Combined Denim Washing Process

Save Time, Energy and Water without Sacrificing Quality

By Anne Merete Nielsen, Senior Life Cycle Economist, Novozymes

TODAY THE MAJORITY of denim garments are abraded using enzymes or a combination of enzymes and pumice stones. A new wash processing concept from Novozymes, called Novozymes Denimax® Core, makes it possible to integrate the abrasion process and the preceding desizing process – with abrasion results equal to or better than conventional processing. This article assesses the environmental impacts of moving from traditional enzymatic denim washing processing to the new, combined denim wash process.

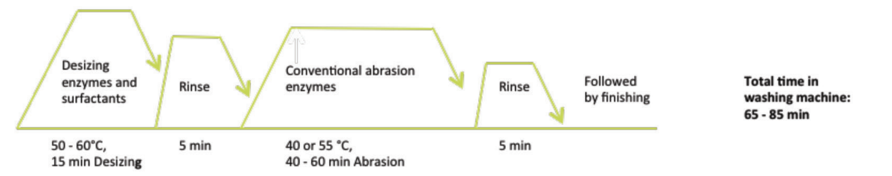

Figure 1: Traditional denim wash process flow chart

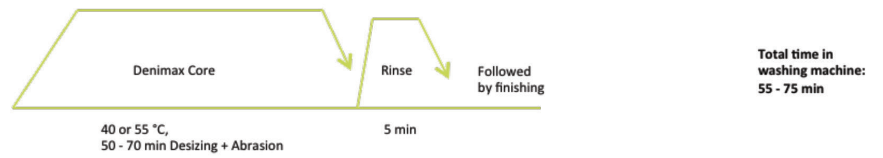

Figure 2: Combined denim wash process flow chart


With Novozymes Denimax Core (Top) there is no detriment to quality or the abrasion effect compared to conventional abrasion (Bottom).

Methodology

The study is based on the life-cycle assessment principles of ISO 14040, where all important processes from raw material extraction up to disposal are included. Environmental impacts are calculated using the CML 2000 characterisation method. Data for the study is provided by Novozymes industry specialists.

All calculations are performed with reference to one ton of denim fabric after abrasion.

The time and temperatures of the traditional process and the new, combined process are shown in Figures 1 and 2. A switch from any of the traditional processes to the combined process will lead to heat savings, due to reduced process temperature, and reduced electricity use, due to reduced process time. It will also reduce water usage.

This article assesses one environmental impact indicator and one indicator of resources:

- Climate change (CO_2 emissions) with reference to electricity, heat and chemical saving
- Use of freshwater resources

Electricity supply

When process time is reduced, the laundry saves electricity. The environmental impact of this savings depends upon what power supply is used. To identify the affected power supply, an analysis of the local regulation as well as local energy production economy must be performed. When electricity is drawn from a public grid, the affected power supply will most likely be the most economically feasible energy supply that is not constrained by physical or political reasons.

This article calculates for three electricity supply scenarios:

1. Nuclear power
2. Power based on natural gas
3. Power based on hard coal

Heat supply

Heat used at the textile laundry is typically based on coal, oil, natural gas or wood chips. All four types of heat supply are included in scenarios in the calculations below.

Inventory

Electricity savings

Process time is reduced from 65-85 minutes to 55-75 minutes (see Figures 1 and 2). Both traditional and combined processes are performed in a machine with an assumed electricity consumption of 22kW per 200kg garment. The electricity savings can thus be calculated:

Table 1: Heat savings due to temperature reduction when switching from the traditional denim wash process to the combined denim wash process. Calculation for textile laundries with traditional denim wash process at 50°C and 60°C.

	Traditional process 50 °C			**Traditional process: 60 °C**		
Goods to liquor ratio / Temperature of incoming water(°C)	1:5	1:10	1:15	1:5	1:10	1:15
5	0.94 GJ	1.9 GJ	2.8 GJ	1.2 GJ	2.3 GJ	3.4 GJ
10	0.84 GJ	1.7 GJ	2.5 GJ	1.0 GJ	2.1 GJ	3.1 GJ
20	0.63 GJ	1.3 GJ	1.9 GJ	0.84 GJ	1.7 GJ	2.5 GJ

Table 2: Chemical ingredient consumption and saved amount in traditional denim wash process and combined denim wash process. All data are in kg per ton of denim fabric.

Ingredient	**Traditional process**		Combined denim wash process
	With amylase enzyme	With pre-wash surfactant	
Amylase enzyme	20	0	0
Cellulase enzyme	20	20	0
Surfactant for desizing (fatty acid ethoxylates)	0	20	0
Denimax® Core	0	0	20
Dispersing agent	5	5	5
Detergent	5	5	5
Lubricant	2	2	2
Antifoamer	1	1	1
Acetic acid	4	4	4

Table 3: Reduced emissions of CO_2 due to electricity savings by the combined denim wash process. Emission reductions are calculated for three different electricity sources.

Electricity source	**Contribution to Climate Change**
Nuclear power	0.23 kg CO_2e/ton fabric
Natural gas	12 kg CO_2e/ton fabric
Hard coal	22 kg CO_2e/ton fabric

•(65 – 55) minutes / 60 minutes/hour * 22 kW / 200 kg garment = 18.3 kWh per ton garment

Heat savings

When the combined denim wash process is introduced, one heated bath (50 – 60°C) is eliminated. Given an ambient water temperature of 20°C and a liquor ratio of 1:10, the heat savings can be calculated:

•4.18 MJ/(ton*°C) * (50 – 20°C) * 10 ton/ton denim fabric = 1300 MJ

In Table 1, the heat savings are calculated for alternative ambient water temperatures and liquor ratios.

Table 1 shows that realistic heat savings when the combined denim wash process is introduced are in the range of 0.6 – 3.4 GJ per ton denim fabric. This estimate is considered conservative, because heat loss from the machinery and heat transmission system is not included.

Some chemicals and enzyme products are added and other chemicals are saved when the sustainable process replaces the traditional process.

Table 2 shows that only few inputs are changed when a textile laundry switches to the combined denim wash process. The combined process adds 20kg of the new Denimax Core compared to either traditional process; this saves either 20kg amylase and 20kg cellulase or 20kg cellulase and 20kg surfactant.

These saved and added chemicals are estimated to have an insignificant impact in terms of climate change, eutrophication, etc. However, when 20kg surfactant are saved, it is likely that the quality of the wastewater from the process is better and requires less treatment. A closer study of the degradation and toxicity of the exact inputs is necessary to say this with certainty.

Results

Electricity savings

Electricity savings are shown in Table 3.

Heat savings

The potential CO_2 reduction of the combined denim wash process is calculated for the four different fuel types in table 4 (Page 18). The minimum estimate refers to the situation where the combined denim wash process is introduced in a textile laundry where the desizing step is traditionally performed at 50°C, the machinery has a goods to liquor ratio of 1:5, and the ambient water temperature is 20°C. The maximum estimate refers to a situation where the process is introduced in a textile laundry where the desizing step is traditionally performed at 60°C, the machinery has a

Table 4: CO_2 emissions from heat supply based on different fuel types. Data are per ton of denim fabric .

Heat fuel scenario	**kg of CO_2 eq emissions**	
	Minimum	**Maximum**
Wood chips	3	16
Natural gas	47	250
Oil	57	310
Hard coal	82	440

Table 5: Saved energy and the corresponding greenhouse gas savings when a textile laundry shifts from traditional enzymatic denim treatment to the combined denim wash process. All data are per 1 ton of denim fabric after abrasion.

Affected inputs	**Amounts**	**Greenhouse gas savings**	
		Minimum	**Maximum**
		kg CO_2e	kg CO_2e
Saved electricity	18 kWh	0.23	22
Saved heat	0.63 – 3.4 GJ	3	440
Changed inputs (chemicals/enzyme products)	--	Negligible	Negligible
Total		3.2	460

goods to liquor ratio of 1:15 and the ambient water temperature is 5ºC. Higher ambient water temperature will lead to lower CO_2 reductions, whereas higher liquor ratios will lead to higher CO_2 reductions.

Fresh water savings

When 2 baths are saved in the combined denim wash process and the goods to liquor ratio of the machinery is assumed to be 1:10, the saved process water can be calculated by:

- 2 * 10 ton of water/ton denim fabric = 20 ton water per ton denim fabric

Discussion

This study does not include quantified assessment of other environmental impact categories than climate change and freshwater use. However, further benefits can be assumed in terms of other environmental impact categories, such as acidification, eutrophication and photochemical oxidation. Reductions in these impact categories are likely, due to the energy savings.

Conclusion

The new, combined denim wash process has potential environmental benefits. No possible environmental problems were identified.

Water: Savings of 20 tons process water per ton denim fabric. This equals 50% of the water used for desizing and abrasion in the traditional process .

Climate change (CO_2): Savings of 3 – 460 kg CO_2 eq. per ton denim fabric, depending on the energy source of the single textile laundry as well as the energy politics in the region. Heat use is reduced by 50% and electricity use is reduced by 12-15% .

In the high estimate it is assumed that saved electricity will lead to decreased production at a coal-based power plant, and that the saved heat will lead to less combustion of coal. In the low estimate, it is assumed that the saved electricity and heat will lead to a reduced production of nuclear power and woodchips. A closer study of energy politics in the region of the textile laundry would be necessary to determine what kind of energy production is actually affected by a reduced need for heat and power.

The environmental benefits of shifting to the combined denim wash process can be expected to be even larger for textile laundries that shift from pumice stone treatment: on top of the environmental benefits shown in Table 5, large amounts of pumice stone waste and water use can be avoided.

The saved and added chemicals are likely to improve the quality of the wastewater from the process, meaning that less wastewater treatment is necessary. A closer study of the degradation and toxicity of the exact inputs is necessary to say this with certainty.

References & Notes

1 See discussions in Weidema B (2003). Market information in life cycle assessments; Technical report, Danish

2 Following EcoInvent processes have been used for this calculation:

1.Electricity, nuclear power, at power plant/US S

2.Electricity, natural gas, at power plant/US S

3.Electricity, hard coal, at power plant/US S

These processes are considered realistic, yet conservative estimates of the CO_2 savings, because they don't include transmission loss.

3. Following EcoInvent processes are used for this calculation:

1.Heat, mixed chips from forest, at furnace 1000kW/CH S

2.Heat, light fuel oil, at furnace, 1 MW/RER S

3.Heat, natural gas, at boiler atm. low NOx condensing non-modulating <100 kW/RER S

4.Heat, hard coal, at industrial furnace 1-10 MW/RER S

4. When the traditional process has two baths and two rinses, and the combined process has one bath and one rinse, 50 % of the water use is saved.

5. When the traditional process has two heated baths of 50-60 ºC and 40-55 ºC respectively, and the first one is avoided, the heat savings is approximately cut in half.

6. When processing time is reduced from 85 or 65 minutes to 75 or 55 minutes, the electricity savings can be calculated: 10/85 = 12% or 10/65 = 15%.