# Aspects of wet wool cleaning

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## Abstract

**Introduction.** The actual problem of the primary wool processing is economical consuming of water and energy resources.

**Materials and methods.** This article contains optimization of the parameters of wool soaking according to the planned experiment using Latin squares. It was determined the technological conditions of wet wool cleaning. Among the factors that affect wool cleaning while soaking, we've also investigated hydraulic kit (ratio water : dry wool), temperature, duration. As a response on changing factors we've chosen refractive index n, the pH of exhaust water.

**Results and discussion.** In the first stage we've determined the impact of hydraulic kit in the range of 10–100, temperature of 20–50 °C and duration of 5–25 minutes. To compare the effect of the studied factors we've normalized values of the factors' levels. Presented equations show that the smaller hydraulic kit soaking, the more extractives are in the water.

In the second stage we've determined the impact of hydraulic kit in a range of 10–90, temperature of 10–30 °C and duration of 2–10 minutes. With the increase in the ratio of water : wool the content of the reduced extractives in waste water is decreased. It was also found that there's a directly proportional linear describing dependence of content of extractives in waste water after soaking on temperature. The higher temperature, the more extractives are removed from the wool to the waste water.

Factors have been ranked according to their influence on the process of wool soaking. The most influential factor that affects removal of extractives is hydraulic kit. Temperature is another influential factor. There are certain rational conditions for extraction of hydrophilic extractives of the wool such as hydraulic kit 60, temperature of 42 °C and duration of 6 min.

**Conclusion.** Rational mode to extract hydrophilic extractives hydrological of the wool is hydraulic kit 60, temperature of 42 °C and duration of 6 min.

## Introduction

The actual problem of the primary wool processing is wool cleaning from the dirt taking into account economical use of water and energy resources, environment protection, and getting the wool suitable for the production of natural fabrics in enterprises of light industry, and wool fat [1-3, 5-7]. Refined oil when taking into account safety indicators [4] could be used in the pharmaceutical, food and cosmetic industries.

There is a classic wool processing which includes dry and wet cleaning. Wet cleaning is carried out with water in three stages: soaking, washing and rinsing. In the first two stages of wet cleaning - soaking and washing - dirt and wool fat are being removed from the wool using the soap-soda solute. Such fat is subsequently used for technical purposes. During wet cleaning the organic and mineral dirt are being removed from the wool. Upon completing the classic process of wet cleaning of the wool fiber they use the following proportions: 100-600 parts of water to one part of dirty wool (hydraulic kit). Output of the dry scoured wool is 40-60% of the original mass.

Wool is a commodity agricultural product. Wool pollution is directly related to the technology of animal housing and keeping it after its cutting. In this article we pay attention to the process of wool soaking. This process is aimed to soak dirt which has been stuck to the fibers and to remove contamination from the fiber.

**The objective of the research** is to investigate the impact of factors on the wool soaking process, to rank factors according to their influence on the process and to determine optimal values of the factors in their selected range.

## Materials and methods

It was determined the technological conditions of wet wool cleaning. To achieve the set objective we've applied mathematical planning of the experiment using the Latin squares. The mathematical planning of the experiment is provided in the Table 1.

**Table 1**

**The mathematical planning of the experiment**

| Hydraulic kit | Temperature, °C | Duration, min. |
|---|---|---|
| 100 | 20 | 15 |
| 10 | 20 | 5 |
| 50 | 20 | 25 |
| 50 | 35 | 5 |
| 100 | 35 | 25 |
| 10 | 35 | 15 |
| 10 | 50 | 25 |
| 50 | 50 | 15 |
| 100 | 50 | 5 |

This experiment plan declares absence of any mid-factorial influences. It foresees a choice of independent factors and use of regression equations of depending repercussion on the factors' change for finding the optimal factor's value in the selected range of its impact on response. Each research of the experiment has been performed in threefold repetition.

Among the factors that affect wool cleaning while soaking, we've also investigated hydraulic kit (ratio water : dry wool), temperature, duration. As a response on changing factors we've chosen refractive index n, the pH of exhaust water.

## Results and discussion

Soaking was performed in two stages with the planning of the experiment and processing of data.

In the first stage we've determined the impact of hydraulic kit in the range of 10–100, temperature of 20–50 °C and duration of 5–25 minutes. Data from the experiment with averaged results (refractive index of waste water and contents of lipid in wool) is provided in the Table 2.

**Table 2**

**Impact of factors during wool soaking on the refractive index of waste water and contents of lipids which have been extracted from the dried wool**

| Hydraulic kit | Temperature, °C | Duration, min. | Refractive index, n | Content of lipids, % |
|---|---|---|---|---|
| 100 | 20 | 15 | 1,3336 | 20,29 |
| 10 | 20 | 5 | 1,3348 | 18,72 |
| 50 | 20 | 25 | 1,3338 | 20,03 |
| 50 | 35 | 5 | 1,3338 | 21,05 |
| 100 | 35 | 25 | 1,3336 | 21,45 |
| 10 | 35 | 15 | 1,3336 | 21,40 |
| 10 | 50 | 25 | 1,3340 | 24,96 |
| 50 | 50 | 15 | 1,3338 | 26,84 |
| 100 | 50 | 5 | 1,3332 | 30,18 |

After soaking not only extractives fall into the water, but also sand, particles of mineral and organic origin. That's why we've filtered the water before determination of the refractive index.

Hydraulic kit and temperature are influential factors, and duration affects the process of soaking the least.

To compare the effect of the studied factors we've normalized values of the factors' levels. The regression equation which approximates impact of the normalized factors on the refractive index of waste water, has the following form:

$$y_n = -\,0{,}0003\ x_1 + 0{,}0002x_2^2 - 0{,}0009x_1 + 0{,}0002\ x_3^2 - 0{,}0007\ x_3 + 4{,}0037,$$

and the influence of factors on the residual content of lipids in wool after soaking is being approximated by the following equation:

$$y_c = 1{,}0154\ x_1 + 1{,}424\ x_2^2 - 2{,}652\ x_2 - 0{,}5213\ x_3 + 65{,}415,$$

where $x_1$ – hydraulic kit; $x_2$ – soaking temperature; $x_3$ – duration of soaking hair.

Presented equations show that the smaller hydraulic kit soaking, the more extractives are in the water. The lower the temperature, the less extractives would be extracted. Experimental data show (Figure 1), that in this planning and coincidence levels of factors in experiments, most of extractives was in the water, which is obtained at a temperature of 42 °C. That means that perhaps at a lower temperature hydrophilic substances will also be extracting from the wool.

Also, the second approximation equation indicates that by increasing content of extractives in waste water we decrease the lipid content in wool. In this case, it seems logical to extract lipid-containing fractions from the waste water.

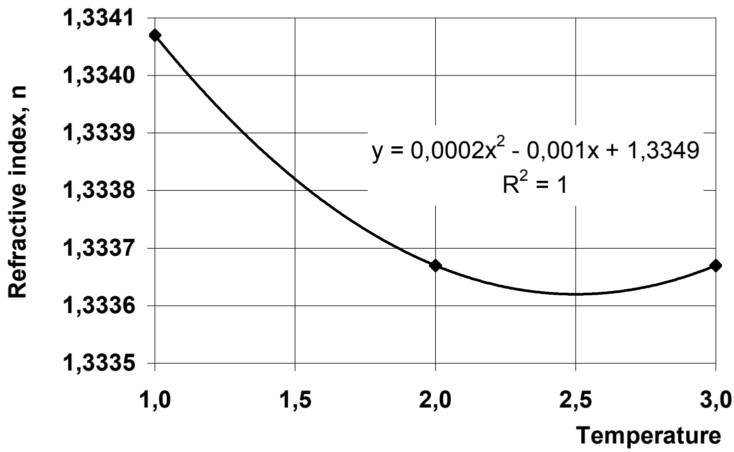


**Figure 1. Effect of temperature on the refractive index of waste water after soaking (fat bottom line is a line which describes the equation)**

In the second stage we've determined the impact of hydraulic kit in a range of 10–90, temperature of 10–30 °C and duration of 2–10 minutes. Data from the experiment with averaged response (refractive index of waste water) is displayed in the Table 3.

**Table 3**

**Effect of factors during wool soaking on the refractive index of waste water**

| Hydraulic kit | Temperature, °C | Duration, min | Refractive index, n | pH |
|---|---|---|---|---|
| 10 | 20 | 10 | 1,3346 | 7,54 |
| 90 | 10 | 6 | 1,3330 | 6,97 |
| 50 | 30 | 2 | 1,3332 | 6,65 |
| 10 | 10 | 2 | 1,3340 | 7,08 |
| 50 | 20 | 6 | 1,3334 | 7,09 |
| 90 | 30 | 10 | 1,3332 | 7,57 |
| 50 | 10 | 10 | 1,3334 | 7,36 |
| 90 | 20 | 2 | 1,3330 | 7,25 |
| 10 | 30 | 6 | 1,3354 | 7,29 |

Regression equation which approximates impact of the normalized factors on the refractive index of waste water, has the following form:

$$y_n = 0{,}0006x_1^2 – 0{,}0032x_1 + 0{,}0004x_2 – 0{,}0004x_3^2 + 0{,}0018\, x_3 + 4{,}0023$$

where $x_1$ – hydraulic kit,
$x_2$ – soaking temperature,
$x_3$ – duration of soaking hair

The most influential factor is the hydraulic kit (Fig. 2). With the increase in the ratio of water : wool the content of the reduced extractives in waste water is decreased. This pattern was observed also in the previous experiment.

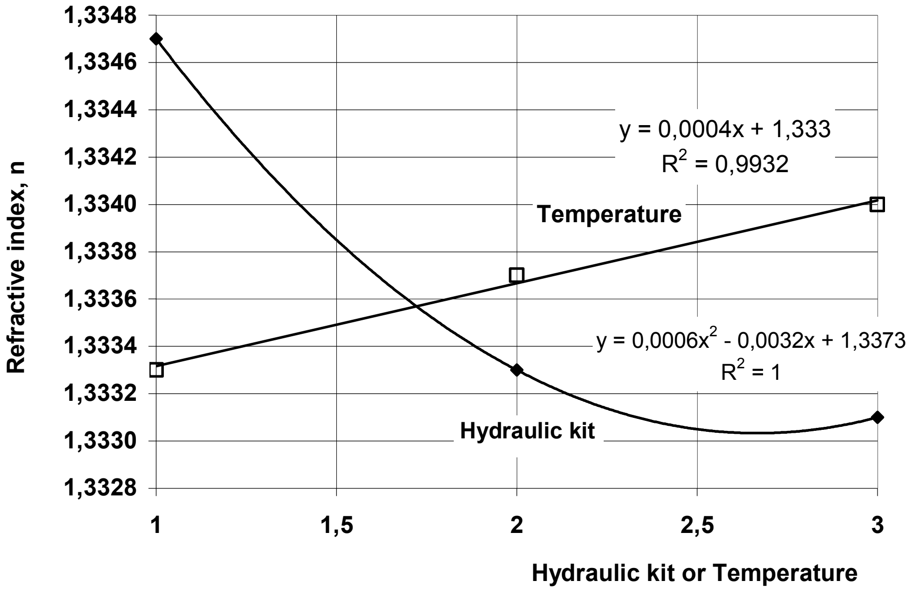


**Figure 2. Effect of hydraulic kit and temperature on the refractive index of waste water**

Graphically we could find (see Figure 2) hydraulic kit values in which the contents of extractive substances in waste water reach saturation (not reduce). This hydraulic kit 2.2 in normalized measurement or 60 parts of water to one part of wool. In order to reduce water consumption in the process of soaking we should reduce hydraulic kit to 10 and perform soaking in several stages (three to six).

It was also found that there's a directly proportional linear describing dependence of content of extractives in waste water after soaking on temperature. The higher temperature, the more extractives are removed from the wool to the waste water. Therefore, decrease in temperature will make it possible to reduce wool pollution by hydrophilic substances. The smallest impact on the removal of extractives has length of soaking in the selected range of variation factor (Figure 3).

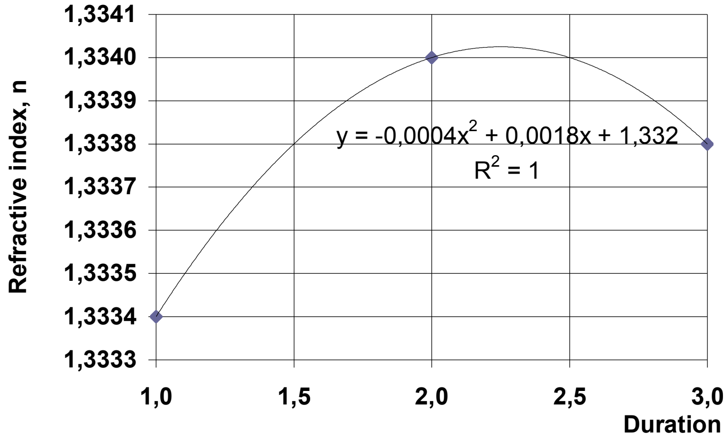


**Figure 3. Impact of duration on the index of refraction of waste water**

For this variation of factors we only needed six minutes for obtaining the highest content of extractives in waste water. Interesting thing is fact of removal of extractives by alkaline reaction, while the pH was not sensitive response to changing factors.

## Conclusion

It was determined the technological conditions of wet wool cleaning. To achieve the set objective we've applied mathematical planning of the experiment using the Latin squares.

Rational mode to extract hydrophilic extractives hydrological of the wool is hydraulic kit 60, temperature of 42 °C and duration of 6 min.

We've performed ranging of factors according to their influence on the process of wool soaking. The most influential factor in the process of extracting extractives is hydraulic kit. Another influential factor is temperature.

Further studies are planned to fulfil the conditions of detection of clean wool fat related substances.

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