NCPC
NATIONAL CLEANER PRODUCTION CENTRE
SOUTH AFRICA

RESOURCE EFFICIENCY AND CLEANER PRODUCTION
BEST PRACTICE GUIDELINE
FOR THE SOUTH AFRICAN TEXTILE INDUSTRY

the dti
Department:
Trade and Industry
REPUBLIC OF SOUTH AFRICA

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1 PURPOSE OF THIS DOCUMENT

The Resource Efficiency and Cleaner Production (RECP) Programme of the NCPC-SA has undertaken a significant amount of impactful RECP assessments within the textiles sector. During these RECP assessments opportunities for improvement were identified that aims to benefit businesses financially and reduce their individual impact on the environment. Capturing and sharing these successes with industry and other relevant stakeholders becomes imperative, as it will enable businesses to identify critical areas for improvement, and potentially use this to achieve internal sustainability targets.

1.1 Context

The sector has realised tremendous growth in South Africa through localisation initiatives driving competitiveness, and this after having suffered severe job losses and closures for more than a decade because of cheap imports. Even so, the sector needs to build a sustainable framework in the face of significant uncertainty introduced by a volatile currency, pending national minimum wage as well as lifting of import tariffs due to international trade agreements being imposed.

1.2 Process overview

The textile sector has many different processes which are broadly summarised in the diagram that follows.

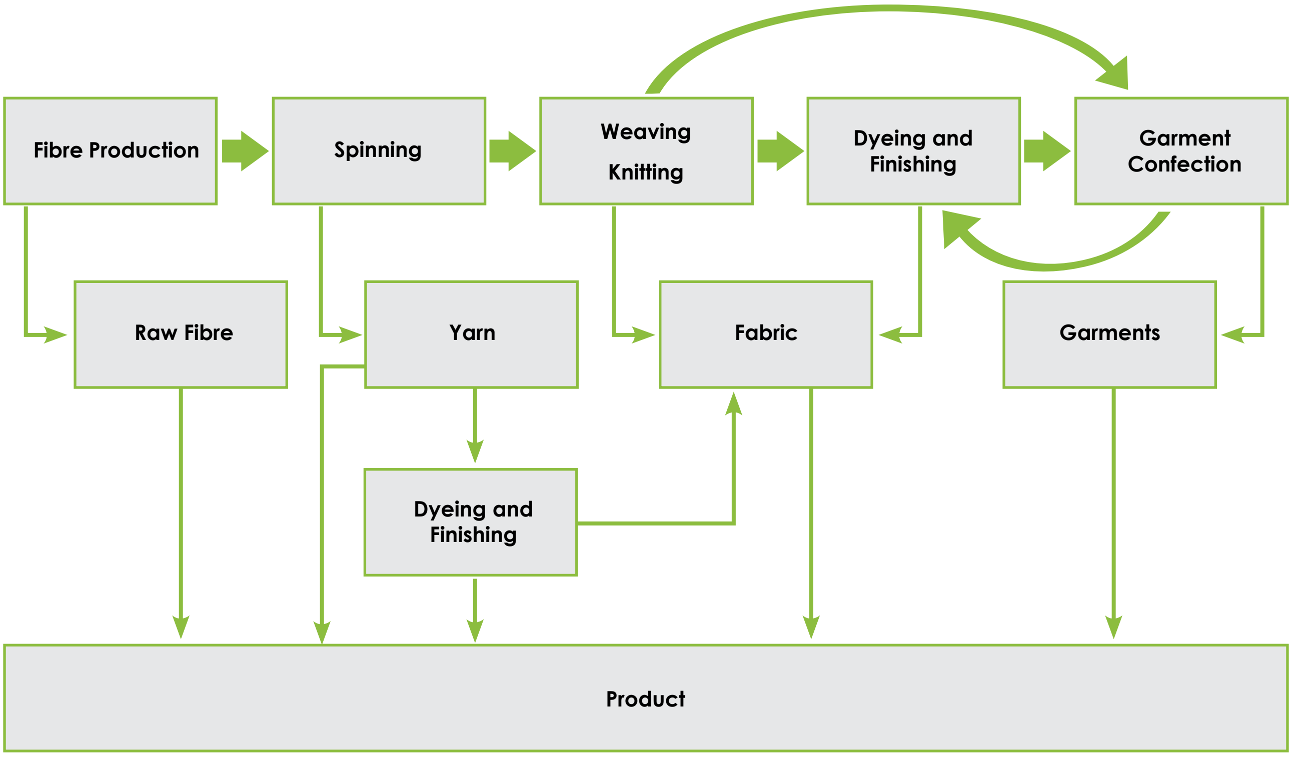

Figure 1. Textile sector process overview

2 PROCESS HEATING SYSTEMS

The textile industry uses large quantities of thermal energy from steam boilers or burners for washing, stenting and drying processes. The fuels used for the production of thermal energy in general are diesel oil, heavy oil, LPG, coal and natural gas.

Typically, the steam boilers and burners are operated on an on-off basis using pressure and temperature set-points as a primary control mechanism.

These systems will usually last over 15-20 years if maintained properly. Should there be a loss in control on the feed and blow-down water, a risk exists of tube failure due to increased corrosion.

Most of the textile sector boilers and burners operate at low utilisation due to shrinking volumes and market demand. In order to reduce their respective wage bills, companies have also opted not to operate weekends and night shifts. This poses challenges in terms of the operation of the steam systems with constant cooling and heating causing increased maintenance of the system.

High losses are experienced in the distribution system through steam leaks, lost condensate return and radiation losses. Significant generation losses are also experienced due to excessive boiler blowdown and combustion inefficiencies as a result of operating at low utilisations.

The following strategies can provide significant reduction in generation and distribution losses:

2.1 Combustion monitoring

Combustion systems require sufficient air to ensure that there is excess oxygen available for complete combustion. A lack of oxygen will result in incomplete combustion of the burner fuel, which in turn will result in significant safety risks due to the potentially explosive nature of the Flue gas that contains volatile hydrocarbons still capable of combusting. For this reason, burners are set to ensure excess air that can be measured by the percentage of oxygen in the stack. Stack temperatures of around 200 °C with oxygen levels of between 4% and 6% are typical. Supplying too much air, however, would result in unnecessary heat loss to the stack. This condition can be identified through elevated oxygen content and lower stack temperatures. Fouled heat exchange surfaces (i.e. fire side fouling) would result in elevated stack temperatures as a result of poor heat exchange even if the oxygen set points were in the optimal range.

COMMENTS

In the case of a company with a steam boiler, the generation efficiency and condensate return can be determined through:

- Metering the feed water;
- Noting the feed water temperature;
- Metering the make-up water metering;
- Fuel flow meters; and
- Boiler feed and blowdown total dissolved solids (TDS).

RECOMMENDED ACTION

Implement an effective combustion efficiency monitoring programme or oxygen trim controls.

POTENTIAL ISSUES/PROBLEMS

Low utilisation (< 40% of rating) will result in poor generation efficiencies and standing losses.

INDICATIVE COST-BENEFIT ANALYSIS

Implementation of oxygen trim controls would typically cost in the vicinity of R200 000 – R300 000 and would result in a 3-5% improvement in combustion efficiencies. The payback would depend on the annual spend on fuel.

2.2 Insulate valves and flanges

RATIONALE

Uninsulated lines, valves and flanges will experience radiation losses which can be quantified by determining the process/ surface temperatures, the type of metal and the external temperatures. Insulating the piping will result in a significant reduction in radiation losses.

COMMENTS

Thermal imaging cameras can be a useful tool to identify areas where significant radiation losses are being incurred as is depicted in the images below.

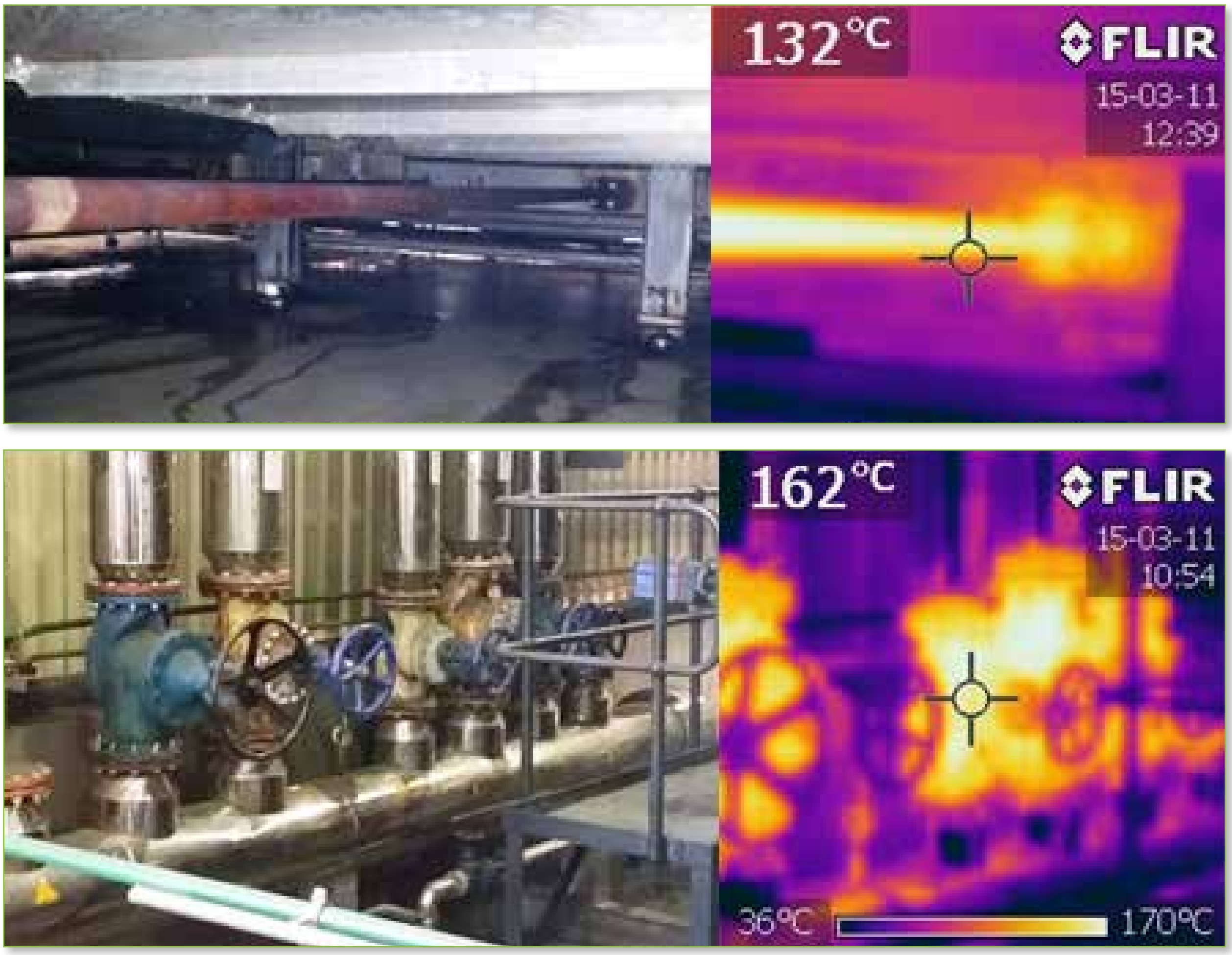

Figure 2. Radiation loss visible in the infrared spectrum

RECOMMENDED ACTION

We would recommend insulating all exposed piping and installing jacket covers on flanges and valves.

POTENTIAL ISSUES/PROBLEMS

Insulation can often hide leaks or inhibit maintenance. Insulation installed should be done so as to ensure that the underlying components can still be readily serviced.

INDICATIVE COST-BENEFIT ANALYSIS

We have noted that improved insulation can reduce energy consumption on heating systems by 5-10% typically with a payback of under a year.

2.3 Boiler blow-down heat recovery

RATIONALE

The salt and chemicals introduced into the boiler through the make-up and chemical dosing increase in concentration as steam is produced. It is important to discharge some of this high concentration salt in order to avoid scaling, which will cause a significant reduction in efficiencies (see Figure 3). Typically, boiler systems are maintained at 35 cycles of concentration.

Too high a discharge rate will result in unnecessary energy losses and reduced chemical treatment concentrations, which will result in increased corrosion rates. Conversely, too low a discharge rate will result in an increase in salt concentration with scale deposition on the boiler tubes. The impact of poor control on the boiler blow-down is illustrated in the diagrams that follow.

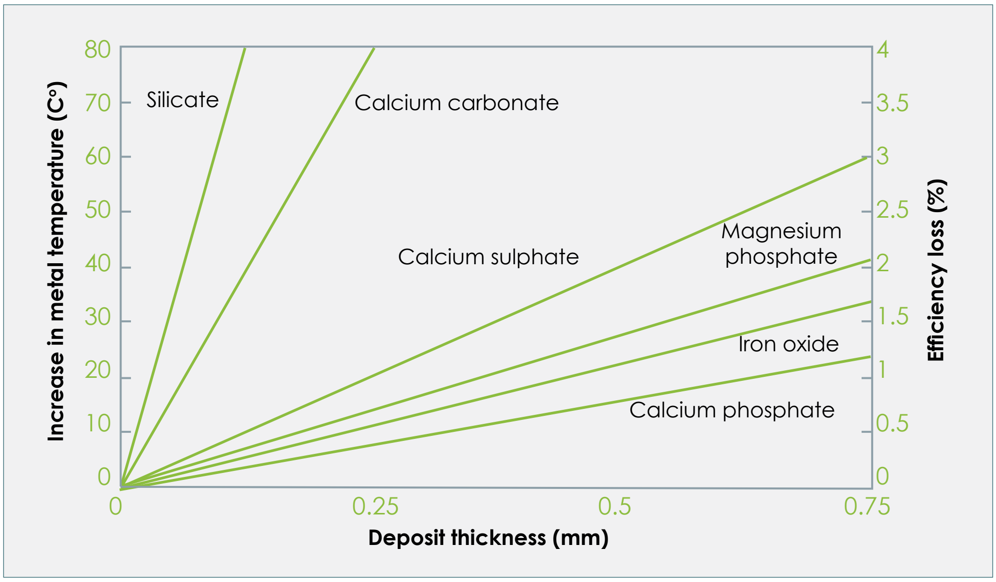

Figure 3. Impact of scale on boiler efficiency

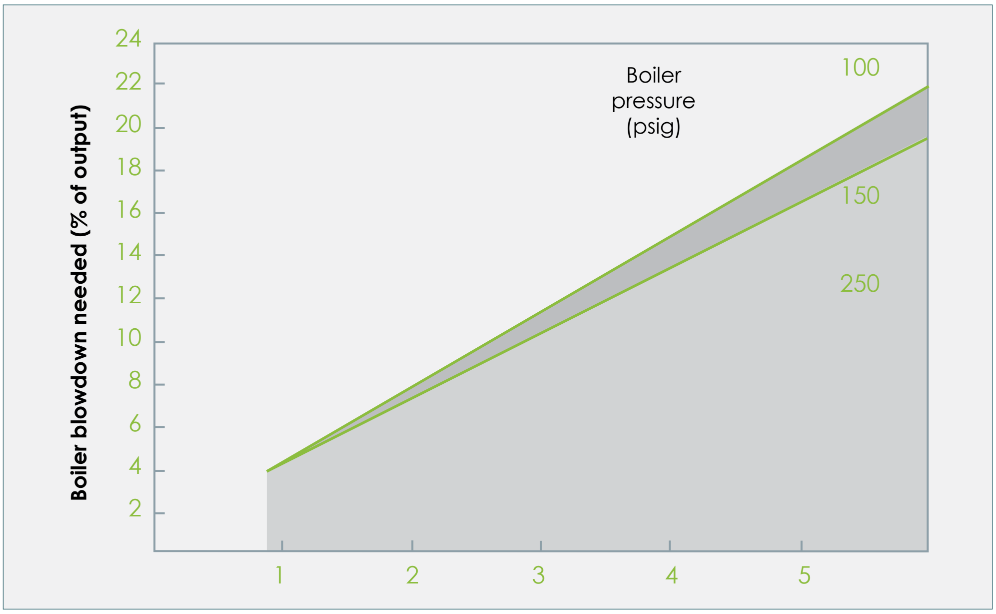

Figure 4. Fuel wasted due to blowdown (%)

RECOMMENDED ACTION

We would recommend installing automatic TDS controls to accurately maintain the cycles of concentration. Sensible heat recovery on the boiler blowdown can also be considered as a potential option. The capital required for the recovery of the energy in the flash steam usually is not economically viable (the capital cost incurred would not have a simple payback of less than three years).

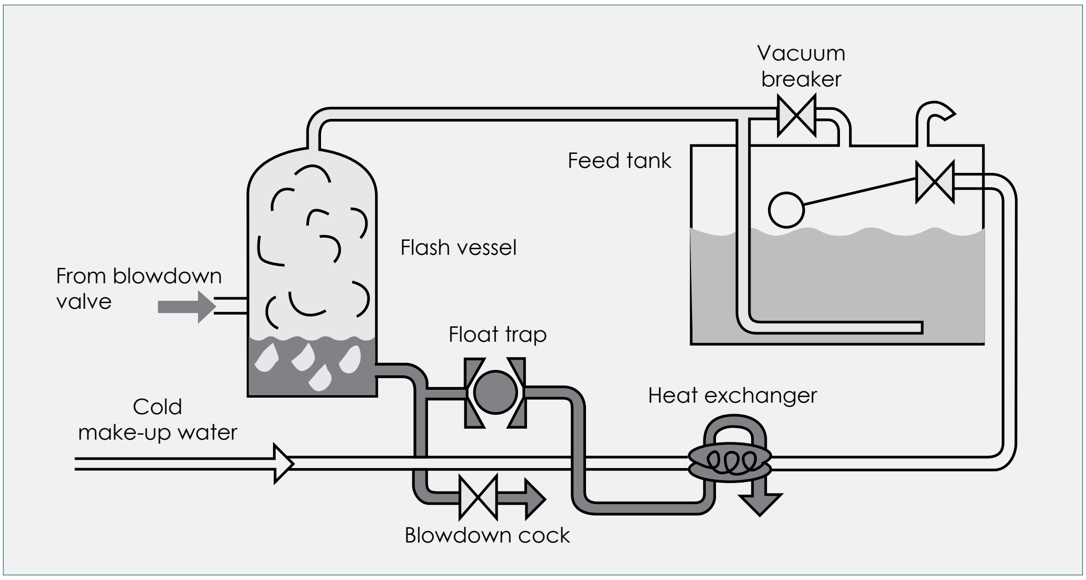

Figure 5. Boiler blowdown heat recover system

POTENTIAL ISSUES/PROBLEMS

The heat exchanger is often fouled due to the high salt concentration in the blowdown and should therefore be periodically descaled to maintain heat transfer efficiencies.

INDICATIVE COST-BENEFIT ANALYSIS

Typically, automatic TDS blowdown and sensible heat recovery systems would realise a 2% reduction in fuel consumption with a payback of less than two years.

2.4 Condensate recovery

RATIONALE

The condensate lost to drain is usually calculated using the difference between make-up water and feed-water meter readings. The theoretical condensate return should be in the vicinity of 90% if there is no direct steam injection in the process, with the remaining 10% lost to flash steam as the pressure of the condensate drops to atmospheric conditions.

RECOMMENDED ACTION

Implement a condensate return programme with a minimum percentage return targeted. Areas where condensate is being discharged to drain should be tied back into the return system. The hotwell make-up level controls should also be carefully managed to ensure that the returned condensate is not discharged to drain through the overflow pipe.

POTENTIAL ISSUES/PROBLEMS

It may not be viable returning condensate at remote locations.

INDICATIVE OUTLINE COST-BENEFIT ANALYSIS

Figure 6 indicates the expected savings through returning the condensate and ensuring the lines are effectively **insulated.**

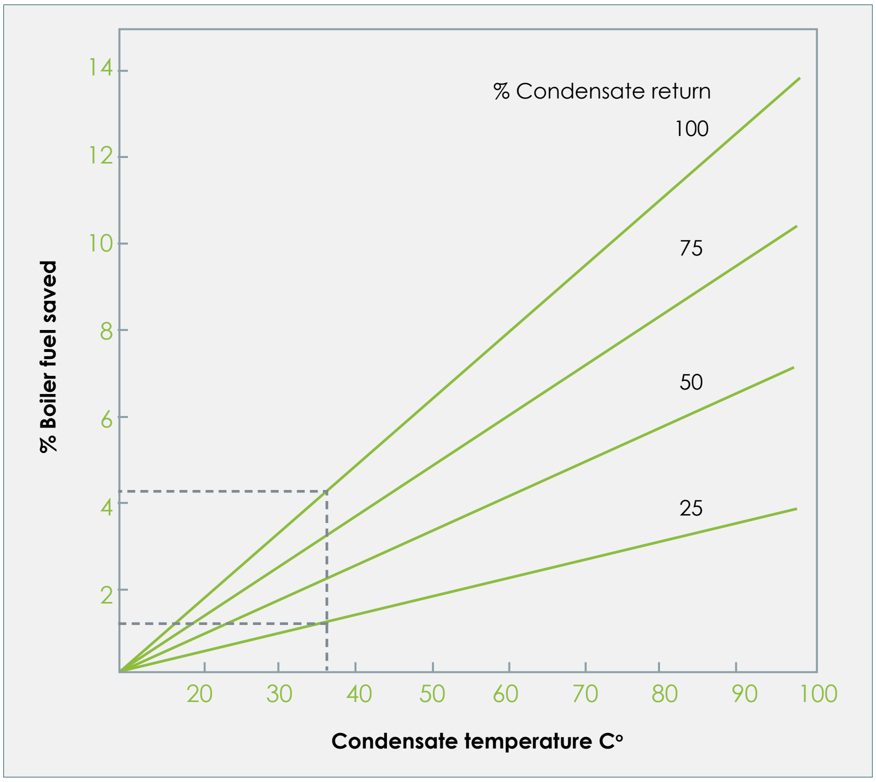

Figure 6. Efficiency improvement based on condensate return

Typically, condensate return system interventions have a payback of less than a year.

3 ELECTRICAL ENERGY OPTIMISATION

The textile industry utilises electrical energy predominantly for pumping, fan and compressed air systems.

These systems are usually continuously operating or, as in the case of the compressed air systems, are load/unload controlled.

While the systems themselves last more than 10 years, there is significant maintenance costs associated with operating off the best operating points on the respective system curves.

High losses are experienced due to inadequate controls or through system effects introduced by the distribution systems.

The following systems will be briefly discussed with common recommendations noted to reduce losses:

3.1 Air compressor optimisation

RATIONALE

For compressed air systems utilising load/unload controls, it is important to keep the number of unload cycles to a minimum as there is energy lost between the unload point and the load point. In addition to power being drawn with no productive air being produced, there is a space between the unload point and the steady state where the motor draws close to the full rated power. This is illustrated by the area in red and pink in Figure 6.

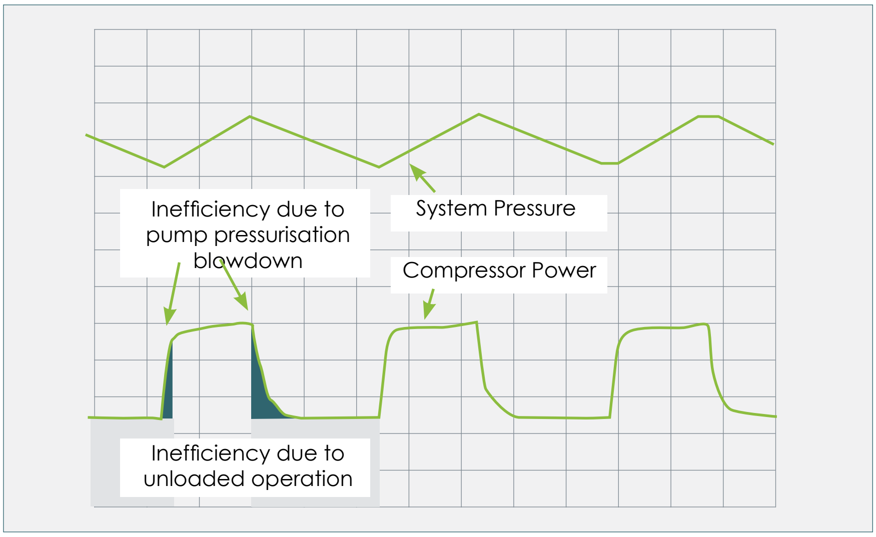

Figure 7. Illustration of efficiency loss during unload cycle

From Figure 7 one can note that part load compressors operate with significantly lower efficiency (kW per m3/min), which is highlighted by the % draw at low loads. One will note that even a variable speed drive (VSD) driven compressor realises significant losses at low loads.

It is important to note that even with optimal control strategies over 78% of the input energy into an air compressor is lost to waste heat. Most of this heat (~94%) can be recovered for use either to pre-heat air or to heat water.

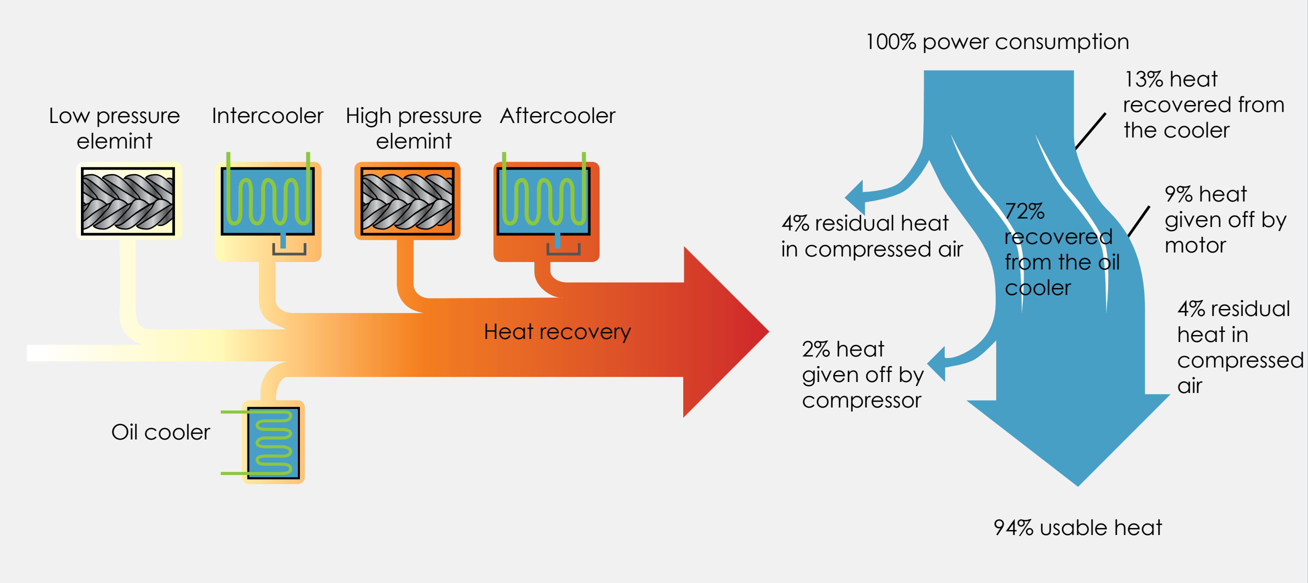

Figure 8. Illustration of heat losses in an air compressor

Significant losses are also incurred through distribution line leakage. Most facilities that actively monitor their leakage will target a leakage rate of 10% of system capacity. Facilities that do not actively manage their leakage will typically experience leakage rates as high as 20-30% of system capacity.

COMMENTS

Compressed air supply should balance the demand and often a more detailed assessment would be required to properly understand the opportunities for saving.

RECOMMENDED ACTION

In addition to optimising the load controls, the diagram below provides some common savings interventions, which include:

- Reduce compressed air leaks;
- Utilise cooler outside air;
- Reduce system pressure; and
- Utilise waste heat productively.

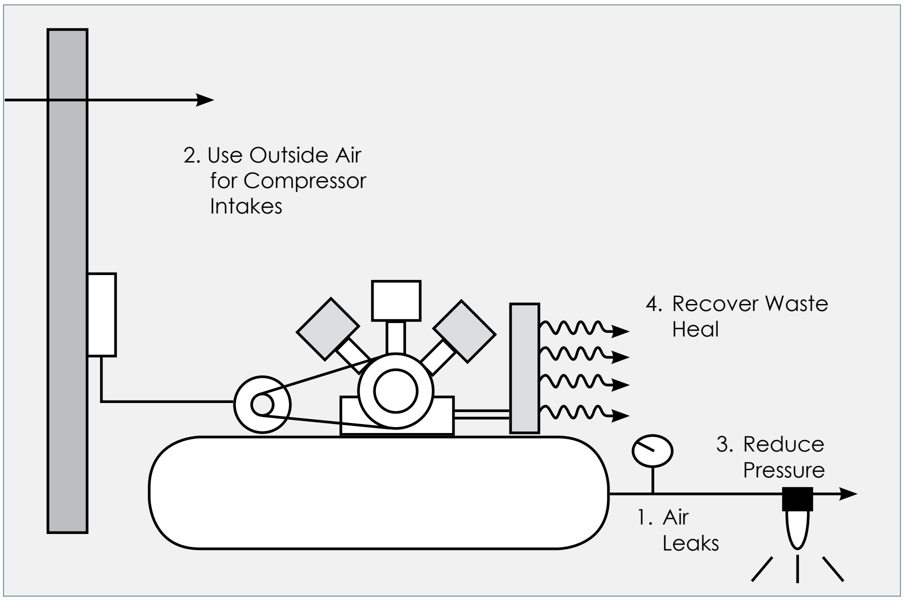

Figure 9. Overview of interventions for compressed air systems

POTENTIAL ISSUES/PROBLEMS

Conducting a detailed compressed air assessment may prove to be costly if not subsidised.

INDICATIVE COST-BENEFIT ANALYSIS

The following rules of thumb apply to compressed air systems:

- Optimising compressor controls can save between 5% and 10% of the energy utilised by the compressed air system by more closely matching the load requirement;
- Reducing air compressor pressure by 2 psi can reduce compressor energy use by 1% (at 100 psi);
- There would be a 1% reduction in compressor electrical energy utilisation for every 2.2oC reduction in intake gas; and
- Typically, companies will realise a 5-10% reduction in energy consumption on the compressors by implementing an aggressive leak detection programme.

3.2 Fan system optimisation

RATIONALE

Conventional air-system design processes result in an ideal fan type, size, and speed for ideal conditions. But in the field, actual conditions are often less than ideal. Obstacles to duct runs lead to sharp turns or changes in elevation, and then another correction to resume the planned path. Or, there might not be enough room for the ideal length of inlet or outlet duct to establish fully developed airflow. The results of less-than-ideal fan conditions are called "system effect". The consequence of this is wasted energy consumption and expense, excessive airflow noise, and increased maintenance and system downtime.

The diagram below illustrates an inlet system effect resulting in altered system condition (lower system pressures) which ultimately results in reduced airflow. Effectively the system will operate as an inlet damper.

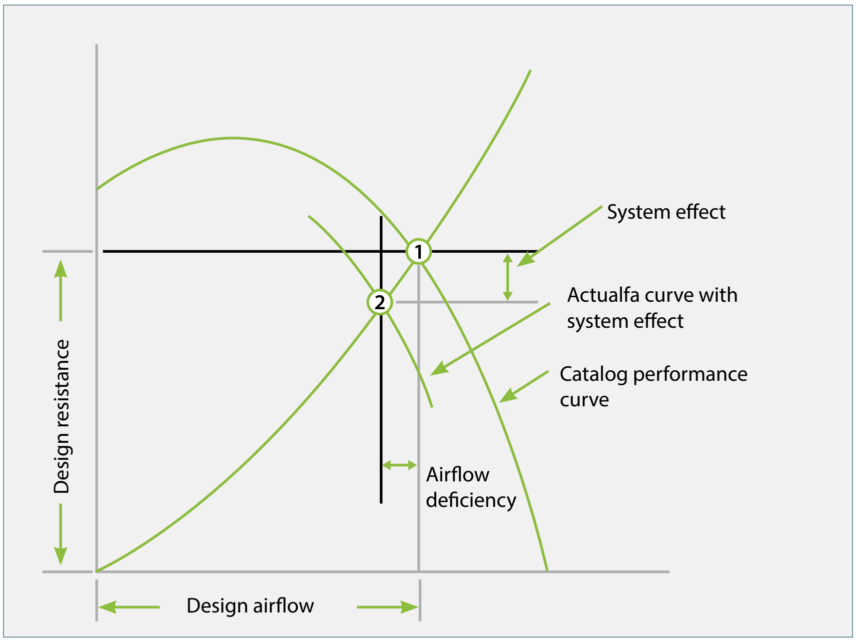

Figure 10. Impact of system effect on fan curve as a result of poor inlet conditions

Poor outlet conditions will inadvertently increase the system resistance resulting in increased system pressures and ultimately reduced flow.

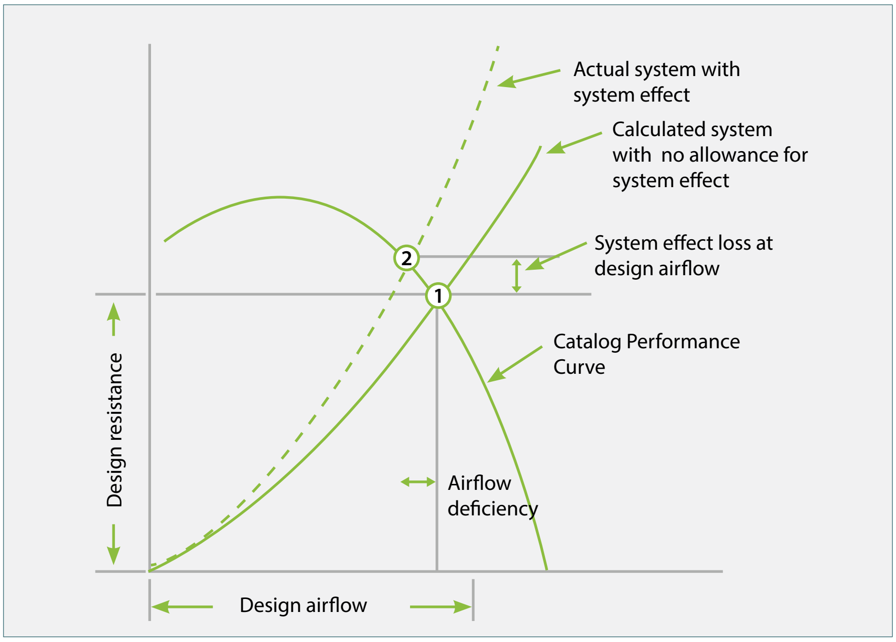

Figure 11. Impact of system effect on the outlet side of the fan

Furthermore, system effect occurs when bends are introduced before the air profile across the duct is uniform. Usually three to five duct lengths are needed as is illustrated in the Figure 12. This effect will be further compounded depending on the angle and direction of the bend introduced. Opposing the natural flow path of the air stream will always increase the system effect.

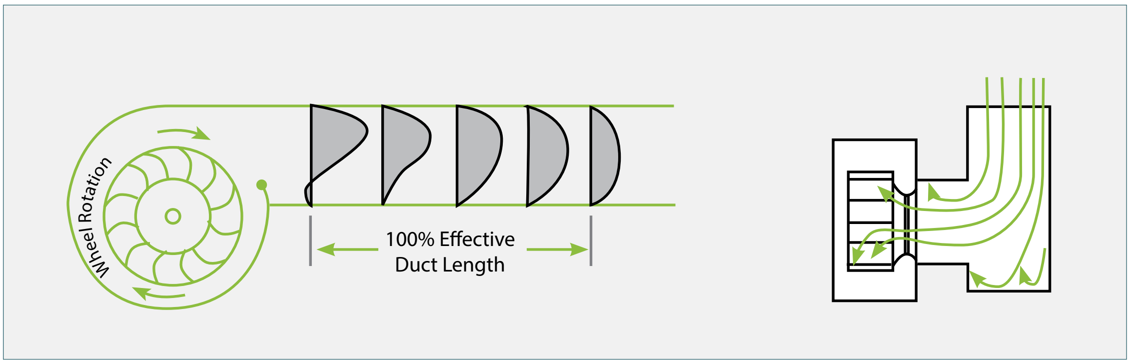

Figure 12. Air profile in a ducted system with an example of the inlet condition of the current installation

COMMENTS

The pictures in Figure 14 provide an example of outlet conditions which will introduce a system effect and result in reduced flow rates.

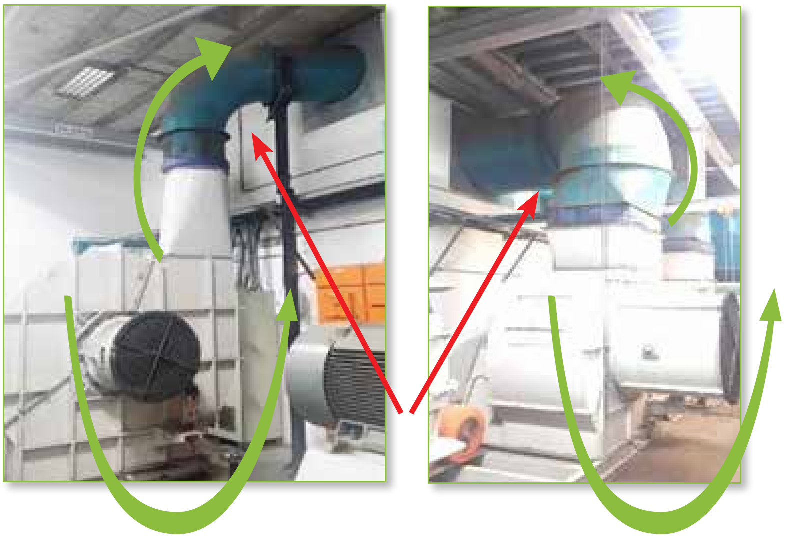

Figure 13. Quenching and cooling fan with two counter flow bends immediately after the outlet

RECOMMENDED ACTION

Consider reducing speed of fans using smaller motors, changing the pulley system or installing VSDs on fans where continuous throttling in the system is evident.

POTENTIAL ISSUES/PROBLEMS

The VSD is expensive and may result in additional energy consumption if the fan speed itself is not adjusted. Fan system assessments are costly to conduct.

INDICATIVE COST-BENEFIT ANALYSIS

Typically, there would be a 10-20% reduction in power consumed once system effect has been minimised, system dampers removed and fan slowed to match the actual air flow requirement.

3.3 Pump system optimisation

RATIONALE

Pump systems are frequently throttled to restrict flow or to elevate pressure. While throttling is a convenient mechanism for altering pump system characteristics, it usually comes at a loss in efficiency as the pump is pushed back on its curve away from its operating point. The following diagrams illustrate the impact of throttling.

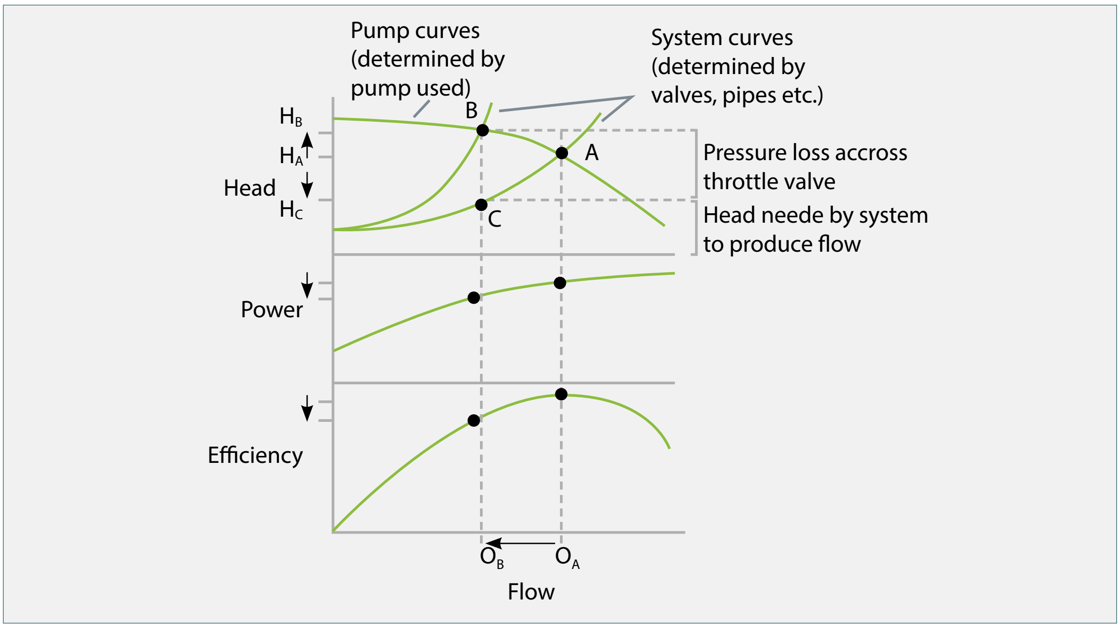

Figure 14. Pump system curve illustrating the impact of throttling

This loss can be avoided by installing pumps that are correctly sized or by fitting VSD drives. The following diagram provides an indication of the impact of reducing the size of the pump.

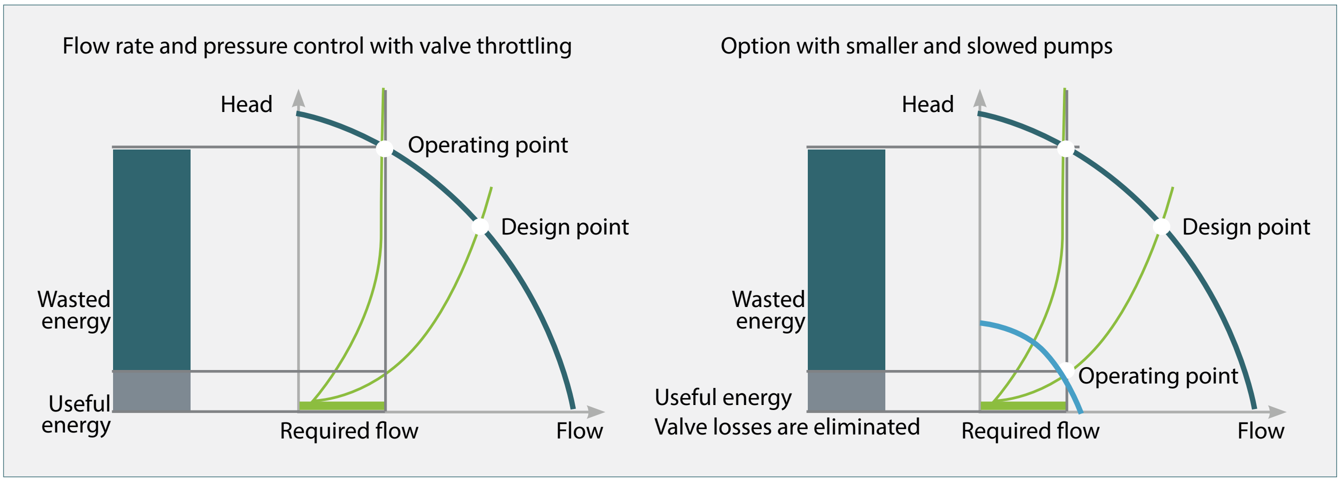

Figure 15. Illustrating waste energy and potential savings by removing the throttle valves

Companies sometimes also operate two pumps on a system designed for one to boost pressure and flow. While there is a marginal increase in pressure and flow it will result in an increased cost per ML pumped (usually around 30-40% higher).

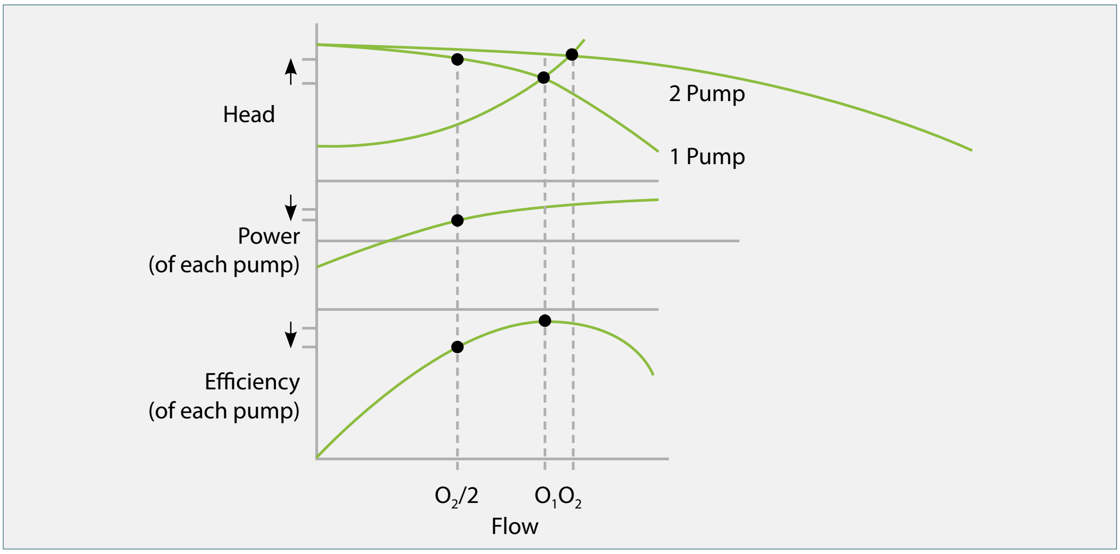

Figure 16. Pump system curve illustrating the impact of multiple pumps on a system designed for one

COMMENTS

The following pictures are examples of recirculation systems that are heavily throttled.

Figure 17. Pictures of throttled pump systems

Many pump systems employ bypass flow as a way of sustaining constant pressure conditions to a given application. The recirculated stream often results in unnecessary kWh consumption which could be managed more efficiently by using VSD drives. The benefit of the VSD drive will be undermined by any static head that may be in the pump system. This is illustrated in Figure 19.

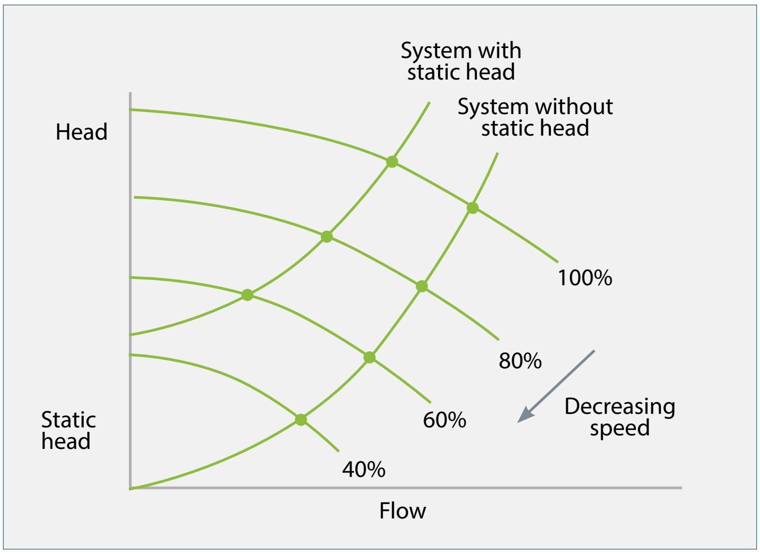

Figure 18. Throttled recirculation pumps

RECOMMENDED ACTION

Consider replacing throttled pump systems with smaller pumps or alternatively introduce VSDs and slow the required flow to the process requirement.

POTENTIAL ISSUES/PROBLEMS

The VSD drives are ideally suited to changing process requirements.

INDICATIVE COST-BENEFIT ANALYSIS

Typically, there would be a 10-20% reduction in power consumed once the pump delivery is slowed to match the actual flow and pressure requirements.

4 WATER AND EFFLUENT OPTIMISATION

The textile industry utilises water for dyeing processes, humidification as well as in the cooling and steam systems. Water is usually sourced from the local municipality and discharged to effluent. Most municipalities will charge the company for purchasing the water as well as discharging. The effluent cost would be determined by the effluent quality (pH, salt and organic content) as well as the quantity.

There are normally significant costs associated with the effluent discharge due to high chemical oxygen demand (COD), which is an indication of the chemical and organic loading of the effluent.

High losses are experienced through the incorporation of dye processes, manual controls as well as poor internal infrastructure resulting in leakages.

The following systems will be briefly discussed with common recommendations noted to reduce losses:

4.1 Reduce water losses/wastage

RATIONALE

All processing facilities will experience losses as a result of leakage. These could be float valves on cisterns or leakage on pipes.

COMMENT

Most textile companies meter the main line coming into the process with very little sub-metering or internal benchmarking.

RECOMMENDED ACTION

Implement a leak detection and repair programme.

POTENTIAL ISSUES/PROBLEMS

Leakages underneath tarred or paved surfaces can be difficult to detect and repair.

INDICATIVE COST-BENEFIT ANALYSIS

Leakages and losses often account for as much as 10% of the facilities' water consumption. These are usually repaired utilising the maintenance budget.

4.2 Effluent sampler

Most municipalities base their effluent charges on a single grab which is not necessarily representative of the monthly average discharge. In addition, an assumption that 95% of the water used in the process is discharged to effluent is often utilised for the effluent calculation.

COMMENT

Grab samples during the day may often coincide with a specific batch or process discharge which may inflate the effluent quality characteristics (salt and organic content). This would typically result in erratic billing where one month the sample is in line with the discharge specifications whereas the next month these specifications would be exceeded.

RECOMMENDED ACTION

- Install an effluent flow measuring device which would send a pulse or 4-20mA output to a sampler;
- Ensure that the municipality samples from the composite sample tank; and
- Negotiate a reduced effluent discharge quantity based on the new metered figures.

POTENTIAL ISSUES/PROBLEMS

The commercial auto samplers are expensive. Customised solutions would prove to be more cost effective.

INDICATIVE COST-BENEFIT ANALYSIS

Companies who have installed auto samplers have often avoided penalties due to exceeding the local municipality thresholds.

4.3 Reduce process use water

Washing and rinsing are both important for reducing impurity levels in the fabric to pre-determined levels. Because water and effluent disposal costs have been low, there has been a tendency to over use water.

COMMENT

The following list provides examples of successful water reduction projects in batch and continuous operations.

- Winch dyeing - By dropping the dye batch and avoiding overflow rinsing, water consumption was reduced by 25%.
- High and low - By replacing the overflow with pressure-jet dyeing batchwise rinsing, water consumption was cut by approximately 50%.
- Beam dyeing - Preventing overflow during soaking and rinsing can reduce water consumption by about 60%. Automatic controls proved to be economical, with a payback period of about four months.
- Jig dyeing - Reductions in water consumption ranging from 15% to 79% were possible by switching from overflow to stepwise rinsing. Rinsing using a spray technique, which was tried on a laboratory scale, was also effective.
- Cheese dyeing - A reduction in water consumption of around 70% proved possible with intermittent rinsing.
- Continuous dyeing - A 20-30% saving was realised by introducing automatic water stops. Horizontal washing equipment delivered double the performance of vertical washing machines, using the same amount of water.

RECOMMENDED ACTION

Consider altering dyeing recipe and processes to minimise water consumption.

POTENTIAL ISSUES/PROBLEMS

The dyeing step is important for quality and insufficient rinsing or fixation due to aggressive water reduction measures may result in deterioration in quality.

INDICATIVE COST-BENEFIT ANALYSIS

These are indicated in the comments section above.

4.4 Cascade rinsing and water re-use

RATIONALE

Some of the recipe steps could be recovered and re-used in the process. These specifically included the bleach steps in the white dyeing process or in the reactive dye process steps. Similarly, a number of the process rinse steps can be recovered and re-used in the previous process steps in a cascade rinse fashion. In most cases, this stream would need no further treatment before re-use and would only require insulated storage vessels.

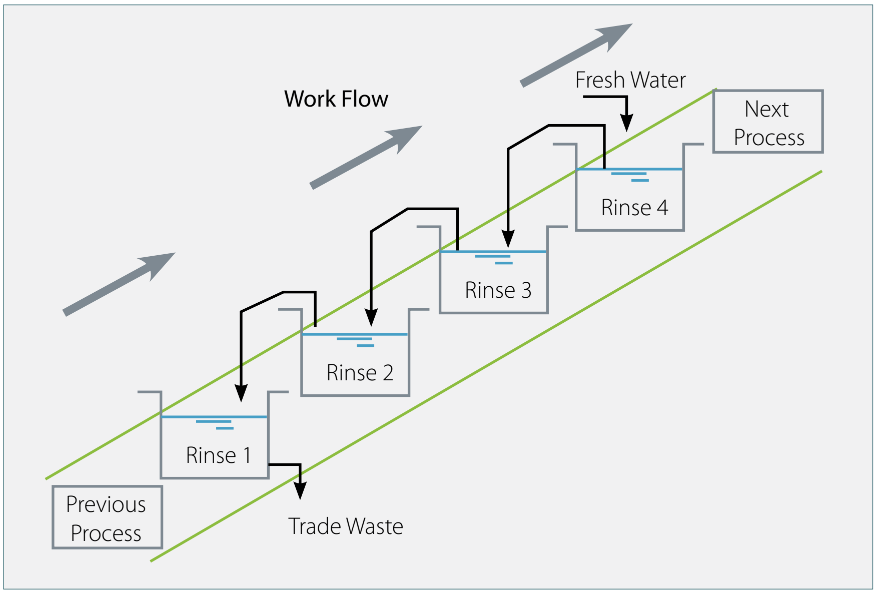

Figure 19. Illustration of counter-current rinse steps

COMMENT

Additional experimentation and controls may be needed to ensure effective segregation and implementation. This presents an opportunity to recover unspent chemicals from the bleaching steps for re-use which would improve the effluent quality. Filtration steps may be needed to partially purify this stream.

RECOMMENDED ACTION

Recover final rinses in process steps and re-use as a first rinse.

POTENTIAL ISSUES/PROBLEMS

Additional storage infrastructure and process controls are needed. Buffer/storage tanks should also be periodically dumped and cleaned.

INDICATIVE COST-BENEFIT ANALYSIS

There would typically be a 10-20% reduction in water and energy for the dyeing process through recovery and re-use of these streams.

PROCESS RINSE RE-USE

As per the process water re-use, we would anticipate a 10-20% reduction in water and energy for the dyeing process through recovery and re-use of these streams.

4.5 Rainwater recovery

RATIONALE

South Africa is a water-scarce region and pressure on water supplies will increase. Rainwater can be recovered and is suitable for use in most peripheral processes such as boiler feed water, cooling tower make-up or toilet flushing.

COMMENT

The recoverable water can be roughly calculated by estimating the roof area (m^2) and multiplying that by 500 mm average rainfall for South Africa. The tank sizing and location would depend on the location of the rainwater downpipes and how much water would be cost effectively recovered. In most instances, only part of the roof would be targeted for rainwater recovery.

RECOMMENDED ACTION

- Model the rainwater pattern to ascertain optimal size tank for rainwater recovery; and
- Install recovery system to top up the existing reverse osmosis reject water recovery system.

POTENTIAL ISSUES/PROBLEMS

The main off-set for the recovered water would be irrigation, cooling tower or humidifier make-up. While these applications are significant water users, the consumption pattern may not coincide with the rainfall patterns.

INDICATIVE COST-BENEFIT ANALYSIS

Rainwater recovery systems typically have a payback of between two and three years.

NOTES

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