Cold Pad Batch dyeing and washing of knitwear

The costs and the quality of a product define its success. The dyeing and subsequent washing of knitwear in open width form is a complex process and is particularly relevant to these two parameters. In the following, the essential points for the successful implementation of this process are described with clear emphasis on the situation in practice.

Dyeing using the cold pad batch (CPB) method is an established and reliable process for obtaining very good dyeing results with minimum use of resources. The different stages of this method comprise:

1. Impregnating
2. Reacting
3. Washing off

1. The impregnation process

During impregnation the following parameters are important:

- Temperature and rate of circulation of the dyeing liquor
- Squeeze line in the padder
- Absorbency of the fabric
- Fabric tension

If these basic conditions are controlled correctly, there is nothing else in the way of a reproducible, controllable, high quality dyeing result.

A) Process requirements

Temperature of the dyeing liquor

As the fabric processed is generally cotton and viscose, reactive dyes are used in the majority of cases. This class of dyestuff features a wide colour range and very high fastness. However, a constant temperature is required during dyeing. Here it is not the end value (which varies depending on the fixing method and dye class) that matters most, but the reproducibility: The temperature must always be the same in summer and winter, on Mondays and on Fridays, when things are going well and when things are going badly. This challenge is made more difficult by the fact that many dyes must be dissolved hot before they are added to the dyeing liquor.
To keep the temperature constant, BENNINGER uses a heat exchanger. This device is used to draw heat energy from the dyeing liquor and ensure the temperature is always constant.

**Squeeze line in the padder**
Vital when dyeing open wide knitwear using the cold pad batch method is the flexible nip line across the width of the fabric independent of the pressure. Only in this way is it possible to compensate for varying fabric compression.

**Absorbency of the fabric**
Like every finishing process, pre-treatment also plays a major role. In this case, the fabric should have an absorbency of one to two seconds and a degree of whiteness of min. 65% Berger.

**Knitted Fabric tension**
A vital aspect during the treatment of knitwear is the tension. Here the motto "less is more" is particularly appropriate. Differences in tension can cause colour variations. Also, a constant low knitted fabric tension is crucial for low knitted fabric elongation and consequential for the shrinking values: in addition attention must be paid to a finely tuned balance between web guiding mechanisms and the resulting fabric tension. Curved expanding rollers and scroll rollers contribute significantly to the increase in the fabric tension. For this reason, selvedge uncurler is used for knitted fabrics susceptible to curling. These devices spread the curled selvedges outwards without any direct action on the overall width of the knitted fabric.

**B) Machine components**
A modern cold pad batch dyeing centre for knitwear should meet the following criteria:

- Centre unwinder (if fabric from batch)
- Segment control roller for centralizing and feeding of knitwear
- Selvedge uncurler in front of trough and squeezing nip
- As many drives as possible
- Good accessibility and view
An important aspect of dyeing knitwear is how the knitted fabric is guided during wetting and on entry into the squeezing nip. In both cases it is imperative that the knitted fabric is fully expanded. On the entry of the knitted fabric into the squeezing nip, a further difficulty is that curled edges cause press marks during squeezing. Glueing the knitted fabric selvedges is one way of fully expanding rolled edges. However a disadvantage here is the high cutting losses. This sizing process can be avoided with the arrangement of the fabric guiding components on the BICOFLEX dyeing padder - there are then no longer any cutting losses as occur during the rope handling of knitwear.

As an option on the BENNINGER BICOFLEX dyeing center, it is possible to impregnate the fabric both in the trough and in the nip. Nip dyeing is particularly interesting for dyeing samples and short lengths, as the liquor content is just 1.8 l per m of fabric width. As a result the costs per dyeing job for waste dyeing liquor are a fraction of the conventional trough method.

Both processes provide a good view of the fabric web and therefore enable quality to be monitored continuously. As a result cold pad batch dyeing is developing from an unmodifiable "black box" to a transparent system in which the machine operator cannot only constantly monitor the process, but is also actively involved in the dyeing process.

After squeezing, the knitwear is guided 100% positively but without tension to winding. This fabric guiding prevents renewed curling of the fabric selvedges and at the same time ensures that the knitwear does not elongate in an uncontrolled manner.

Important is that the hardness of the batch remains constant even with increasing diameter.

2. The reaction process
Reaction is performed with continuous rotation of the batch to prevent trickling of the padded dyeing liquor. No energy is consumed during this process, no personnel are involved and with intelligent production planning, the time the fabric spends in the reaction process is not even affected.
An important aspect here: the batch should be covered by plastic foil to prevent it drying out and to prevent mosquitoes leaving unsightly marks through several layers of the fabric. Constant temperature and no direct sunlight are further important parameters for a successful reaction process.

3. The washing process
Washing off of the padded dyeing liquor places various requirements on the washing processes used. After rinsing the fabric, there follows a boiling and soaping process (fastness wash) that should ideally last three to four minutes. Acid treatment and washing out complete this part.

A) Process requirements
As per Sinner’s washing cycle, the parameters chemistry, time, mechanics and temperature are very important for all washing processes. While the rinsing process at the start must primarily provide significant turbulence and the related mechanical washing action to quickly remove the surface dye and alcaline from the fibres, during the fastness wash time and temperature parameters are of primary importance. The final neutralisation stage with final rinse again requires a large amount of turbulence along with chemistry.
B) Machine components

While the reaction time for rinsing and neutralisation processes in conventional TRIKOFLEX drum compartments is carried out, as already mentioned treatment for up to four minutes (viscose 8 min) is required for the fastness wash (soaping, boiling). This time is realised using a dwell system that addresses the aspects of both fabric guiding and process reliability. The fabric is placed on a roller bed that comprises a large number of driven rollers. The rotational speed of these rollers provides the protective and absolutely tension-free fabric transport of the knitwear for dwelling until it reaches the end of the reaction line.

Spray devices continuously spray the fabric package with washing liquor such that continuous penetration takes place. Due to the temperature, the hydrolysate migrates to the surface of the fibres. The liquor soaks through the fabric taking unfixed dye with it. As already mentioned in the introduction: the fastness wash is a temperature and time-dependent process. Both these factors are provided appropriately by the reaction compartment on the TRIKOFLEX series.

The reaction time can be specifically adjusted to suit the appropriate knitted fabric quality, the capacity of the roller bed ranges from 30 to 120 m of knitted fabric.

At the end of the roller bed a TRIKOFLEX washing drum is installed; this feature concludes the soaping with a rinsing process. In this way it is ensured that the fastness wash meets the requirements of every customer.
Knitted Fabric guiding

Exactly as with the application of the dye, fabric guiding plays a major role during the various washing processes. Positive knitted fabric guiding and low tension transport of the knitwear using advanced drive and control technology are the most important aspects here. For this reason the fabric paths on the new generation of the TRIKOFLEX washing compartments have been shortened to the extreme. As a result the distance between immersion roller and TRIKOFLEX washing drum can be as little as one centimetre. This configuration suppresses the curling of the fabric selvedges due to fabric tension.

Wave water

A phenomenon that is often underestimated on drum washing machines is the topic of wave water. Wave water is the water that lands on an open knitted fabric in an uncontrolled and therefore un-reproducible manner and as a result causes elongation. An example of this aspect is the washing liquor applied to the washing drum using spray pipes as it passes downward and falls on the open fabric web (Fig 6.).

\[\text{BENNINGER Fig. 6: Wave water}\]

4. Laboratory methodics for CPB-dyeing

An integral part of the cold pad batch concept is the interaction between laboratory and practice: the quality of dyeing process also starts in the laboratory. The laboratory equipment required is very straightforward: a laboratory padder, some glass rods and plastic foils the minimum requirements for a cold pad batch laboratory. The fabric sample is padded in the nip, wound on the glass rod and then sealed in the plastic foils to react.
The reaction time is identical to the practical values and washing out is performed in glass beakers with appropriate process parameters.

**5. Cost effectiveness**
A cost comparison for 100% cotton, 130 g/m² (250 g/m run) and a daily production of 7.5 metric tonnes has shown that massive savings can be made in the areas of steam (- 57%) and water (- 76%) due to the cold pad batch dyeing method. Not included in this comparison is the advantage resulting from better quality (smooth surface, no pilling, no creases). Here further savings of up to € 70'000.-p.a. can be achieved (basis: reduction of seconds by 1% with a daily production of 7.5 metric tonnes and a cost structure of € 2.30 per kilo).

**6. Summary**
Dyeing using the cold pad batch method is an economical method for dyeing cellulose-based fibres. By optimising the fabric guiding and innovative roller handling, this method has also become a reliable variant for knitwear compared to conventional dyeing processes.

In addition to the seeping wash during dwelling on the roller bed, new washing technologies have also been presented that further address the different aspects of the fastness wash.

BENNINGER considers CPB dyeing of knitted goods as a holistic concept with the integrative steps impregnation, dwelling and washing. To ensure maximum reproducibility and transferability as well as easy handling focus was also set on the preliminary procedures in the Lab. The CPB process is no longer dependant on geographical or climate factors but a global reliable method for the dyeing of even sensitive cellulosic fabric.