A survey of the dyeing and finishing industries in the UK and Europe, carried out in 1973, revealed that the profit margins, particularly in the UK, were too low and that the return on capital expenditure was poor. A more recent survey showed that the average return on capital employed, which was 15.4 per cent in 1973, had dropped to an average of 5.6 per cent with a significant increase in the number of loss-making companies. In the same period, there had been a considerable downward trend in the industry, mirroring the textile industry as a whole.

The layout should be such that bottle-changing processes are involved which require large amounts of steam over short periods. Steam load should preferably be as large as possible so that the boiler plant can be run at optimum conditions most of the time. Valve and drain sizes must allow for short draining and filling times.

Water and effluent

There was a time when water and effluent disposal costs were almost entirely discounted. This is no longer the case and the increasing costs of raw water and effluent disposal, allied to last year's water shortage, has made dyehouses aware of the need to economise on water usage. There are a number of areas in which water and effluent savings can be obtained. Some of these are peculiar to the dyehouse but others are dependent on the co-operation of either customers or companies engaged in prior processing.

(a) The use of water-soluble or non-scouring lubricants in spinning which do not require a separate scouring process for removal and will remain stable in the dyehouse will reduce water consumption both for processing and rinsing operations.

(b) Processes should be combined where possible and one-bath dyeing techniques are advantageous. For example, when dyeing acrylic fibres with basic dyes, softening and dyeing can be carried out together and since complete exhaustion is achieved, rinses can be dispensed with.

(c) Planning of dyelots from pale through to heavy shades will avoid machine boil-outs. Apart from saving water, this will increase productivity.

(d) Water used for cooling dyebaths in closed coil systems can be returned to a storage tank for further use.

(e) Machining must be operated at maximum loading, thereby saving water by reducing the liquor ratio and incidentally increasing production. This principle can be extended to package dyeing of yarn by making the largest possible packages and pressure packing on the spindle.

(f) Processes using machines of intrinsically lower liquor ratio should be chosen where possible. Thus jigs, jets or beam dyeing machines would be used wherever possible in place of winches while package dyeing would be used in preference to high-liquor-ratio dyeing machines. In this respect also continuous dyeing operations have much to offer regarding water savings when compared to the alternative batchwise process, without considering the cost of plant itself which may be in favour of the continuous process.

(g) By monitoring liquor levels in dye machines, thereby avoiding over-filling, significant water savings accrue. Well-defined cesses result in minimum water use especially by avoiding unscheduled rinses.

(h) Overflow rinsing should not be practised.

(i) Careful choice of processing condensate may assist in reducing the strength of effluent produced. In this respect, the use of temperature techniques for dyeing polyster is recommended. Surface-active agents are always exclusively removed.

(j) Recovering effluent and re-using water after processing can result in water savings. It is estimated that or per cent of water required. However, the cost of the necessary equipment is high and process costs are also recovered at the textile industry as a whole.

It is well known that certain processes are more expensive in water demand. A batch of tow yarn dyed with vat or reactive dye package form requires nearly ten times the amount of water needed for the similar continuous web process. However, by using the methods listed above, water consumption by the dyehouse can be reduced to about 40 per cent of that used formerly. Statistical records should be kept to monitor performance and obtain a figure for litres required per processed batch.

Energy

Much can be done to effect savings in the use of energy.

(a) Steam. Suitable lagging of steam and pipeline kerosene heaters will reduce radiation losses. Proper slope of pipes will prevent water hammer. Specialised computer-operate valves have been found to reduce the use of water in a typical cycle. The steam circuit is progressively water blocked to a steam steam circuit. Specialised computer-operated valves have been found to reduce the use of water in a typical cycle. The steam circuit is progressively water blocked to a steam

(b) Depreciation and overheads.

(c) Raw materials, which includes not only dyes and chemicals but also water, effluent and energy, will be unnecessarily inflated. Thus we are seeking benefits in each of these areas.

General considerations

When planning the dyehouse there are a number of factors which, if considered with care, will result in savings. If these are missed at this stage, then costs thereafter will be unnecessarily inflated. Thus there should be available a suitable water supply, in terms of both quantity and quality, so that minimum treatment is required. The most suitable equipment for the processes being undertaken should be chosen. The plant should be so balanced between processes, and the layout should be such that bottlenecks do not occur and downtime is kept to a minimum. Steam-raising plant must be adequate, especially if rapid-dyeing procedures are involved which require large amounts of steam over short periods. Steam load should preferably be as large as possible so that the boiler plant can be run at optimum conditions most of the time. Valve and drain sizes must allow for short draining and filling times.

Water and effluent

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(a) The use of water-soluble or non-scouring lubricants in spinning which do not require a separate scouring process for removal and will remain stable in the dyehouse will reduce water consumption both for processing and rinsing operations.

(b) Processes should be combined where possible and one-bath dyeing techniques are advantageous. For example, when dyeing acrylic fibres with basic dyes, softening and dyeing can be carried out together and since complete exhaustion is achieved, rinses can be dispensed with.

(c) Planning of dyelots from pale through to heavy shades will avoid machine boil-outs. Apart from saving water, this will increase productivity.

(d) Water used for cooling dyebaths in closed coil systems can be returned to a storage tank for further use.

(e) Machining must be operated at maximum loading, thereby saving water by reducing the liquor ratio and incidentally increasing production. This principle can be extended to package dyeing of yarn by making the largest possible packages and pressure packing on the spindle.

(f) Processes using machines of intrinsically lower liquor ratio should be chosen where possible. Thus jigs, jets or beam dyeing machines would be used wherever possible in place of winches while package dyeing would be used in preference to high-liquor-ratio dyeing machines. In this respect also continuous dyeing operations have much to offer regarding water savings when compared to the alternative batchwise process, without considering the cost of plant itself which may be in favour of the continuous process.
use*

Steam-raising plant must be adequate, especially if rapid-dyeing processes are involved which require large amounts of steam over short periods. Steam should preferably be such as to enable boiler plant to be run at optimum condition most of the time. Valve and drain arrangement allow for short draining and starting times.

Here was a time when water and effluent savings could be almost entirely dismissed. This is no longer the case and the easing costs of raw water and effluent disposal, allied to last year's water shortage, made dyehouses aware of the need to nominate on water usage. There are a number of areas in which water and effluent savings can be obtained. Some of these are in the domain of the dyehouse but others are dependent on the cooperation of customers or companies engaged in processing.

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(g) By monitoring liquor levels in dyeing machines, thereby avoiding over-filling, significant water savings accrue. Well-defined processes result in minimum water usage, especially by avoiding unscheduled rinses.

(h) Overflow rinsing should not be practised.

(i) Careful choice of processing conditions may assist in reducing the strength of effluent produced. In this respect, the use of high-temperature techniques for dyeing polyester is preferred to the use of carriers while biodegradable surface-active agents are now almost exclusively used.

(j) Recovering effluent and re-using the water after processing can result in large water savings. It is estimated that only a 10 per cent top-up supply of fresh water is required. However, the cost of the necessary plant is high and process costs are also high.

It is well known that certain processes are extravagant in water demand. A batch of cotton yarn dyed with vat or reactive dyes in package form requires nearly ten times the amount of water needed for the similar weight of acrylic yarn. However, by using the viable methods listed above, water consumption in the dyehouse can be reduced to about 40 per cent of that used formerly. Statistical records should be kept to monitor performance and obtain a figure for litres required per kilo processed.

Energy

Much can be done to effect savings in the use of energy.

(a) Steam. Suitable lagging of steam pipes, hangings and even machine kettles will cut down radiation losses. Proper sloping of pipes will prevent water hammer. Correct reducers where the bore of a pipe changes in diameter will prevent water blockage in a steam circuit. Specialised computer-operated valves have been found to reduce the length of a dye cycle. If the steam circuit operates at the minimum feasible pressure, maximum use can be made of the latent heat. Steam used as a gas at high temperatures is relatively inefficient and the use of latent heat is markedly more efficient. More efficient use can be made of steam is obtained by the use of heat exchangers in a closed steam circuit rather than open steam coils. Heat can be recovered from both dyebaths and cooling water as a source of low-grade hot water which is often used, with additional heating, for dyebath make-up. Maximum use can be made of this technique if high-temperature and pressure drains with the necessary heat-exchangers are fitted to machines which regularly dye polyester under high-temperature conditions. By releasing the dyebath at around 130 degC not only is heat recovered but oligomer redeposition is avoided.

The use of a dual fuel supply—for example, oil and gas—will allow these to be purchased. When the price is most advantageous. Gas has been cheaper than oil for some time. Depending on labour utilisation and specific factory pay rates, the use of hydro-extraction wherever possible with the minimal use of thermal drying can reduce costs significantly. The installation of curtain doors to the dyehouse raises the ambient temperature of the building, cuts radiation losses and gives saving in space heating. It is essential that adequate metering is carried out and statistical records kept so that fuel cost in the system can be pin-pointed rapidly.

(b) Electricity. Adequate switching arrangements are necessary so that all lights and machinery can be switched off individually when not in use. The correct motor should be used for the size of plant. Controllers or computer.

Air conditioning or a mechanical ventilation plant to provide clean, fresh air at the correct temperature for the season of the year will improve working conditions and remove any need for space heating. Space heating as such is expensive and care must be taken to see that it is not used unnecessarily.

Engineering services

Adequate engineering services are essential so that a planned maintenance scheme can be carried out. This results in minimum loss of productive machine time. When breakdowns do occur, they can be remedied quickly and, to this end, a suitable supply of spares should be kept. Full details should be kept on a matrix chart of all repair and renewal costs and this will assist in the decision to be made as to whether to repair or renew.

Dyeing processes

Processing times should be as short as possible, consistent with achieving adequate quality of the product, since machine costs are high especially when there is a large depreciation factor due to the installation of new plant. Thus dyeing procedures based on rapid-dyeing methods or on calculation techniques can be used with advantage. These methods give savings for a number of reasons including the following:

(a) Appropriate selection of the minimum number of dyes of similar dyeing properties as regards compatibility and fastness.

(b) Calculation of any auxiliary products required, thereby avoiding over-use.

(c) Control of pH and the avoidance of casual acid additions.

(d) Selected starting temperature with the avoidance of long heating-up times.

(e) High degree of dyebath exhaustion with minimum times at top temperature.

(f) High degree of reproducibility.

(g) Processes readily programmed on to controller or computer.

Continued on next page
Cost savings in the dyehouse—cont.

The use of combined processes for scouring/dyeing or dyeing/finishing contribute to shorter dyeing cycles. Among the processes where combined techniques can be used, the following are included:

1. The dyeing and scouring in one operation of a number of fibre types including wool, nylon and polyester.
2. The combined shrinkproofing and dyeing of wool.
3. Combining bleaching and dyeing processes.
4. The incorporation of syntans into the dyebath or exhausted dyebath when dyeing nylon.
5. The application of softening agents during the dyeing process.

When dyeing blends, the selection of dyes for one fibre which give minimum cross-stain on the other will allow clearing and rinsing to be omitted. The use of short processing times and low-temperature dyeing techniques, apart from yielding financial savings in energy; machine cost and so on, also leads to improvement in the quality of the material with the preservation of the physical properties of the goods.

Reproducibility

There is a need to obtain a high degree of reproducibility both between laboratory and bulk dyelots and between bulk dyelots. Obviously adequate laboratory facilities are mandatory in the modern dyehouse and laboratory and bulk dyeing methods must correlate. With good reproducibility, the need for additions or subtractions of colour disappears and a large proportion of batches become "no-addition" or "blind" dyes. For this to be achieved a number of factors must be carefully controlled3,4.

Machines must be run at maximum and constant loading to achieve minimum, constant liquor ratios together with constant liquor flow characteristics. The pH of the dyebath, and the dyeing time/temperature sequence, must be well defined. Standard procedures are required for the operation of machines, including the definition of running speed and reversing sequence.

The substrate weight and its moisture content for each batch must be known so that the formulation can be calculated accurately. Accurate weighing of dyes and chemicals is essential while variation in the moisture content of the dye due to adverse storage conditions can lead to serious problems regarding reproducibility. It has been shown5 that the moisture content of dye powders can vary from 3 to 20 per cent over a short period of time if storage conditions are poor and if the powder is allowed to be exposed to ambient conditions. Dye stuff strength in relation to a standard sample held by the laboratory must be known. It has been suggested that the weighing of substrate, dyes and chemicals together with the strength of the current batch against standard must all be within an accuracy of one per cent. Variations in the substrate itself, which includes differences in dyeability, changes in lubricant or the degree of other contaminations, can cause serious reproducibility difficulties. Most dyehouses have suffered through the purchase of so-called cheap fibre with a resultant increase in processing times and costs, often not covered in the original costing and therefore difficult to pass on to the customer.

Dye and Chemical Purchasing

A positive purchasing policy for dyes and chemicals must exist and by rationalising the number of dyes used, so that the maximum number of shades on any one substrate are obtained from the minimum number of dyes, many technical advantages occur. In addition, by the use of fewer products, two principal cost advantages accrue:

1. The smaller number of dyes purchased can be obtained at advantageous prices due to larger quantities being bought.
2. Cash is liberated due to a smaller stockholding and the elimination of non-moving dyes.

When a product is available from a number of suppliers, the source should be chosen on the basis of a strength versus price comparison, having established that other technical properties are comparable. Routine testing of deliveries should also be undertaken to see that uniformity of product is maintained. Surprising variability occurs since dyestuff manufacturers have their problems also which can give rise to both strength and tonal differences. By purchasing fewer dyes, larger batches can be calibrated, thus keeping testing and batch changes to a minimum.

Bulk storage of large moving chemicals with the use of tanker deliveries results in cost reduction due to:

(a) A better price being obtained for larger quantities.
(b) Avoidance of spillage.
(c) The amount of material returned in "empty" drums being eliminated. With viscous substances, this can be greater than the quantity lost through spillage.

Drying

Over-drying must be avoided since this is not only wasteful in energy but may adversely affect the physical properties of the material. To avoid this, several instruments have been developed for the various types of drying equipment, for example, the WiRa tenter control. Hydro-extraction is preferred to thermal drying and high-speed rotary hydro-extractors will reduce the moisture content of textile materials to low levels, thereby saving on subsequent thermal drying. This is particularly the case with synthetics.

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Cost savings in the dyehouse—cont.

Loading and unloading from centrifuges followed by the same operations on the thermal dryer is labour-intensive and the ultimate objective must be to process from dry to dry without handling, as exemplified in the use of rapid dryers for yarn packages. In this situation, dry yarn is loaded on the cage for dyeing; after dyeing the dripping wet yarn on the cage is loaded into the dryer and dry yarn is subsequently unloaded after drying. This sequence of events is devoid of labour but costly in energy, so that the method used must be chosen after adequate costing.

When mechanical removal of water is based on the use of squeeze rollers, it has been found that greater removal of water occurring if hot mangling is practised. If the goods are immediately passed into the dryer, drying efficiency is increased since less heat is required to raise the temperature of the goods. It has been found that direct gas heating with natural gas is the most economical drying source as regards hot air drying. It has also been suggested that an increase in the number of drying zones in continuous hot air drying machines, such as stenter, leads to cost reductions. Suggestions have been made regarding the reuse of the considerable heat wasted in dryer exhausts. By passing this exhaust through heat-exchangers and the like, it is possible to use the recovered energy for air-conditioning and water-heating purposes.

It is likely that in the future most drying operations will be carried out by radio-frequency, although this method has not yet been perfected for all stages where drying is required.

Planning

An important function of dyehouse management is the positive planning of production, and by suitable means considerable savings can be obtained. This function is too important to be left to the shift dyers or to be neglected. Textiles are notorious for their seasonal fluctuations in the level of activity and little can be done to overcome this entirely, except possibly by diversification into a number of areas to minimise the trend. The use of maximum loads has been mentioned already but close co-operation between the dyer and his customer may overcome some planning difficulties. The customer may be prepared to forward order and thereby give a more uniform work flow. The availability of standard substrates on which standard shades are dyed is also helpful. The sequence of dyeing shades can be adjusted to give the best follow-on with a reduction in the number of boil-outs. It may be necessary to select customers since some may be receiving a cut-length service at bulk prices. Similarly, sample dyeing is expensive and is in many cases abused. It is worth attempting to rationalise the number of qualities and shades since this will result in longer runs with increasing productivity.

Having obtained short cycle times, the time between dyelots must also be studied to obtain maximum utilisation of plant. If this is not done, very little advantage can be taken from the reduction in dye cycle times. Due to high depreciation costs, multi-shift working is mandatory in the modern plant.

Labour

Recent legislation has signalled that employers will become increasingly responsible for the remuneration of their employees during periods of short-time working. Additionally, where modern plant has been installed, short-time working is inconceivable from a financial standpoint. In the past the textile industry has been notorious for its seasonal lay-offs. These factors mean that employers may be forced into rationalisation whereby they reduce the work force to a level so that it can be guaranteed full-time working. Extra seasonal business will then not be considered. This means that the former lowest production level becomes the norm with the requirement for less production capacity and fewer people.

Labour costs are very high and will no doubt continue to increase in the near future. Everything possible must be done to reduce the amount of labour required to produce a unit of product. This will include the use of work study procedures, the availability of adequate equipment—not only for the dyeing operation but in terms of materials handling—and the use of incentive schemes. Above all, an atmosphere of enlightened self-interest must prevail on both sides for success to be achieved. Phased relocation of labour is much more preferable than redundancy, even if it takes a year or so to relocate some of the personnel. Much more can be achieved if the work force are reassured of their jobs. When a new section starts or an established section expands, and there is thus a labour requirement, this gives an ideal opportunity to reduce labour in other areas by relocating personnel. The introduction of correctly balanced incentive schemes should give better rates of pay but with a reduction in costs. Such opportunities should be grasped and not lightly dismissed.

Productivity can often be increased by the use of a unified work force in which everybody on the shift undertakes all tasks. When a specialised work force is used, consisting of machine minders, loaders, etc., productivity can be seriously reduced through waiting time while, in addition, many sub-grades of semi-skilled jobs develop, with different pay rates.

Productivity generally tapers off as the lengths of shifts are increased over eight hours. Thus longer shifts and overtime are not highly productive. It is useful to calculate productivity in terms of kg/operating hour, this being a useful basis for comparisons. For example, the productivity of package dyeing is approximately 2½ times that of hank dyeing in terms of kg/operating hour.
Cost savings in the dyehouse—cont.

There has been much discussion in recent years regarding the use of automation in the dyehouse and it has been established that both the hardware and the technology are available. Many companies have installed automation have been disappointed with the effect but this seems to be due to the fact that most of the technical advantages of automation can be obtained from the discipline which must be instilled before automation is considered. This includes the rationalisation of dyes, correct procedures, the availability of correct weighing facilities and so on. The real benefit to be obtained from automation is that only if the amount of labour required for a given output can be reduced or conversely more output can be obtained from a similar work force.

Colour physics

The use of match prediction techniques can not only give savings in laboratory effort and costs but will enable a smaller range of dyes to be used, thereby giving further savings. In addition, a number of formulations can be examined for a given shade and that of least cost with the necessary properties can be selected. It is claimed that this type of system can save at least 10 per cent of the annual dyestuff bill. It was estimated in 1975 that the cost of laboratory matching is approximately $20 per formulation if visual methods are employed but this can be reduced to $12 per formulation by the use of computer colour matching. It would appear that the cost-saving is likely to occur only if the laboratory has to deal with ten or more match we per day. Since below this level the visual method may still be cheaper.

The use of the technique will undoubtedly increase in the future but the possible savings which can result can easily be thrown away many times over if the information is not correctly utilised.

Colour difference measurement is now being practised although, at this time, its application is limited to certain end-products. The results of the first prolonged trials indicate that this technique gives fewer rejections for off-shade than visual assessment since the subjective element is eliminated. This is greatly to the benefit of the dyer since fewer reprocesses will occur.

Rejects

A reduction in the amount of reprocessing will give considerable cost savings and the amount of material rejected may well be the difference between profit and loss. To obtain minimum rejects, adequate processing techniques are essential and the avoidance of rejects gives financial savings not only in a reduction in the amount of reprocessing required but also in the increased volume of new work which can be handled.

The faults that do occur must be carefully analysed as to type and origin using a matrix chart so that immediate corrective action can be taken.

Technical services

From the foregoing, it is obvious that the modern dyehouse must be serviced and supported by a well-equipped and staffed technical services unit. The foundation of cost savings is the availability of the correct processes and of processes using suitably selected products.

Data must be recorded from all areas so that statistical information can be generated and costs studied. The dyehouse will, of course, file recipes and procedures but in addition a daily production summary is required together with a reject analysis. Similarly, data must be collected for water, effluent, steam and electricity.

Conclusions

There are many areas in which dyehouse management can look for effective cost savings. Technical competence is a precursor of this and adequate documentation is required. It has been stated recently that although basic research is likely to decrease in volume due to mainly financial reasons, the information of a technical nature which is required for a viable dying and finishing industry already exists. All we have to do is read it.

There is always a better way, a cheaper way of doing a thing; we only have to look and find it. The strive for a reduction in cost is a never-ending task but one which the competent management team will not shirk.

References


Man-Made Fibre Production in the UK

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