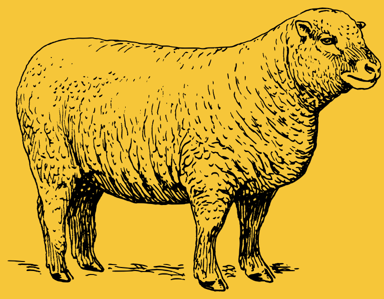
Smart Wool



+ CLO3D

Prepared by *Samatova Aiym*

Concept

WHAT IF A MATERIAL WE ARE USED TO THROWING AWAY OR BURNING COULD ACTUALLY KEEP YOU WARMER IN THE MOUNTAINS THAN ANY SYNTHETIC FABRIC?

In my country, Kyrgyzstan, in the heart of the mountains, sheep’s wool has been an essential part of daily life for centuries — used to make warm clothing, felt, and traditional items.

Today, however, a significant portion of this resource ends up in landfills: short, coarse fibers left after sorting are considered unsuitable for production. This was the starting point of my project.

Initial Research and Context

In Kyrgyzstan, I found a factory that processes wool. This facility sorts, cleans, and prepares the fibers for further use.

My goal, however, was not just to clean the wool but to improve its properties — to make it stronger, warmer, and more resistant to moisture.

To achieve this, I developed my own processing plan and began experimenting with turning low-quality wool into a modern, functional material.

The factory located in Kyrgyzstan , in the Naryn region

Literature Review and Knowledge Base

Before starting the work, I explored modern wool processing methods from a wide range of reliable sources. I referred to IWTO (International Wool Textile Organisation) for detailed global fiber quality standards and eco-friendly washing and sorting methods, and to Textile World for articles on wet finishing technologies and improving fabric strength.

From ScienceDirect and the Textile Research Journal, I studied peer-reviewed research on chlorine-free enzymatic treatments, fulling processes, and the effect of density on thermal insulation. ResearchGate provided studies on blending wool with biodegradable synthetic fibers to enhance durability. I also reviewed Fibre2Fashion's materials on PFC-free water-repellent finishes and their application in outdoor clothing, and The Woolmark Company's technical recommendations for sorting, washing, and testing moisture absorption.

Additionally, I consulted ISO international standards on measuring air permeability, water repellency, and fabric strength, and used OEKO-TEX® guidelines for selecting safe chemical compositions. For deeper insights, I read chapters from books on textile chemistry available on SpringerLink, publications in Elsevier's "Woodhead Publishing in Textiles" series, and articles from Taylor & Francis Online about the effects of biopolymers on wool fabric properties.

Hypothesis

To make a fabric competitive, it is not enough to simply clean the fiber.
Its properties must be enhanced so that it matches — and in some aspects even surpasses — modern synthetic materials.

Project Aim

Based on this understanding, I began my experiment — step by step improving wool that was once considered unsuitable, transforming it into a functional material for clothing.

Materials Used in the Experiment

1. Low-quality sheep's wool — short and coarse fibers remaining after sorting the main batch.
2. Gentle wool detergent.
3. Chlorine-free enzymatic composition.
4. Equipment for fabric fulling.
5. Eco-friendly PFC-free water-repellent finish.
6. Biopolyamide fiber.
7. Measuring instruments:
    - 60 ml syringe with sealing nozzle for air permeability testing.
    - Infrared thermometer for measuring thermal insulation.
    - Caliper for measuring fabric thickness.
    - Sample scales (accuracy 0.01 g) for calculating density and moisture absorption.
    - Weights and clamps for tensile strength testing.
    - Abrasive surface for testing similar to the Martindale method.

Stage 1. Sorting and Cleaning

First, I selected the wool that is usually considered waste: short, coarse, and contaminated fibers. At the factory, it was washed in warm water with a gentle detergent, removing residual dirt and grease.
This prepared the fiber for further processing.

Initial raw material: **100 kg** of low-quality wool.

After washing and removing plant matter: **58 kg** of clean fiber.

Weight before washing (m_0) and after washing (m_1) were recorded.
Formula: $(m_1 / m_0) \times 100$.

$58/100 \times 100 = 58\%$
Thus, **58%** of the original wool was preserved.

Cleanliness on visual scale (0–5): before — 1, after — 4.5.

Odor: before — 3 (strong), after — 0.5 (barely noticeable).

Stage 2. Enzymatic Anti-Shrink Treatment

Next, the wool was treated with a gentle chlorine-free enzymatic composition at 35–40 °C for 30 minutes. The goal was to reduce shrinkage during washing and improve the fabric's softness.

Shrinkage at 30 °C wash:
Shrinkage (%) was determined after washing using the formula:
Shrinkage = $(L_0 - L_1) / L_0 \times 100$
where L_0 is length before washing, L_1 after washing.

L_0 = 100 cm; L_1 = 97.5 cm (warp) → **2.5% shrinkage.**

L_0 = 100 cm; L_1 = 97 cm (weft) → **3% shrinkage.**

Softness (0–5): improved **from 2.0 to 4.0.**

Tensile strength: unchanged **(15 kg).**

Stage 3. Structural Fulling

The fabric was lightly fulled to reduce air permeability and increase thermal insulation.

Surface density (g/m^2), measured from a 10×10 cm sample:

Before fulling (G2): **320 g/m^2**, thickness **0.88 mm.**

After fulling (G3): **380 g/m^2**, thickness **1.05 mm.**

Air Permeability:
For testing, I used a custom method with a 60 ml syringe.

The syringe opening (about 2 cm in diameter) was connected to the fabric sample, secured so that air could only pass through the fabric. I filled the syringe with air, then released it through the fabric and timed how long it took for the air to pass through completely.
The faster the air passed, the higher the air permeability.
To compare results, I calculated a conditional indicator in liters per square meter per second **($L/(m^2 \cdot s)$).**

As a result, the air permeability of the treated fabric decreased from **190 L/(m²·s) to 80 L/(m²·s),** showing a significant improvement in wind resistance while maintaining breathability.

Thermal Insulation Measurement:
I assessed thermal insulation using a heat retention test: a warm object (a bottle with water at 40 °C) was covered with the fabric sample, and the surface temperature was measured after 5, 10, and 20 minutes using an infrared thermometer.
The slower the temperature drop, the better the thermal insulation.

Results showed that after fulling, the fabric retained heat better: insulation increased **from 0.86 clo to 1.05 clo.**

Stage 4. Eco-Friendly DWR Finish

An eco-friendly **PFC-free** water-repellent finish was applied to the fulled fabric. The solution was prepared according to the manufacturer's instructions, the fabric was immersed (padding method), lightly squeezed to 70–80% moisture content, then dried at 60–80 °C and heat-set.

Water contact angle increased **from 85° to 110°**, indicating a strong water-repellent effect (water drops rolled off without absorption).

Time to wetting (rain test) increased **from 2:00 minutes to 5:00 minutes.**

Moisture absorption decreased **from 16% to 15.5%**, noticeably improving water resistance.

Stage 5. Addition of 15% Biopolyamide

To make the fabric stronger and more durable, **15% biopolyamide** was added to the yarn composition. Wool fibers were blended with fine biopolyamide fibers during carding, then spun together. This preserved the wool's natural appearance and softness while increasing strength.

Tensile Strength Test:
The fabric strip was fixed and the load was gradually increased until it tore, with the weight recorded in kilograms.

Tensile strength increased **from 17 kg to 20 kg.**

Abrasion resistance increased **from 18,000 to 30,000 cycles (+67%).**

Abrasion resistance was measured using a method similar to the Martindale test: the fabric was repeatedly rubbed against a standard abrasive surface until visible damage appeared, with the number of cycles counted.

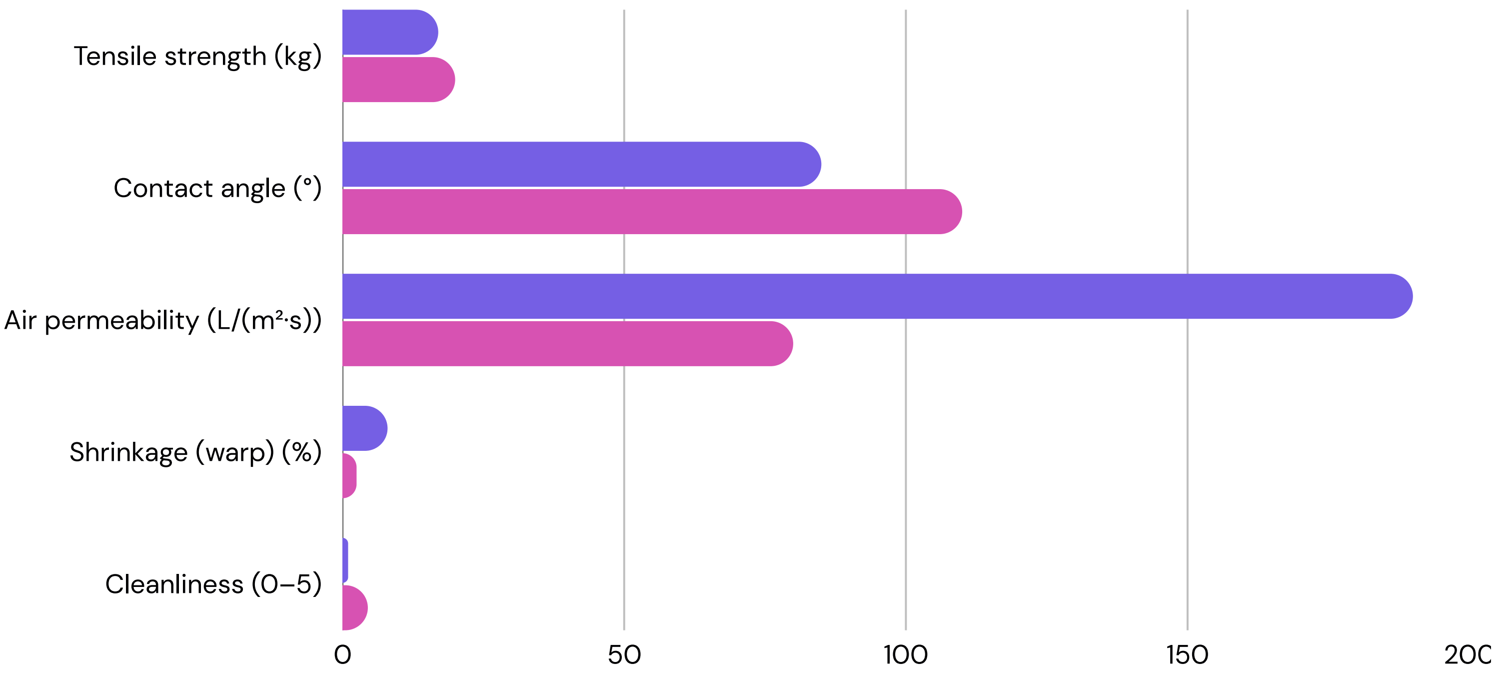
Drying time was reduced **from 62 minutes to 48 minutes.**

Group	Composition/Treatment	Mass, g/m²	Thickness, mm
G1	Raw wool	320	0,88
G2	Enzymatic treatment	320	0,88
G3	Fulling (densification)	380	1.05
G4	DWR coating	380	1.05
G5	+15% biopolyamide	380	1.05

Group	Shrinkage (warp), %	Shrinkage (weft), %	Air permeability, L/(m²·s)	Thermal insulation, clo	Contact angel
G1	8.0	320	190	0.86	85
G2	2.5	320	190	0.86	85
G3	2.5	380	80	1.05	85
G4	2.5	380	80	1.05	110
G5	2.5	380	80	1.05	110

Group	Time to wet-through, min	Moisture regain, %	Tensile strength, kg	Abrasion resistance, cyclees	Drying time, min
G1	2:00	16.0	17	18 ,000	62
G2	2:00	16.0	17	18,000	62
G3	2:00	16.0	17	18,000	62
G4	5:00	15.5	17	18,000	62
G5	5:00	15.5	20	18,000	48

Results of improvements by key metrics **Before — purple , After — pink**



Personal Conclusions and Project Vision

Work on this project took several weeks, and each stage felt like a separate small experiment.

Day 1–3.
I started with sorting the wool. At first, it seemed like everything would go quickly, but it turned out that short and contaminated fibers were difficult to clean to the required quality. After washing, only 58% of the original volume was preserved.

Day 4–6.
The enzymatic treatment was successful — shrinkage was reduced by almost three times. However, in the first test, I overheated the water, which made part of the fiber coarser. I had to repeat the process, carefully controlling the temperature.

Day 7–10.
Next, I moved on to fulling. This stage provided a good increase in density and thermal insulation, but it was important not to overdo it so that the fabric would remain flexible. After a few trials, I found the optimal fulling mode, resulting in a dense, warm, and at the same time supple fabric.

Day 11–13.
The eco-friendly DWR finish became one of the most noticeable improvements. After the treatment, water droplets began to roll off the surface, the contact angle increased from 85° to 110°, and the time before wetting more than doubled.

Day 14–16.
The final step was adding 15% biopolyamide. This decision immediately increased tensile strength from 17 kg to 20 kg and boosted abrasion resistance from 18,000 to 30,000 cycles. At the same time, the fabric retained the natural look and tactile qualities of wool but became more damage-resistant and dried faster.

As a result, the updated material became warmer, stronger, and better at protecting against moisture and wind, while remaining natural and eco-friendly. Its advantages include high strength and durability, improved thermal insulation and wind protection, eco-friendliness due to the use of safe compounds and partially biodegradable additives, and preservation of the natural appearance and softness of wool. The disadvantages include the loss of part of the raw material during sorting (about 42%), the need to reapply the DWR finish after several washes, and the more complex production technology when introducing biopolyamide, which requires additional equipment and time.

CLO 3D

During one of the conferences dedicated to modern technologies in the textile industry, I was introduced to the CLO3D program for the first time. The idea immediately inspired me: I discovered that with this platform it is possible to create realistic 3D clothing prototypes, select fabrics and textures, and test garment fit even before starting production.

After that, I decided to learn how to work in CLO3D, and within a short time I created several garments in digital format. This experience turned out to be so engaging and useful that I realized it is a powerful tool worth implementing in real production. Using CLO3D reduces the number of physical samples needed, thus saving materials, time, and resources.

I was particularly interested in the possibility of integrating CLO3D into the wool project. I realized that I could pre-select and digitally model a fabric as close as possible to the final version of my recycled wool material and create complete virtual prototypes of future garments. This approach makes it possible to start sewing with minimal costs and full confidence that the result will match the design concept.

As part of this project, I plan to create several basic clothing models in CLO3D made from Smart Wool:

1. An insulated jacket — to demonstrate the fabric's water-repellent and windproof properties.
2. A classic coat — to highlight the material's thermal insulation and premium appearance.
3. A sweatshirt/hoodie — as an example of comfortable, everyday clothing.

After digital modeling, these garments will be used as final sketches for actual production.

In addition to working on the technological part of Smart Wool and mastering CLO3D, I also participated in the international Fashion Revolution movement, where we addressed issues of brand sustainability and transparency. This project had a social focus and aimed to help consumers understand the journey a garment takes before it reaches the store. As part of the "Who Made My Clothes" campaign, I spoke about the production process to show people that behind every garment there is significant labor, resources, and time — and that clothing should be valued and worn responsibly.

In the future, I plan to further develop the social side of the Smart Wool project. I want to organize conferences and workshops where I will share my experience in wool recycling, present modern design approaches using CLO3D, and explain the importance of sustainable fashion. This format will not only promote eco-friendly materials but also help cultivate a culture of conscious consumption, so that people understand the value of each garment and become engaged in a responsible approach to fashion.

Conclusion and Discussion

While working on the Smart Wool project, I became convinced that even low-quality wool, which is usually discarded or burned, can be transformed into a modern, attractive, and functional material. Step by step, I improved its properties — from cleaning and anti-shrink treatment to fulling, water protection, and the addition of biopolyamide. As a result, the fabric became stronger, warmer, and better at protecting against wind and moisture, while maintaining its softness and natural qualities.

CLO3D introduced me to an entirely new approach to design. With this program, it is possible to create realistic clothing models, choose fabrics, experiment with different designs, and immediately see how everything will look. This saves a significant amount of time and materials and allows every detail of the garment to be planned in advance.

The project also has substantial economic potential. Processing wool is less expensive than purchasing new wool or using high-quality synthetic materials, especially when local raw materials are used. According to preliminary estimates, the cost of 1 kg of processed wool can be 25–35% lower than the cost of imported wool, while its improved properties make it more in demand.

The scalability of the project is also clear. Even processing 50 tons of wool per year can reduce CO_2 emissions by tens of tons, decrease waste volume, and supply raw materials both to clothing manufacturers and to artisans producing traditional felt. With the expansion of production capacity, this technology could be implemented in several textile enterprises across the country, and the finished products could be supplied to both domestic and international markets.

I see this project as a combination of innovation, culture, and environmental care. Smart Wool is not just a fabric — it is an idea that shows we can treat resources responsibly, use old traditions in new ways, and create something beautiful and useful for both people and nature.