COST ASSESSMENT OF AN ALTERNATIVE TANNING PROCESS, USING A NOVEL PRE-TANNING RESIN

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Abstract. This paper presents an alternative technology for bovine leather tanning, by using an oligomeric tanning agent based on a benzenesulfonate melamine-formaldehyde resin (BSMF), in an additional pre-tanning step. The proposed technology improves the economic yield of processing, especially in small and medium size tanneries. The cost study was carried out starting from the pre-tanning technology that was performed at pilot scale. Evaluation of total cost showed that, when the novel tanning process is applied, the variable expenses depending on the tannery production capacity can balance the cost increase due to the fixed expenses, if the tanning plant applies the novel process 27 times per year at least, instead of applying the conventional one.

Key words: melamine-formaldehyde resin, pre-tanning, leather processing cost.

1. Introduction

In the course of time, the leather and fur industry identified four issues with high impact on the economic yield of the chemical processing of hides and furs at industrial scale (European Commission, 2003): (a) the consumptions of

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processing chemicals and auxiliaries; (b) the industrial water consumption; (c) the overall energy consumption and (d) the pollution control requirements.

Lately, leather industry and related industries (mainly the leather chemicals and auxiliaries industry) were focused on the environmental issue, namely the prevention and abatement of pollution and the decrease of the pollution treatment costs.

Chrome tanning is the most common type of tanning worldwide; chrome basic salts meet the quality requirements for “tanned leather” at the highest degree. On the other hand, chrome is one of the main pollutants in leather processing. Because chrome basic salts cannot be entirely replaced by any other tanning agent, efforts have been made to change the tanning technologies by reducing the chrome input in the tanning floats (Fierro & Nyer, 2007; Mereuță et al., 2003).

The reduction of chrome use in the tanning process and the reduction of the chrome content of chrome leather wastes can be attained if splitting and shaving are performed as early as possible in the overall process flow.

Splitting can be done on leather in pelt state, but the shaving operation necessarily requires a certain stiffness of the in-process leather, which can be achieved by a pre-tanning step. Various pre-tanning agents are in current use. Promising results were reported when a benzenesulfonate melamine-formaldehyde resin with oligomeric structure was used as pre-tanning agent. Even if the insertion of a pre-tanning stage complicates the overall process, the modified technology has certain technological and environmental benefits over the conventional chrome tanning technology. A comparison between the conventional and the alternative tanning technologies is given in Fig. 1 (Deselnicu et al., 2005; Pruneanu et al., 2010; Pruneanu et al., 2009; Maier et al., 2008; Maier et al., 2009; Pruneanu et al., 2011).

The main effects of the pre-tanning operation are: (1) significant savings of chrome salts and (2) a significant reduction of the chrome content of the shaving wastes, which have a joint positive effect on the environmental impact of the overall process.

This paper is a technical-economical assessment of an alternative tanning technology, modified by the insertion of a pre-tanning operation, with a melamine-formaldehyde oligomeric resin, compared with the conventional chrome tanning process.

2. Comparative Cost Estimation of the Conventional and Modified Tanning Processes

Cost study of the alternative tanning process was performed starting from the pre-tanning technology, as elaborated and performed at pilot scale.
Materials and energy inputs and associated cost for the conventional tanning process and the novel technology that includes a pre-tanning step are comparatively presented in Figs. 2 and 3.

In both cases, the total cost is computed as the sum between a fixed term that accounts for the energy input and a variable term that accounts mainly for the chemical auxiliaries’ consumptions. The variable term depends on the weight of the pelt batch, G.
One can see that both the fixed and the variable costs are higher when the alternative technology is applied. The cost rise is due to: (1) the presence of extra operations in the overall process, compared with the conventional tanning process; (2) higher water consumptions, and (3) increased number and amounts of the processing chemicals and auxiliaries.

Fig. 2 – Chemicals and energy inputs and corresponding expenses for the conventional chrome tanning process.
Fig. 3 – Chemicals and energy inputs and corresponding expenses for the modified tanning process.

3. Results and Discussions

When the overall alternative process is considered, a shift in the variable costs occurs, which makes the novel technology attractive from an economical point of view. The main reasons for this reversal are:

– lower cost for wastewater treatment; the novel technology considerably reduces the pollution charge because float exhaustion is higher and the residual pollutants, which belong to the organic class, are easily removable by precipitation or biodegradation; the residual chrome content in the spent float of the post-tanning operation decreased by three times;
elimination of chrome shavings resulted from the shaving after chrome tanning; when the modified technology is applied, shavings contain organic chemical species only, which makes them biodegradable and lowers the disposal costs. Moreover, chrome-free shavings can be efficiently processed for the obtaining of protein-based hydrolysates.

A comparison between the additional costs related to the two processes is given in Fig. 4. Calculations were done assuming that all the other expenses are identical, excepting the direct manual labour expenses, and that the manual labour expenses are almost identical in both cases.

Thus, the overall costs, computed for the two processes are as follows:

1. Conventional chrome tanning process:

   Total cost = 2.88\times G +151.15 + (11.5\times G-3.3\times G) = 11.08\times G +151.15 \text{ RON}

2. Alternative process: oligomer pre-tanning, followed by 1\% Cr\textsubscript{2}O\textsubscript{3} tanning:

   Total cost = 9.08\times G +193.14 + (3.2\times G-2.8\times G) = 9.48\times G +193.14 \text{ RON}

A slight decrease of the variable cost can be noticed, because the variable cost depend on the amount of processed leather, G; this fact can balance the difference coming from the fixed expenses (which is 193.14 – 151.15 = 41.99 RON) at industrial scale, provided the amount of raw hide is at least 26.24 times as big as the amount processed in the conventional process.

In other words, the above mentioned difference is nullified after twenty seven processing cycles, by using the pre-tanning step. This figure derives from the following calculations:

\begin{align*}
11.08 \times G + 151.15 &= 9.48 \times G + 193.14 \quad (1) \\
(11.08 - 9.48) \times G &= 193.14 - 151.15 \quad (2) \\
1.6 \times G &= 41.99 \quad (3) \\
G &= 26.24 \quad (4)
\end{align*}

The costs evolution in a tanning plant that simultaneously applies the both technologies, on identical batch weights, is given in Fig. 5. One can see that if the annual production capacity corresponds to 270 batches (which is ordinarily met in the industrial practice) if only 27 batches (which is one tenth of them) are processed by the novel technology, the cost difference coming from the increased energy consumption is balanced and the average annual cost per batch becomes equal to 440.92 RON, no matter the applied technology. This state is reached only if the chemicals and auxiliaries in spent floats are recycled and the solid wastes are revalued.
4. Conclusions

The alternative tanning process that includes a pre-tanning step with an oligomeric resin is both technologically and economically attractive, because it results in lower wastewater treatment costs and in chrome-free shaving wastes, which can be easily revalued for different applications.

When the novel tanning process is applied, the variable expenses, dependent on the tannery production capacity, can balance the cost increase due to the fixed expenses (which is 193.14 – 151.15 = 41.99 RON) if the tanning plant applies the novel process 27 times per year at least, instead of applying the conventional one.

![Diagram showing the calculation of additional costs](image)

**Fig. 4 – Calculation of the additional costs related to the conventional and alternative technologies.**
Fig. 5 – Comparison between the evolution of costs of the conventional and alternative tanning technologies.

REFERENCES


EVALUAREA COSTURILOR IMPLICATE DE UTILIZAREA UNEI RĂȘINI TANANTE ÎN OPERAȚIA DE PRETĂBĂCIRE A PIEILOR BOVINE

(Rezumat)

Prezentă lucrare propune o variantă de modificare a abordării tehnologiilor în firmele de prelucrare a pieilor și blănurilor. Se prezintă posibilitatea utilizării unor oligomeri tânăți, pe bază de rășină melamin-formaldehidică benzensulfonată (RMFBS) destinați pretăbăciri pieilor, capabile a aduce îmbunătățiri la nivelul randamentelor economice ale prelucrării, mai ales în cadrul unor unități economice de mici sau medii dimensiuni. Studiul costului aplicării produsului de sinteză s-a realizat pornind de la tehnologia de pretăbăcire elaborată și testată la nivel pilot. În urma evaluăriii costurilor cheltuielile variabile, ce depind de cantitatea de piele prelucrată poate anula diferența datorată cheltuielilor fixe (de 193,14 – 151,15 = 41,99 RON), dacă o unitate industrială aplică într-un an calendaristic de cel puțin 27 de ori tehnologia modificată, în detrimentul celei clasice.