7. Wool Scouring Systems

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Learning objectives

On completion of this topic you should be able to:

- Describe the following and compare the advantages and disadvantages of:
  - Solvent scouring versus aqueous wool scouring
  - Traditional scouring versus mini-bowls
  - Standard scouring versus suint scouring
  - Two stage and three stage scouring systems
  - The scouring of coarse wools and fine wools
- Explain the main innovations contained in the Wool Research Organisation of New Zealand (WRONZ) Comprehensive Scouring System and sketch a simple diagram of the bowls, flowback paths and effluent treatment flows
- Describe the design of a typical mini-bowl
- Outline the requirements of fine wool scouring for topmaking, and how these are achieved in modern scouring systems such as Siroscour

Key terms and concepts

Solvent scouring, aqueous scouring, Duhamel process, WRONZ Comprehensive Scouring System, Lo-Flo, Siroscour, mini-bowls, suint bowl, multistage scouring, topmaking

Introduction to the Topic

The main aim of woolscouring is to remove as many contaminants as possible from greasy wool, thus leaving the wool in the best possible condition (i.e. clean and free of contaminants) for further processing. This may be achieved with different levels of performance and cost by solvent scouring or aqueous scouring. Today the aqueous process is the dominant method.

A scouring train comprises a number of wash bowls and squeeze heads, and is usually linked to an inline dryer and a woolgrease recovery system. The 'standard' modern scouring line for coarser and carpet wools, based on the WRONZ Comprehensive Scouring System, typically comprises three scouring bowls and three rinse bowls. More complex two- and three-stage scouring systems (Siroscour) have been developed in Australia specifically for fine wools. In Siroscour the first bowl may be a suint bowl, which is designed to remove as much dirt and suint as possible from the wool before the grease-removal action of the detergent commences in the second bowl.

The Cardmaster and Topmaster ranges of scouring systems from Andar exemplify the most efficient and effective technologies for the scouring of coarse wools and fine wools respectively. They incorporate multi-hopper mini-bowls, flowback and flowdown systems for efficient use of water and energy, and are integrated with advanced effluent treatment systems. For fine and superfine wools, where the risk of entanglement is highest, the Topmaster LE system replaces some of the rake action bowls with suction drum bowls to provide a more gentle action in scouring.

The principle references for this topic are Stewart (1988a), Stewart (1988b) and Christoe and Bateup (1987). The assistance of Andar Holdings Ltd (http://www.andar.co.nz/) in the preparation of this topic is gratefully acknowledged.

For the mathematically inclined, the reading "Mathematical Modelling of a Wool Scour Bowl" (Barry, Mercer and Marchant.pdf) will be of interest.

7.1 Impurities of raw wool

Raw wool has natural, applied, and acquired impurities. These impurities vary from fleece to fleece and between wool types.

The primary objective of woolscouring is to remove these impurities and present a clean, uniform product for subsequent processing. They are:

1. Suint, which is mainly dried sweat and contains mainly potassium salts. Suint is soluble in water and non-polar organic solvents
2. Woolgrease, which is a complex mixture of compounds called *esters*. Esters are formed by a reaction between acids and alcohols, with the elimination of water. While woolgrease is insoluble in water, a solution of water and detergent forms an emulsion with woolgrease to facilitate its removal from the fibre. Woolgrease is soluble in non-polar organic solvents
3. Surface soiling, which includes dust, stones, faeces, and vegetable matter, such as burrs picked up when the sheep is grazing. Traces of dipping and branding agents may also be found.

When all the three types of impurities have been removed by scouring, the natural colour of wool, i.e. creamy white, remains. Wool can be made whiter by bleaching if required and bleaching also destroys residual natural contaminants.

The two techniques for removing woolgrease, suint and dirt from wool are **solvent scouring** and **aqueous scouring**. Solvent scouring removes the woolgrease in solution and both the dirt and suint in suspension while aqueous scouring removes the woolgrease in emulsion, the suint in solution and the dirt in suspension.

7.2 Solvent scouring

There are a number of advantages in solvent scouring over aqueous methods:

- Felting and entanglement associated with aqueous scouring are virtually eliminated
- Woolgrease recovery is increased
- Suint recovery may be designed into the process
- The effluent is less polluted. The woolgrease is removed from the solvent/grease mixture. The solvent is then recycled so that little or no grease or solvent enters the effluent
- Aqueous effluent problems are avoided.

Solvent scouring has been tried in various parts of the world since 1950 without achieving sustained commercial success. The most successful solvent scouring technology has been the de Smet process, with seven plants in operation in 1990. It uses a combination of non-polar (hexane) and polar (isopropyl alcohol) solvents to target to remove woolgrease and suint respectively. The market for this technology has dwindled, primarily because of the high capital cost of such plant compared to conventional aqueous plant during a time of low profitability in the wool industry generally.

An alternative solvent scouring technology has been developed by Wooltech Ltd of Brisbane, using a solvent 1,1,2 trichloroelthylene (TCE) that is non-flammable and does not deplete ozone. However, TCE is toxic to humans and requires appropriate handling. Enhancement of fibre properties have been claimed by the TCE treatments, including increased tenacity, elongation and resilience and low residual grease, all promoting good quality yarns.

When compared with conventional aqueous scouring equipment, which is simple, robust and has a long working life, solvent scouring is much more complex and requires a more sophisticated chemical engineering approach to its operation. However, if the aqueous scouring plant has a comprehensive effluent treatment system added to comply with strict environmental regulations, the levels of engineering sophistication are similar.

It will always be difficult to remove the suint and dirt from the wool using TCE, but subsequent processing can be arranged to include further cleaning to obtain a satisfactory product, e.g. by backwashing. However, despite the advantages of solvent scouring and these process innovations, aqueous wool scouring remains the dominant method around the world.

7.3 The development of aqueous wool scouring systems

Traditionally wool was scoured in hot, aqueous solution of soap and alkali. Synthetic detergents have largely replaced soap today however.

For many years, woolscouring of the wide range of wools produced was viewed as an art rather than a science. Even wools from the same breed and with the same micron and length ranges vary widely in their scouring properties, depending on where the sheep were raised and the methods of husbandry.

Duhamel process

As an improvement on basic wool scouring systems of the time, an early system, the *Duhamel* or suint scouring process, was introduced in France in the 1920s. It was developed because a water solution of suint has an approximate pH of 7.5. With this pH level, there is less chance of damaging the wool than with the old soap-soda method.

Suint is easily removed from wool. When removed, it forms a slight soapiness when combined with the wool grease in the water. This slight soapiness helps to cleanse and scour the wool. Because the suint solution is not as harsh as the soap-soda solution, it was thought to be better for the wool. No alkali was used in the process.

The system worked as follows:

Bowl 1 – A cold water bowl that removes suint and dirt; the liquor is constantly run off and separated; the suint solution returns to the bowl and the dirt goes to waste
Bowl 2 – A hot water bowl at about 55^{o}C; the remaining suint combines with grease to form a slight soap solution. The solution is constantly run off and suint recycled. The dirt and grease are separated
Bowl 3 – Rinse bowl
Bowl 4 – Hot soap solution to scour the wool
Bowl 5 – Final rinse.

During scouring, the dirt and suint are separated and the suint solution is returned to the bowl. After scouring, the grease dirt and suint in the liquor can be separated and the suint solution can be reused. The system included several features that have become the cornerstones of modern woolscouring – bowls with conical-shaped bottoms and the use of decanter and nozzle-disk centrifuges to remove dirt and woolgrease from the liquors, respectively. However, the process did not receive wide acceptance because poor scouring could be expected under the liquor conditions used.

WRONZ comprehensive scouring system

In the 1960s research and development on scouring machinery centred on the design of individual scour bowls. Despite a number of innovations, the woolscouring industry still had increasing problems with:

1. Effluent disposal
2. Grease recovery
3. High water usage
4. High heating costs, and
5. A need to improve efficiency and to be competitive.

In the early 1970s a new scouring system was introduced by WRONZ. The system was called the *WRONZ Comprehensive Scouring System*. This was the first modern system to be commercialised, in 1972. The main outcomes of this system, which was designed primarily to handle New Zealand wools, were:

- The integration of the contaminant removal systems into the operation of the scour so that all heavy effluent (i.e. that originating from the hot scouring bowls rather than from the rinsing bowls) received treatment before discharge. Such treatment included the removal of fibre and heavy solids and the recovery of woolgrease
- Batchwise operation, where the scour bowls were 'dumped' to drain periodically, was replaced by a fully continuous process
- Liquor management also became better controlled, with the avoidance of bowl overflows and the use of bowl-to-bowl flowback running in the opposite direction to the wool flow
- The 'flowdown' of heavy liquor to the drain was at a controlled rate that could be set manually or automatically via measurement of a property of the liquor
- Heat was recovered from the flowdown and used to pre-heat fresh water being fed to the scour.

Lo-Flo and Siroscour processes

The Lo-Flo was released by CSIRO in Australia in 1977. This system had a high level of effluent treatment integrated with the scouring process. It relied on 'concentration destabilisation', i.e. when this stabilisation condition was reached, all of the suspended solids were able to be removed by centrifuging, and the liquor was then able to be re-used indefinitely. Siroscour was developed in response to the need for cleaner wool and better dirt recovery, both of which had been identified as problems with Lo-Flo. Residual contaminants affect processing performance in several ways – they produce dust and fly in the mill, affect performance of processing additives, and provide visual defects in topmaking, spinning and dyeing. Studies by CSIRO showed that the usual wool contaminants (grease, suint and dirt) had easy-to-remove and hard-to-remove fractions, which needed to be addressed separately.

To facilitate the scouring of most of the contaminants and their removal from the liquor, 'two-stage' and 'three-stage' scouring was promoted, with the latter being the preferred mode of operation for lower-yielding wools.

The first stage (bowl 1) removes dirt without removing woolgrease, by using a modified suint bowl. Small additions of detergent and soda ash are made and the temperature kept below 35^{o}C. This improves the recovery of dirt via settling tanks or hydrocyclones in the liquor treatment loop connected to bowl 1.

In the second stage (bowls 2-4) the easy-to-remove contaminants are removed. Bowls 2 and 3 are scouring bowls containing hot detergent liquor while bowl 4 acts both as (a) a rinsing bowl to remove the easy-to-remove contaminants and (b) a soaking bowl to encourage further swelling and hydration of the hard-to-remove contaminants.

The third and final stage (bowls 5 and 6) removes the hard-to-remove contaminants.

Siroscour provided a system for effectively washing the full range of fine wools, much in the same way that the WRONZ system provided a similar outcome for New Zealand crossbred wools. While the WRONZ system with mini-bowls is capable of efficiently and effectively washing the better types of fine wool, it is not capable of washing all types well.

Today the manufacturers of woolscouring machinery such as Andar (http://www.andar.co.nz/) provide scouring lines customised to the specific needs of the customer.

7.4 Scouring line design and operation

Traditional scouring lines

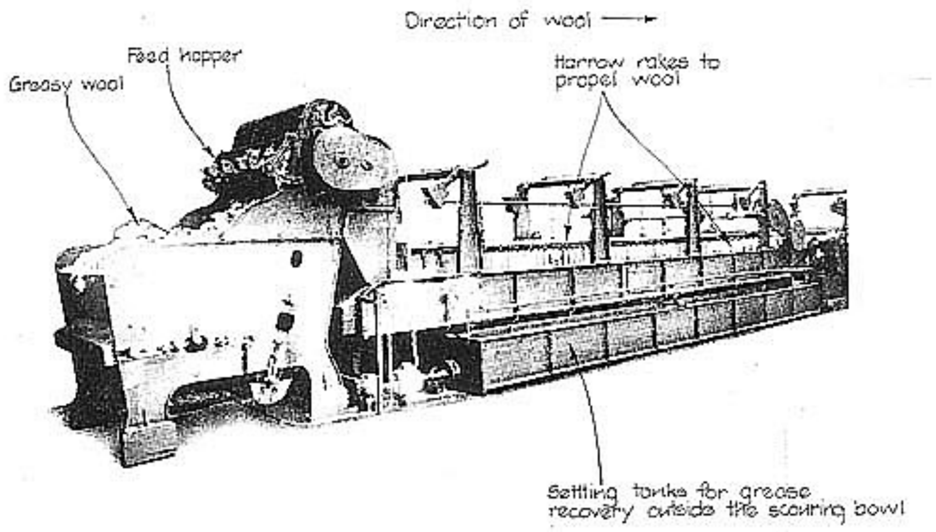
Older conventional scouring lines typically include four bowls with rake or harrow mechanisms that dunk and transport the wool. The scoured product from such designs is satisfactory for most purposes, so that the basic mechanical actions of aqueous bowl design have not changed greatly over the past 100 years. Most greasy wool in the world is processed in aqueous systems using rake and harrow mechanisms, but the design of the bowls has changed significantly.

A traditional scouring line consisted of an automatic feed and three to six cast-iron bowls. The first two or three bowls were for scouring and the remainder for rinsing. At the end of each bowl was a set of squeezing rollers. At the end of the train was a travelling apron dryer. In some plants, the scoured wool was hydro-extracted before drying. A hydro-extractor acted like a spin dryer, forcing the water out as it was spun at high speed.

Most scouring trains contained four or five long bowls, as in Figure 7.1. The bowls were about 1.8 metres wide and the whole train was about 28 metres long.

The first bowl (and sometimes the second bowl), was self-cleaning, with the accumulated solids being regularly flushed away to waste by the bowl liquor via a dump valve.

Figure 7.1 Older type scour, first bowl. Source: Wood, 2006.



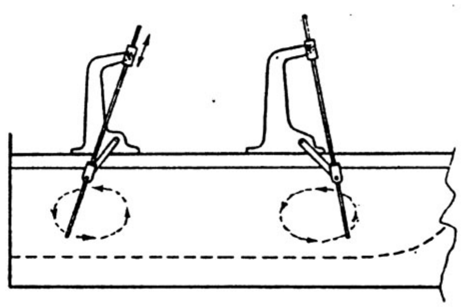
Except for cleaning times, the system was continuous and reasonably productive, but:

1. Wool grease was lost with the liquor used to flush away the heavy solids
2. Heat recovery from the flushing liquor was uneconomical because its discharge was intermittent
3. The discharge of liquor was not metered, and so the use of liquor was poorly controlled, and
4. Liquor flow control and removal of heavy solids was needed to give better effluent treatment.

The earliest means of propelling the wool through the scouring liquor in the bowl was with swing rakes. Each swing rake, as Figure 7.2 shows:

1. Works independently of the others, and
2. Has a circular motion.

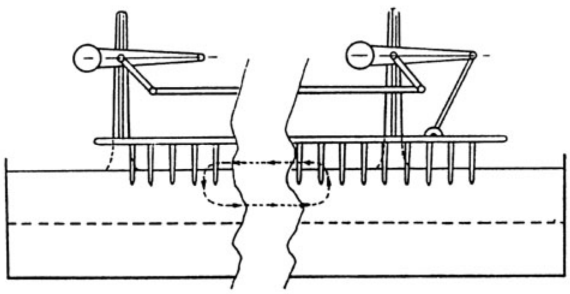
Figure 7.2 Swing rake motion. Source: Wood, 2006.



The motion of the swing rakes causes a great deal of agitation; hence they are more suited to scouring coarser and dirtier wools than fine wools.

The second method of propelling wool through the liquor was with harrows, and it is the method that is mostly used today. With harrows, all the rakes are mounted on one frame so that they all move through the liquor together. Figure 7.3 shows the harrow motion.

Figure 7.3 Harrow motion. Source: Wood, 2006.



The harrow motion gives a more gentle action than the swing rake. It is ideal for moving all classes of wool, especially fine wool.

One of the following methods is used to remove the wool from the scouring bowl up to the nip of the squeeze rollers:

1. Swing rakes
2. Independent harrows, or
3. An elaborate device called a *Belgian lift*. This consists of a lifting plate on to which the wool is deposited. The plate reciprocates to and from the nip of the squeeze rollers, this reciprocating action moving the wool continuously to the rollers.

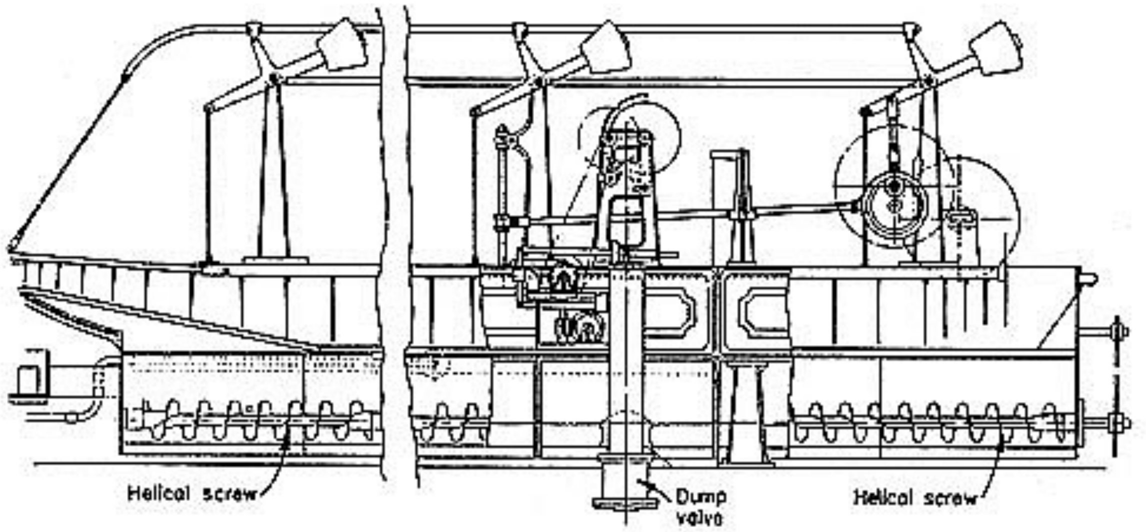
The squeezing rollers have a plain bottom roller and a lapped top roller. The bottom roller can be made from cast iron or steel. Roller lapping is made from wool and synthetic fibres wound on to the roller in sliver form. A sliver is fibres in a rope form without any twist. The lapping absorbs moisture from the wool as it passes between the top and bottom rollers.

During scouring, a lot of sludge sinks to the bottom of the bowl through a false bottom. The sludge is made up of emulsified grease and insoluble dirt. Most of the grease and dirt in the raw wool is removed in the first and second bowl, with less grease and dirt being removed in the second bowl than in the first bowl. To remove the sludge, the first and sometimes the second bowl had self-cleaning mechanisms.

The self-cleaning mechanism was a slowly revolving helical worm gear in the bottom of the bowl. The worm gear ran the length of the bowl. It moved the sludge to a dump valve that opened regularly to get rid of the sludge.

Figure 7.4 shows a self-cleaning bowl with a harrow mechanism for moving the wool.

Figure 7.4 Self-cleaning scour bowl. Source: Wood, 2006.



Scouring was stopped, usually once a week, to thoroughly clean out the self-cleaning bowls. This is still done today on such scouring lines that still operate. Depending on the amount of grease and dirt, cleaning may need to be done more than once a week.

Concentration and temperature of scouring bowls

In the early days, no standard concentrations of scouring liquors existed and the amount of soap and alkali used in the liquor depended on the experience of the scour staff. Considerable skill was needed to avoid damaging the wool (at high temperatures, alkali solutions can damage wool). Operators also had to decide on the liquor ratio of soap and alkali relative to the amount of contaminants in different batches of wool.

For scouring merino wool in a four-bowl scour, Table 7.1 shows the general guidelines used.

Table 7.1 Bowl conditions for soap and soda scouring Merino wool. Source: Wood, 2006.

Bowl	% Bowl Volume of Soap	Alkali	Approx Temp °C	% Grease in Wool
Scour 1	0.5	0.2	52	20
Scour 2	0.5	0.1	52	4
Scour 3	0.2		48	1
Rinse			45	0.5

Note

1. Wool grease melts at about 40 °C, and so the wool grease is removed in all the scour bowls, but mostly in the first bowl.
2. Wool can be seriously damaged in alkaline liquor of pH 11 at 55 °C and above.

A trickle of steam into the bowl was usually enough to keep the temperature constant. The temperature of a large amount of water does not change quickly.

Little development occurred in soap-soda scouring until synthetic detergents came into use in the late 1950s.

Scouring bowl innovations

Various designs of aqueous **jet scours** were produced in Australia in the 1960s. These were aimed at improving the combing performance on conventional machinery. However it was shown that conventional scouring mechanisms could be developed to achieve a similar improvement in processing performance and jet scours did not proceed to commercial systems.

Another innovation, which has enjoyed more success, is the **Fleissner suction drum scouring bowl** (http://www.fleissner.de/main_e.htm). Perforated suction drums are used to transport the wool and also to wash it by means of liquor flow from outside to the inside of the drums. The original design allowed for flexibility in bowl length, ranging from one to three suction drums long. The suction drum design has been successful mainly for high yielding fine wools; however, on dirtier wools cleanliness becomes an issue. The wool acts as a filter for fine dirt, some of which may remain in the wool mat at the exit of the final suction drum. For this reason, hybrid systems have been developed with a combination of suction drum bowls (for grease and suit removal) and rake bowls (for dirt removal) in the scouring line.

The WRONZ comprehensive scouring system

A number of factors influenced the basic design of the system, some being related to existing (and desired) emulsion scouring practices and others arising from the need to improve certain aspects of the process.

The initial design sought to accommodate the following provisions:

1. Scourers should be able to operate their plant economically under a variety of conditions, including: with or without grease recovery; replacing all or part of the first bowl liquor without losing recoverable grease or heat; running the last bowl of the train either as a hot standing rinse or as a cold running rinse and drawing liquor and solids from the bottom of both the main scouring bowl(s) and the side tank(s)
2. Solids should not accumulate in any part of the liquor circulation system except where they can be specifically removed. This necessitated redesigning the side tank
3. Suitable pumps, valves and pipelines should allow suspended solids to flow easily. Purge lines and isolating valves should facilitate rapid clearing or replacement should a blockage or breakdown occur
4. The amount of discharge liquor (flow down) should be metered and should be easily adjustable. All other alterations in liquor flow rates resulting from an adjustment in flow down (except those to and from the heavy solids tanks) should be automatically compensated
5. A wool grease recovery plant, by virtue of its dual role as a grease and dirt removal unit, should be an integral part of the liquor circulation system. This necessitated completely redesigning the two-stage recovery plant with emphasis on ensuring trouble-free operation for long periods while scouring any type of wool
6. Wherever possible, automatic control should be used to remove the decision-making from the bowl minder, transferring this function instead to the plant manager. Other design considerations included: removal of all fibre from liquor flows, recovery of heat from all the hot liquor discharge and eliminating the carry-over of contaminated liquor with the wool.

These design requirements formed the basis for the design of the prototype plant commissioned in August 1972. The plant was installed in conjunction with a new 1.8 metre-wide five-bowl scouring train fabricated throughout in stainless steel.

The WRONZ comprehensive scouring system was at first designed with conventional scouring trains. It was a liquor-handling system that rationalised the scouring process and made the continuous operation both technically feasible and economically desirable.

The system also included a primary effluent treatment by reducing the total volume discharged and flow-balancing the remainder at the same time as it removes settable solids, wool grease and heat.

In this system, first-bowl scouring liquor is withdrawn continuously from the bottom of the bowl (instead of being intermittently discharged as was the convention) and the heavy dirt settles out in a special tank. The settled liquor is heated, passed to a grease centrifuge and then a portion recycled to the first bowl and a portion (able to be measured and thus controlled) discharged to waste via a heat exchanger. As part of the system, all leaks of scouring liquor are avoided and no discharges are made to waste other than heavy dirt from the setting tank or measured 'flow down' via the heat exchanger.

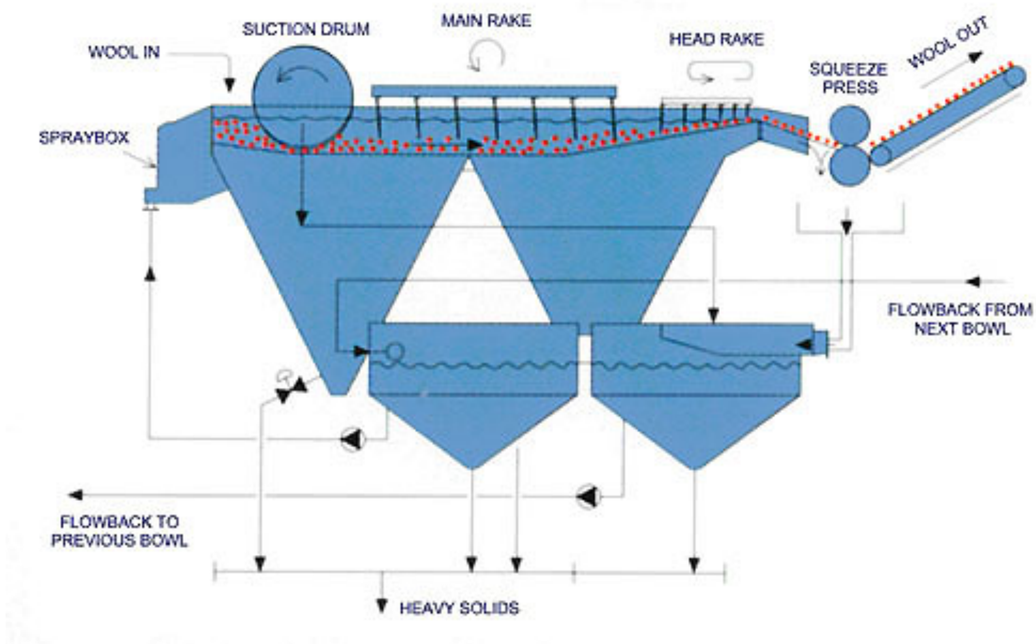
Operation of a scour plant in this way brought about dramatic savings in energy and water used, and benefits in extra wool grease obtained, also a reduction in pollution as more grease is recovered rather than discharged.

Mini-bowl scouring

In 1977, CSIRO released their Lo-Flo process, and this encouraged the wool industry in New Zealand to also use smaller bowls for scouring. They have since become standard for scouring bowl design world-wide.

Figure 7.5 shows a modern, hopper-bottomed mini-bowl design. Hopper-bottomed bowls may be from 1 – 4 hoppers, where each hopper is about 2 metres long. These bowls are essentially self-cleaning and can operate for extended periods, say a week, without having to dump the water in them or clean out the hoppers.

Figure 7.5 Mini-bowl layout. Source: Andar Holdings Ltd. (a).



The wool is fed into the bowl and is submerged and wet out by the suction drum, which is mechanically driven at the required speed. A perforated screen a little below the surface of the water prevents wool from sinking.

Liquor within the scour bowl is circulated from the squeeze press to the spray box by means of the flow-around pump. A heat exchanger may be installed within the spray box or installed separately to heat the liquor between the flow-around pump and the spray box.

The main rake moves the wool through the bowl where it is picked up by the head rake, which in turn delivers it to the drain tray. The squeeze press removes liquor from the wool and then transfers it to the outfeed conveyor for delivery to the next stage in the process.

Water removed at the squeeze press is directed through a flock catcher filter to remove suspended fibres. This water then flows into a side tank where some settling of solids takes place. Recirculated water from the side tank is fed back into the scour bowl via the spray box. Often this is the site of the heat exchanger for heating the bowl water. The water is sprayed on the wool which helps to ensure it is wetted out quickly.

The side tank fulfils other functions. It allows control of the scour bowl water level by providing overflow control and is a reservoir for water returning to the bowl via the spray box.
Mini-bowls are preferred because:

1. They are about one-third the length and volume of conventional bowls
2. Wool is immersed in the liquor for one-sixth of the time it is immersed in conventional bowls
3. The wool is given greater agitation
4. The thickness of the web of wool is about half that in conventional bowls.

Undue felting of the wool usually arises from excess agitation. Mini-bowls do not cause undue felting because the wool is immersed for only a short time. Increased agitation means that the thinner web does not pick up dirt suspended in the scouring liquor. This means cleaner wool.

7.5 Modern scouring of carpet wools and other coarser types

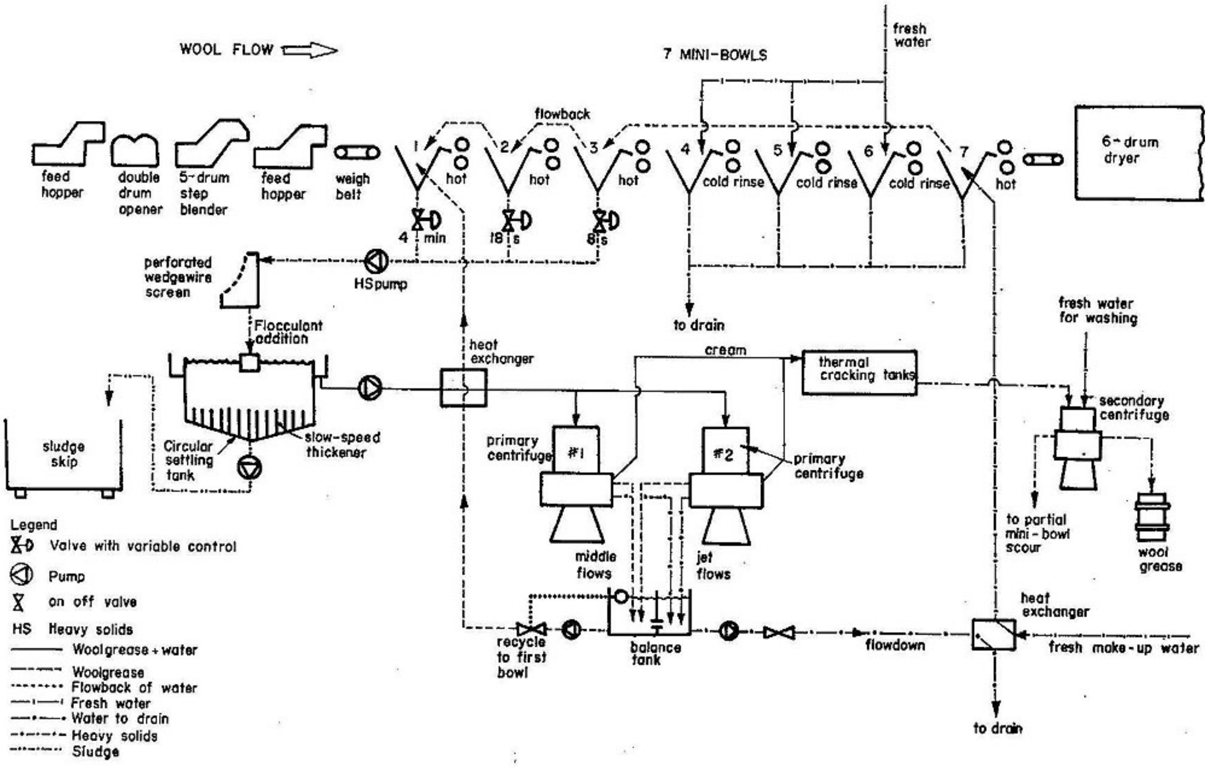
The important technical features of the WRONZ system with mini-bowls are:

1. Draw-off is from the bottom of each bowl only: side-tank flows are completely pumped back to sprays or weir boxes via heat exchangers which enable precise temperature control to be maintained
2. Bowl volumes are small (about 2250 litres/bowl) and the bowls now have close-fitting, easily raised covers which give further savings in energy
3. Fibre removal precedes solids removal, a wedgewire screen usually being employed
4. Solids removal is by gravity settling in either a rectangular heavy solids tank (HST) with baffles and a slow speed stirrer for normal settling duty, or a circular settling tank (CST) with a surface scraper and sludge thickening if flocculate is employed; the sludge level in the CST must be maintained at a certain depth in the tank to allow thickening to take place - an ultrasonic sludge detector is suitable. In a comparatively recent development (1991), WRONZ has introduced hydro cyclones to replace the solids settling tanks
5. Decanter dewatering has been employed on the sludge discharge so as to produce a ‘spadeable’ solid; alternatively the 20-30% slurry can be carted away or included as one of the components in the feed for incineration
6. The clarified flow from either type of settling tank is heated in a remunerative exchanger and passed to a first stage (primary) centrifuge, either a nozzle or self-opening type, both of which allow for discharge of sludge and dirt during operation. The grease emulsion so produced is pumped to specially designed jacketed storage tanks where, under the influence of uniform heat (about 95^{o}C), the emulsion cracks when heated and dirt and water can be run off
7. The flows of degreased liquor from the primary centrifuge are collected in a balance tank which automatically controls the amount of liquor recycled to the first scouring bowl via the regenerative heat exchanger (which cools the recycle flow to scouring temperature)
8. The discharge of effluent is controllable and indicated on a flow meter. This flow down is taken preferentially from the dirtier (jet) discharge of the two flows from the centrifuge by the automatic action of the balance tank. Waste heat is recovered from this flow before final discharge; the important point is that at this stage management can note, select, and control the amount of effluent run to waste or to further effluent treatment; the flow down rate is selected according to wool type and throughput.

Figure 7.6 shows a WRONZ Comprehensive System with seven mini-bowls.
Note these points about Figure 7.6:

1. The times shown below bowls 1, 2, and 3 are the intervals at which the heavy solids are removed from the bowls. For example, the heavy solids are removed from bowl 1 every 4 minutes
2. A flocculent is added to the liquor at the entry to the circular settling tank to separate the wool grease from the rest of the liquor
3. The sludge from the bottom of the circular settling tank is pumped at set times to a rubbish skip, which is emptied daily
4. The *cream* from the primary centrifuges contains 70 - 95% grease.

Figure 7.6 WRONZ Comprehensive Scouring System. Source: Wood, 2006.



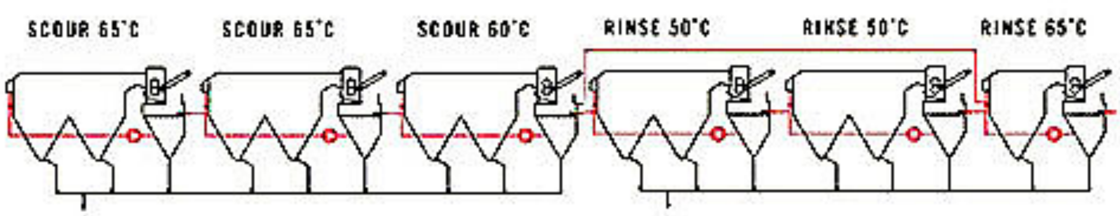
The WRONZ system with mini-bowls was found to give the following benefits compared with the older type system:

1. An increase in wool grease recovery of about 50%
2. Recovery of about 80% heat from the effluent by using heat exchangers
3. Effective effluent treatment before discharge, including:
   (a) maximum removal of heavy solids, fibres, and wool grease, and
   (b) less discharge to about 2 litres/kg of scoured greasy wool
4. Less water used through positive control. A set regulated amount of:
   (a) fresh water enters the bowls, and
   (b) scouring liquor leaves the system
5. Less energy or power is used. With less effluent discharge, less steam is needed to heat the water. Heat recovered from the effluent also saves energy
6. The scouring runs before bowl cleaning are longer. The liquor has a higher detergency with a more effective contaminant removal, and so the bowls need washing out only about once a week. In the old system, the bowls were washed more often
7. Longer runs mean increased production
8. Efficiency is improved and scouring is easier.

The Cardmaster scouring system, manufactured by Andar, is the latest version of the WRONZ Comprehensive Scouring System, with additional enhancements. This system is designed to handle the rigorous demands and high volume processing associated with coarser carding and carpet wools. This system is capable of processing 4,000 – 5,550 kg/h.

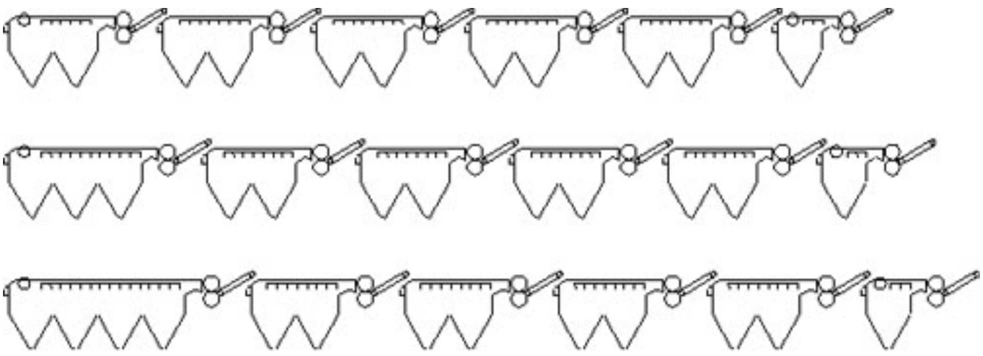
Figure 7.7 shows a typical configuration, with the three scouring bowls and three rinsing bowls.

Figure 7.7 Cardmaster scouring line. Source: Andar Holdings Ltd. (b).



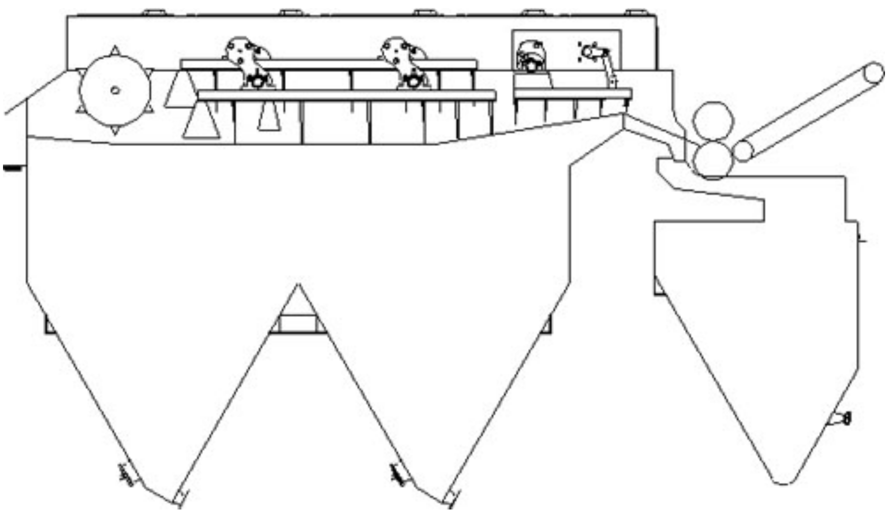
Three bowl configurations are available in the Cardmaster range, as shown in Figure 7.8. These are designed for high yield wools (top), medium yield (55-70%) wools (middle) and low yield wools (bottom). The latter incorporates a long bowl to provide increased residence time and to maximise dirt removal at high throughout rates.

Figure 7.8 Cardmaster configurations for high, medium and low yielding coarse wools. Source: Andar Holdings Ltd. (b).



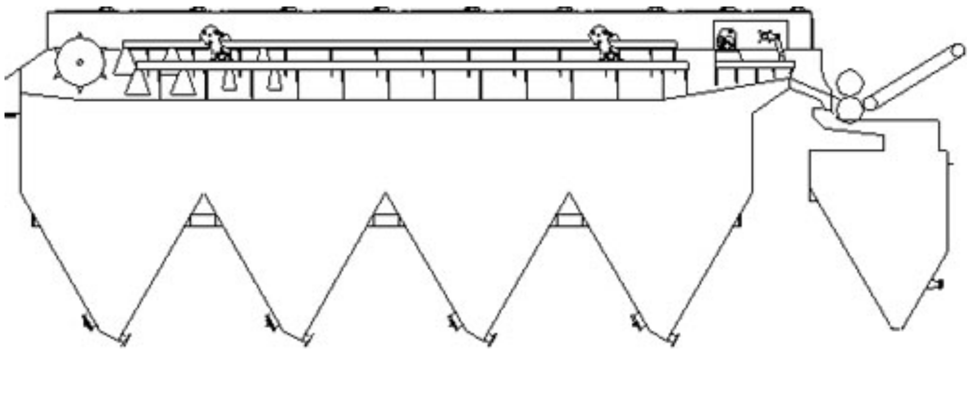
All Cardmaster scouring lines are based on rake action bowls; a two-hopper type is shown in Figure 7.9.

Figure 7.9 Two hopper rake action bowl. Source: Andar Holdings Ltd. (b).



The longer, multi-hopper bowls are designed for low yielding wools. Figure 7.10 shows a 'quad' bowl supplied by Andar.

Figure 7.10 Four hopper rake action scouring bowl. Source: Andar Holdings Ltd. (b).



The amount of wool that a single scour train can process depends on the width of the train – the typical range is from 0.6 – 5 tonnes per hour. The wool passes through the entire plant (scouring, drying and baling) in about 20-30 minutes.

7.6 Modern scouring techniques for fine wools

The sophisticated, multi-stage scouring systems from CSIRO, called Siroscour, incorporate the outcomes of recent research on the ease of removal of the various types of contaminants in greasy wool. Australian wools can be divided into two main types:

a) fleece wools containing high levels of grease, but relatively low levels of suint (wool pH 6.6) and suint,
b) bellies/pieces which are much lower yielding types with high suint levels (wool pH 8.4) and high levels of dirt.

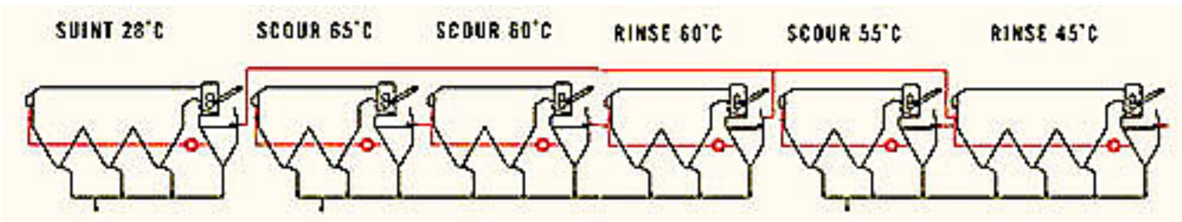
In order to obtain maximum whiteness and cleanliness of the scoured wool, two multi-stage systems are available as options from Andar. The two-stage system, which is the traditional combination of scouring bowls followed by rinse bowls, is suited to fleece wools.

The three-stage system, which is suited to bellies, pieces and oddments, uses a combination of suint, scouring and rinse bowls. Using a suint bowl, dirt and salts are removed, while protecting the fibres from damage or entanglement. This is achieved by ensuring the woolgrease remains on the fibre, i.e. by operating the bowl at a temperature lower than the emulsification point of grease.

The separation of bowl function in both the two-stage and three-stage scouring lines allows improved control of liquor concentrations in the bowls and splits the effluent streams to allow dedicated treatments for each phase. The flow principle is based on a counter current flow, to maximise the re-use of water while ensuring that contaminants are not allowed to flow over the wool mat.

The Andar Topmaster range of scouring lines exemplifies the most modern systems for scouring fine wools (Figure 7.11).

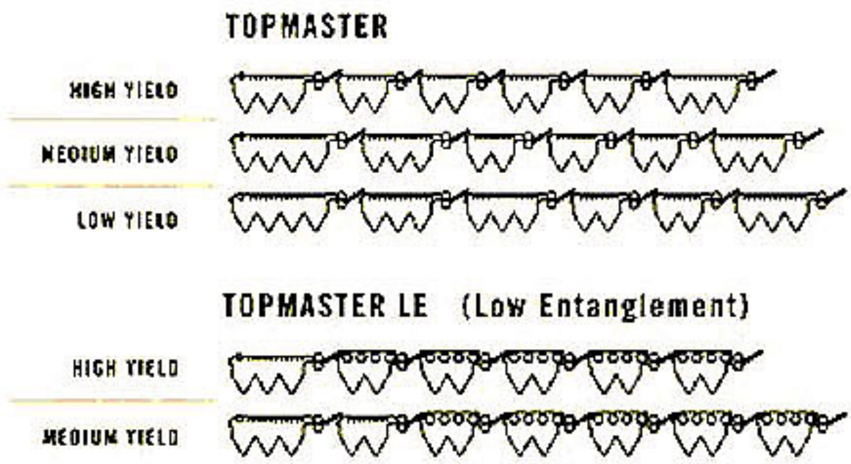
Figure 7.11 Three-stage Topmaster scouring line. Source: Andar Holdings Ltd. (b).



Three different bowl configurations are available in the Topmaster range, as shown in Figure 7.12. These configurations, all based on rake bowls, are designed for:

(a) High yielding wools (top) – the short first bowl can be used as a suint bowl or for scouring
(b) Medium yield – this configuration is designed for fine wools yielding 55-70%; the first bowl can be a suint bowl
(c) Low yield – the first bowl can be a suint bowl.

Figure 7.12 Topmaster and Topmaster LE configurations for fine wool scouring. Source: Andar Holdings Ltd. (b).



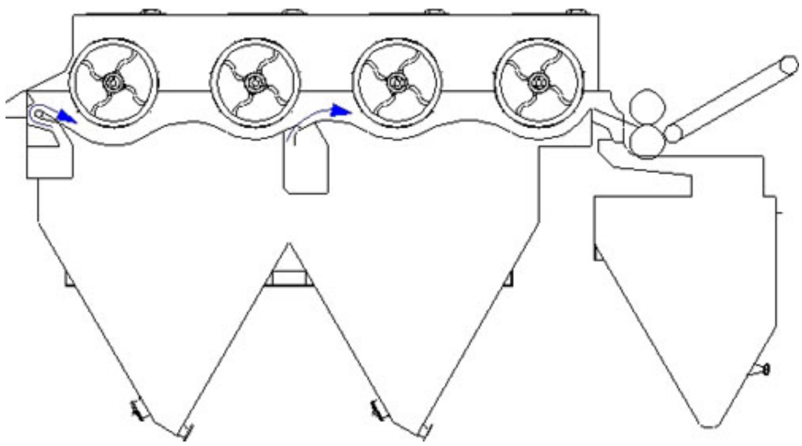
Also shown in Figure 7.12 are the configurations for the Andar Topmaster LE (Low Entanglement) range. Using the most advanced scouring technologies and processes, the fibre entanglement of fine wools (which is of major concern to topmakers) is minimised. Two versions are available:

(a) High yield – designed as a specialist system for topmaking, to provide the highest levels of performance for all fine and superfine types. The six bowl line can include one suint bowl if required

(b) Medium yield – this is a seven bowl system, with two rake action bowls to remove most of the heavy contaminants before entering the suction bowls.

The suction bowl design is shown in Figure 7.13.

Figure 7.13 Suction bowl. Source: Andar Holdings Ltd. (b).



7.7 Industrial trials

Countless industrial trials have been carried out to validate the many improvements in wool scouring technology in the past 30 years. These have been reviewed by a number of authors, including Stewart (Stewart 1988a; 1988b).

Of particular note has been the considerable amount of research that has been conducted to establish the Siroscour system as the dominant process for fine wool scouring, comprehensively reported in a paper presented at the Top-Tech ’96 seminar (Bateup and Christoe 1996). As an example, Table 7.2 is taken from this paper. It shows the results of a trial comparing conventional and three stage scouring, which confirm the superior performance of the latter, both in terms of mean fibre length in the top (as measured by the parameter Hauteur) and the whiteness (Y) of the tops. These are the results sought by scourers of fine wool and they disprove the proposition that better colour can only be achieved at the expense of a more felted product (leading to increased fibre breakage in opening and carding and reduced fibre length in the top). The results in parentheses were obtained with a reduced level of mechanical action in greasy wool opening and in the bowls. This had the desired effect of improving the top length, but with a small reduction in whiteness.

Table 7.2 Comparison of quality outcomes between conventional and three stage scouring. Source: Christoe and Bateup (1996).

	Hauteur (mm)		Whiteness (Y)	
	Conventional	**Three-stage**	**Conventional**	**Three-stage**
Mill A	65.6	67.3	65.1	65.5
CSIRO	68.7	69.1 (70.6)	66.4	67.0 (66.2)

Readings

The following readings are available on CD:

1.Andar Holdings Ltd. Wool Scouring Information, product brochure, New Zealand
2.Andar Holdings Ltd. Technical Data – 3.0 metre width woolscour data sheet, product brochure, New Zealand
3.Andar Holdings Ltd. Scour Comparisons, product brochure, New Zealand
4.Andar Holdings Ltd. Topmaster Production Data, product brochure, New Zealand
5.Andar Holdings Ltd. Topmaster Technical Guidelines, product brochure, New Zealand
6.Barry, S.I., Mercer, G.N., and Marchant, T.R. 2002, *Mathematical Modelling of a Wool Scour Bowl, School of Mathematics and Statistics,* ADFA, UNSW.
7.Christoe J R and Bateup, B O. 1987, ‘Developments in wool scouring: an Australian perspective,’ *Wool Science Review,* vol. 64, pp 25.
8.Stewart, R.G. 1988a, Aqueous and other systems, in: *Woolscouring and Allied Technology,* Caxton Press, Christchurch, New Zealand, ISBN 0-908699-23-9.
9.Stewart, R.G. 1988b, ‘Aqueous scouring as a process”’ in: *Woolscouring and Allied Technology,* Caxton Press, Christchurch, New Zealand, ISBN 0-908699-23-9.

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Summary

The principle objective of woolscouring is to remove as many contaminants as possible from greasy wool, thus delivering the wool in the best possible condition for further processing. This objective may be achieved with different levels of performance and cost by solvent scouring or aqueous scouring. The effectiveness of these two methods is compared in this topic.

An aqueous scouring train comprises a series of wash bowls, rinse bowls and squeeze heads, and is usually integrated with an inline dryer and a woolgrease recovery system. The ‘standard’ modern scouring line for coarser and carpet wools, based on the WRONZ Comprehensive Scouring System, typically comprises three scouring bowls and three rinse bowls. More complex two- and three-stage scouring systems (Siroscour) have been developed in Australia specifically for fine wools.

This topic describes the WRONZ system and Siroscour, as well as the Cardmaster and Topmaster ranges of scouring systems from Andar. The two Andar scouring systems exemplify the most efficient and effective contemporary technologies now available for the scouring of coarse wools and fine wools respectively.

References

Andar Holdings Ltd. (a) Scourmaster – The range of woolscours for superior wool processing, product marketing brochure, New Zealand.

Andar Holdings Ltd. (b). digital images provided by Batchelor, D. Andar Holdings Ltd., New Zealand.

Christoe J.R. and Bateup, B.O. 1996, ‘Siroscour: Study of Technical Innovation,’ *Top-Tech ’96,* p. 419.

Christoe J.R. and Bateup, B.O. 1987, ‘Developments in Wool Scouring – An Australian Perspective,’ *Wool Science Review,* vol. 64, p. 25.

Stewart, R.G. 1988a, Aqueous and other systems, in: *Woolscouring and Allied Technology,* Caxton Press, Christchurch, New Zealand, ISBN 0-908699-23-9.

Stewart, R.G. 1988b, Aqueous scouring as a process, in: *Woolscouring and Allied Technology,* Caxton Press, Christchurch, New Zealand, ISBN 0-908699-23-9.

Glossary of terms

Aqueous process	A process involving the use of water
Carpet wool	Wool from a crossbred sheep, generally coarser than around 33 microns
Centrifuge	The use of a high rotational velocity (high centrifugal force) to cause a liquor to separate into its phases
Cracking	The use of heat to destabilise an emulsion containing woolgrease, thereby making more easy the subsequent separation of wool grease by a centrifuge
Cream	The phase that is richer in the dispersed component, obtained by separating an emulsion (e.g. by centrifuging)
Decanter	Pour off a liquid, leaving the solid material (sediment) behind
Dump	The process of relieving a scouring bowl of its contents
Emulsion	A colloidal suspension where the particles or droplets of one material are dispersed in another material, e.g. milk
Flocculate	Finely divided particles in a suspension amalgamate to form larger particles
Flowdown	Liquor discharged from a scouring bowl

Harrow	A set of rakes moving in unison to move wool along a scouring bowl
Hauteur	A measure of mean fibre length of a sliver or top (in mm)
Heat exchanger	A device in which a flow of warm liquid transfers its heat energy to a flow of cooler liquid
Heavy solids	Another name for sludge
Hydration	Formation of a chemical compound of water with another compound
Hydro-extractor	A machine which applies a high centrifugal force to wet wool to extract a large amount of water
Liquor	The liquid contents of scouring bowl
Mini-bowl	A scouring bowl, shaped somewhat like an inverted pyramid, designed for efficient scouring
Non-polar solvent	A solvent having a symmetrical molecule so that no extremities are charged (positive or negative); has no affinity for water
Polar solvent	A solvent with a molecule having opposite charges at the extremities (has an affinity for water)
Rake	A row of teeth, used to move the wool along a scouring bowl
Sludge	A slushy sediment, the dirt, sand etc. that falls to the bottom of a woolscouring bowl
Soap	The product of a fat, oil or grease reacting with an alkaline liquid such as caustic soda
Solvent	A liquid that is capable of dissolving a material; an organic solvent, as used in solvent scouring dissolves oils, fats and grease
Suint	Dried sweat of the sheep coating the wool fibre, mostly potassium salts
Suint bowl	A bowl which may be optionally be used as the first bowl of a fine wool scour for the removal of dirt and suint before detergent action commences on the grease in the second bowl. It operates at a low temperature, i.e. around 28^{o}C
Topmaking	The conversion of scoured wool into a uniform rope of fibre (a top), by carding, gilling and combing machines; the first half of the worsted processing route for yarn manufacture
Whiteness	A measure of the brightness (as opposed to greyness) of wool; equivalent to the Y tristimulus value from a colorimeter
Woolgrease	Technically, woolgrease is a wax secreted by the sebaceous gland of the sheep and coats the fibre with a thin film. This term is used once it is removed from the wool fibre
Wool yield	The amount of clean fibre in a quantity of greasy wool; the ratio of weight of scoured wool / original weight of greasy wool, expressed as a percentage