines but the ropes of fabric are transported by a combination of a winch reel <u>and</u> a jet of dye liquor:-

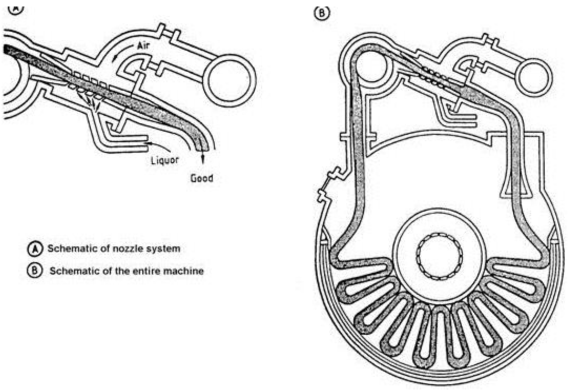
The high levels of fabric/liquor interchange are delivered by the use of a pumping system that takes dye liquor from the dyeing vessel and then forces it onto the fabric in the form of a high pressure jet of dye liquor. The machine is configured so that the jet of dye liquor not only creates fabric/liquor interchange but it actually pushes the fabric around the machine at high speed.

Because the jet dyeing machines operate at lower liquor ratios than winches the dye liquor is more concentrated and the potential for unlevel dyeing is greater. Therefore it is necessary to move the ropes at high speed to ensure they don't sit in the bottom of the machine for too long and that each part of the rope passes through the jet of dye liquor every couple of minutes – the combination of a driven winch reel and liquor jet makes this high rope speed possible.

Most jet dyeing machines have a round cross section and are suitable for robust fabrics – such as 100% cotton weft knits and fabrics with low elastane content.

The winch reel can be situated outside the main circular cross section dye vessel or inside the circular vessel – see diagrams and pictures below.

EXTERNAL WINCH

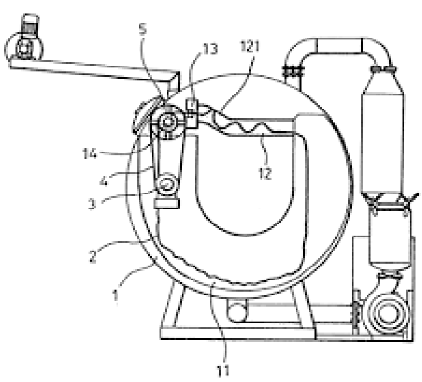


All early generation jet machines had external winches and external jets – the size of the tube in which the water jet was generated had to be tailored to the type of fabric and this necessitated that actual physical interchange of jet nozzle mechanisms.

Many jet dye machines are designed with maintenance in mind – they are very complex (a need to control, fabric speed, jet pressure, winch reel speed, temperature, pH , accurate dosing of chemicals, fabric plaiting, lint management and so on) and key parts are kept accessible by being outside the main dyeing vessel.

With the external winch variety there can be very high tension placed on the fabric as it is lifted up from the front of the dyeing machine at high speed and this can lead to excessive stretching of fabric that, if not corrected during finishing, can lead to shrinkage problems.

INTERNAL WINCH



Machines with internal winches have been developed to make the passage of fabric smoother to reduce tension – this has been achieved by the development of variable jets – the size and configuration can be varied without the physical interchange of jet nozzle mechanisms.

However it does mean that key parts of engineering are quite inaccessible in the event of a machinery breakdown.

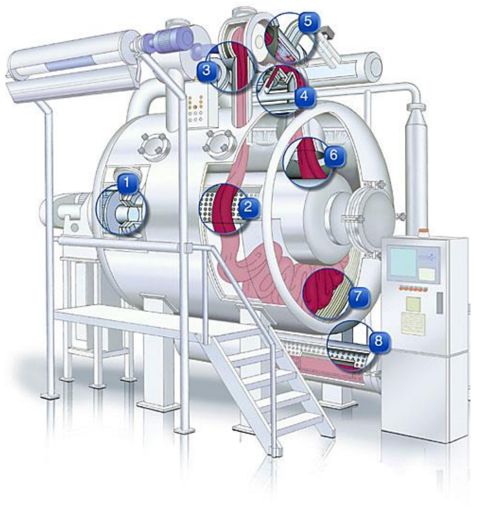
Early round jet dyeing machines operated at around 10:1 liquor ratio and the most modern (iMaster from Thies) can operate at 4:1. Most modern jet dyeing machines operate between 5:1 and 7:1 but that depends on optimum loading.

Some dyers use slightly higher liquor ratios for difficult shades (e.g. turquoise) or difficult fabrics e.g. filament viscose and it is perfectly reasonable to use higher liquor ratios in some washing processes – where 1 bath at 8:1 may give better washing results than 2 baths at 5:1.

AIR JETS

In order to get very, very low liquor ratio's some machine manufacturers have developed machines that use a winch reel in combination of a high pressure jet of <u>air</u> to drive the fabric ropes around the machine. The dye liquor is sprayed onto the fabric in a fine mist as it exits the jet mechanism.

In the diagram below of the Then Airflow – the most popular airjet machine on the market – '5' is the air jet and '4' is the water spray.



Air jets can achieve liquor ratios as low as 2.5:1 but they are only really used at these very low liquor ratios for synthetic fibres. Also the very, very low liquor ratios are only really used for dyeing as longer liquor ratios are normally employed for efficient washing processes

HORIZONTAL JETS

Even with internal winch mechanisms some fabrics that are prone to distortion or creasing cannot be processed successfully on round jet machines and horizontal jet machines have to be employed – these operate at higher liquor ratio to enable the fabric to 'swim' in liquor and avoid tangling. The fabric has to be lifted only a very small height before going through the jet mechanism meaning that processing is done at low tension.

The newest machines (e.g. Thies TRD) can operate at 8:1 liquor ratio but most operate at 10 or 12:1.

ADVANTAGES OF JETS OVER WINCHES

- Lower liquor ratio – lower water consumption
- Lower energy consumption
- Lower chemical consumption
- Lower effluent loading
- (Generally) sophisticated controls – better right first time
- Faster processes (due to faster rope speed) meaning greater productivity
- Most jets can be pressurised – so dyeing polyester is possible

LIMITATIONS AND DISADVANTAGES

- Round jets with external winches place tension on fabric – leading to shrinkage issues
- Low liquor means better control is absolutely necessary to get level dyeing and consistency
- Machines are expensive – largely due to necessary control systems
- Machines are complex – requiring expertise to run them and on going maintenance
- Many jets are aggressive – resulting in surface abrasion, leading to use of biopolishing
- Ropes can tangle if machines are not set up correctly – resulting in downtime
- Fabric faults can occur if winch reel speed and fabric rope speed are not synchronised

WHY SHOULD JET DYEING BE PROMOTED?

See advantages above.

There is no environmental justification for using winch machines for dyeing.

Occasionally printers will link winch machines together to create a 'home-made' wash range and these always use more water than state of the art counter-flow wash ranges