Wool Carbonising

1 Carbonising of Wool in Loose Stock Form

Carbonising is the chemical process which is used to remove vegetable matter (VM) from wool. The VM, which may be seeds, burrs, grass etc., is predominantly made up of cellulose, hemicellulose and lignin whereas the wool is principally protein. The carbonising process makes use of the difference in the stability of proteins and cellulose to the effects of mineral acids. Cellulose is made up of carbon, hydrogen and water with a chemical formula of $C_6H_{10}O_5$. It can be seen from the formula that the hydrogen and oxygen are present in the same ratio as they are in water. Therefore, in considering the underlying principle of carbonising, it may be assumed that all the VM consists of carbon and water in certain proportions. If these two substances are separated the latter can be evaporated away leaving the carbon in a brittle form. The most commonly used acid for this purpose is sulphuric acid. In its simplest form, carbonising follows a traditional wool scouring process and consists of acidification, drying, baking, mechanical crushing and dusting, neutralisation and final drying. This basic process of loose wool carbonising has remained essentially unaltered for many years.

Carbonising is primarily used for treating card waste, noils and high VM wools which are destined for subsequent processing via the woollen route. Very little processing of wools for worsted production is carried out. Where the VM content is from medium to low, say a maximum of 2-3%, mechanical removal of the VM is usually adequate with the various stages of carding, gilling and combing in the worsted process being sufficient to produce a speck free top. The machinery used in woollen processing generally cannot accommodate medium to high levels of VM. Low to medium levels of VM can be accommodated if the spun wool is to be processed into a fabric which will subsequently be carbonised in the piece.

In the first half of the 20th century a considerable amount of research was carried out by various workers whose prime aim was to minimise the chemical damage imparted to the wool fibre by the acidic conditions. Various alternatives to sulphuric acid were proposed, such as calcium chloride, hydrochloric acid, aluminium chloride and thionyl chloride to name but a few. Commercial operators have in general, though, stuck with the sulphuric acid process due to its cheapness and ease of control. During the 70s and 80s some fundamental research was being carried out on such topics as acidising conditions, drying and baking, effect of detergents and rapid test procedures at DWI in Aachen as well as in Australia. In more recent times, though, this important area of wool processing has seen no new work published.

1.1 Processing Stages

The conventional technique of wool carbonising has the following basic steps:

a. Scouring of the raw wool with non-ionic detergent.
b. Rinsing.
c. Immersion in a long bowl containing 5-7% (w/v) sulphuric acid, 1-2 g/L detergent at 20-30^{o}C.
d. Double squeezing and/or continuous centrifuging prior to drying.
e. Drying at 60-80^{o}C to a low regain.
f. Baking at 95-120^{o}C to carbonise the VM.
g. Pass through heavy fluted rollers to crush the embrittled VM.
h. Convey to a rotating shaker/de-duster to remove the charred VM dust.
i. Pass through a neutralising bowl usually containing sodium carbonate.
j. Rinsing with a small addition of detergent.
k. Bleaching with hydrogen peroxide at approximately pH 5 with formic acid.
l. Final drying.

The production rate through the process is usually low, typically 500-600 kg/h for an 1800 mm wide line, since sufficient time must elapse for the VM to adsorb the acid from the bowl and for subsequent baking to embrittle the acidified cellulose.

1.2 Recent Developments

As noted earlier very little in the way of research into the carbonising process has been conducted in more recent times. What work that has been done in the latter part of the 20th century is summarised below.

- **Acidising**
  - Stainless steel replaces wood for bowl construction
  - Use of wetting agents to improve and even out uptake of acid
  - Alternative acids (aluminium chloride, HCl, thionyl chloride etc)

- **Moisture removal**
  - High pressure squeezes
  - Double sets of squeeze rollers
  - Continuous centrifuges
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- **Drying/Baking**
  - Lower temperature drying preceding baking to minimise chemical damage
  - Moisture control systems for more even drying and energy conservation
  - Two stage baking

  - Intermediate crushing

- **Burr crushing and dedusting**
  - Multiple stage crushing and step dedusting
- **Neutralisation**
  - pH control
  - Alternative neutralising agents (eg ammonia, ammonium carbonate)

1.3 Typical Problems

Preparation/Scouring
- Degree of opening
- Poor scouring

Acidising
- Yellowing of wool
- Localised damage
- Ineffective carbonising

Moisture Removal
- Poor squeeze efficiency
- Uneven moisture content

Drying and Baking
- Yellowing of wool
- Poor carbonising of VM

Burr Crushing and Dedusting
- Fibre breakage
- Loss of fibre
- Poor crushing
- Poor dedusting

Neutralisation
- Wool pH too low
- Wool pH too high
- Ineffective bleaching

2 Useful Web Links

http://www.wool.com.au/
http://www.andar.co.nz/Products/process/subproc.asp?parentid=27
http://www.austehc.unimelb.edu.au/tia/
http://www.woolwise.com/

3 References/Readings

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