COMPARATIVE STUDY BETWEEN WOODEN AND POLYPROPYLENE DRUMS: PHYSICAL AND PROCESS CONSIDERATIONS.

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Abstract:
This paper compares the physical properties of traditional Wooden drums respect to Polypropylene ones. In the first part of the paper, we report the results of our studies on drum's structure, Outer size respect to volume, thermal conductivity of Iroko Wood respect to Polypropylene and comparative materials deterioration after long continuous usage. The second part studies the practical behaviour during process: Thermal loss, comparative exhaustion during process and quality results.

Introduction:

Leather Industry in globalisation years is bringing to us many tough topics to develop such as making our tanneries as environmentally friendly as possible, keeping higher than ever quality standards, optimising spaces, saving energy and reducing running costs.

Environmentally friendly sounds simple but involves many very different issues. It means reduction of pollutant effluents, and thus saving treatment costs; it means energy saving, means high standard articles for high demanding customers. In this context enters the Development of new elements to aid this new generation of tanners.

Picture. 1 - Polypropylene and Wooden drum running side by side

Note:

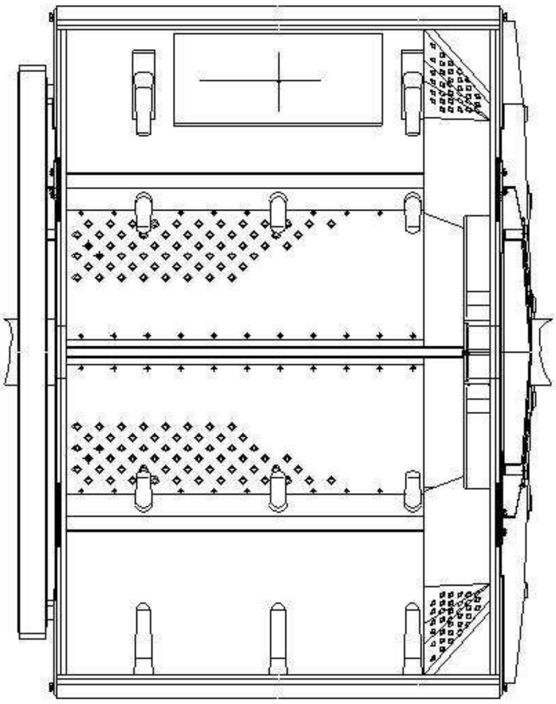
Most of the trials were carried on in tanneries working both in Wooden and Polypropylene drums and following similar processes.

Because it is not always possible to achieve the same load, for these trials purpose, speed in the Polypropylene drum was adjusted to achieve similar mechanical action as described in the chapter devoted to chemicals exhaustion.

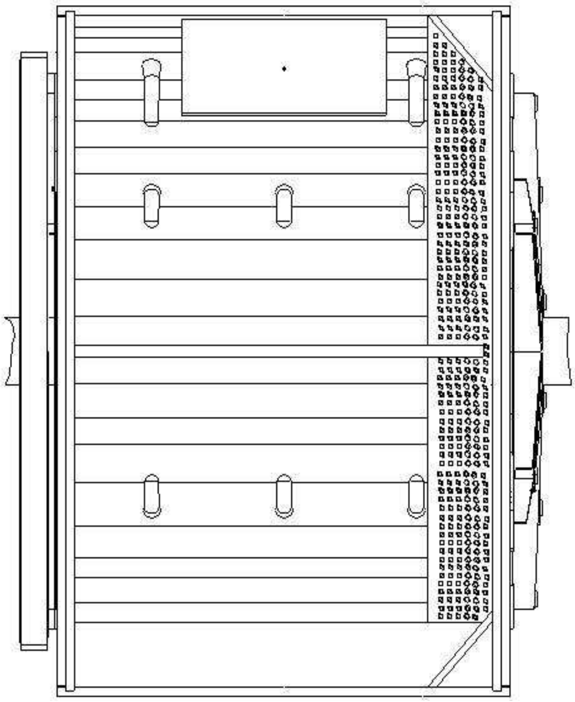
In Picture 1 we can see two drums of comparative dimensions running side by side.

Drum's structure:

To achieve the optimal mechanical effect, some modifications were introduced to the recycle system so as to achieve a high turbulence liquids flux. In Picture 2 we can see an optimised Polypropylene drum, to be compared with Picture 3 a wooden drum layout. The first advantage we found in Polypropylene is it's particularly smooth surface, high chemical corrosion resistance even to peroxides at normal liming temperatures, excellent mouldability allowing to design high performance recycling systems.



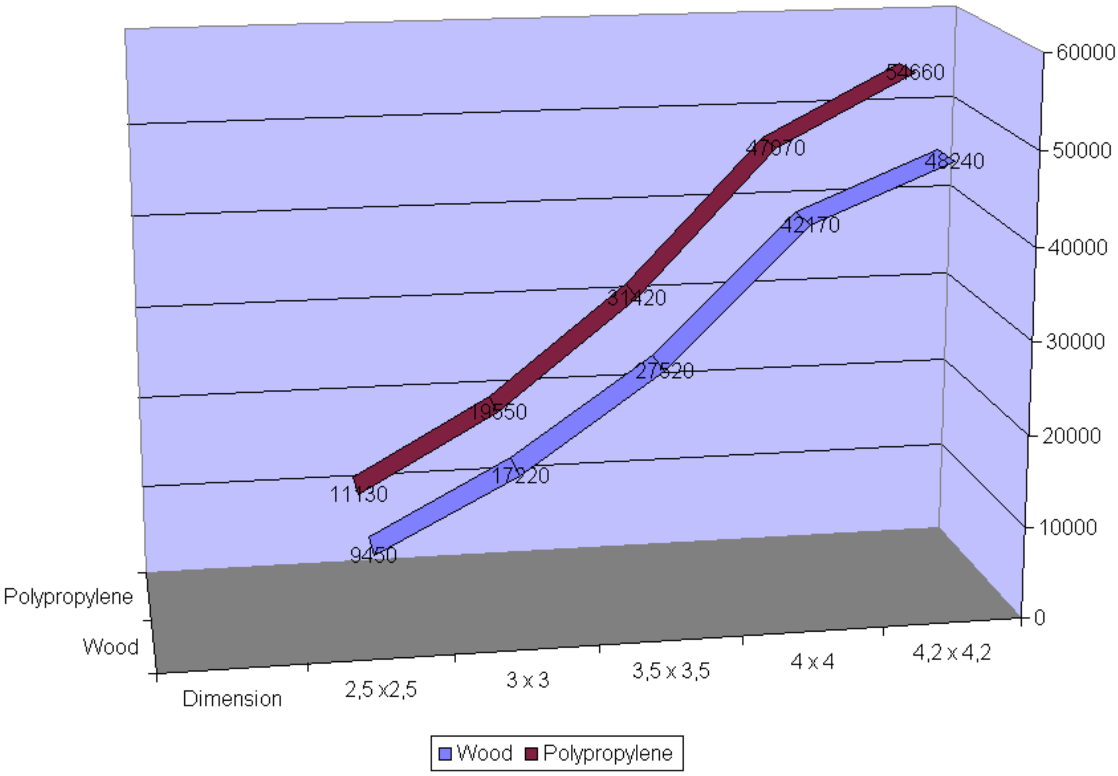
Picture 2: Polypropylene drum section



Picture 3: Wooden drum section

Outer size respect to volume:

Due to the lower thickness of Polypropylene drum's walls, we note a volume increment in comparatively similar outer dimensions vessels. This increment may vary between 11,6 % in a 4m x 4m drum up to a 17,8 % in a 2,5 m x 2,5 m one, as we can see in Picture n.4



Picture 4 : Compared volume of similar outer size vessels.

Outer Dimension	Wooden drum capacity	Polypropylene drum capacity	% Volume increment
2,5 x 2,5	9450	11130	17.8
3 x 3	17220	19550	13.5
3,5 x 3,5	27520	31420	14.2
4 x 4	42170	47070	11.6
4,2 x 4,2	48240	54660	13.3

Compared Thermal Conductivity of Iroko Wood respect to Polypropylene.

Analysing the problem physically and theoretically, and with the data actually available, we may say that there is no advantage in thermal insulation: Thermal conductivity constants are of the same order:

Iroko wood : k = 0,18 Kcal . m / hr .m^2.°C

Polypropylene : k = 0,19 Kcal . m / hr .m^2.°C

The only data available refers to the same condition i.e. dry. Reality shows a different landscape. Polypropylene being impermeable will remain dry. Obviously wood will absorb humidity till a regime equilibrium.
Considering a thickness 75 mm. for the wooden drum respect to 20 mm. for Polypropylene one, and using the following calculations, we found a theoretically notorious advantage for the wood:

$$Q = \frac{kA\Delta t}{Sp}$$

where:

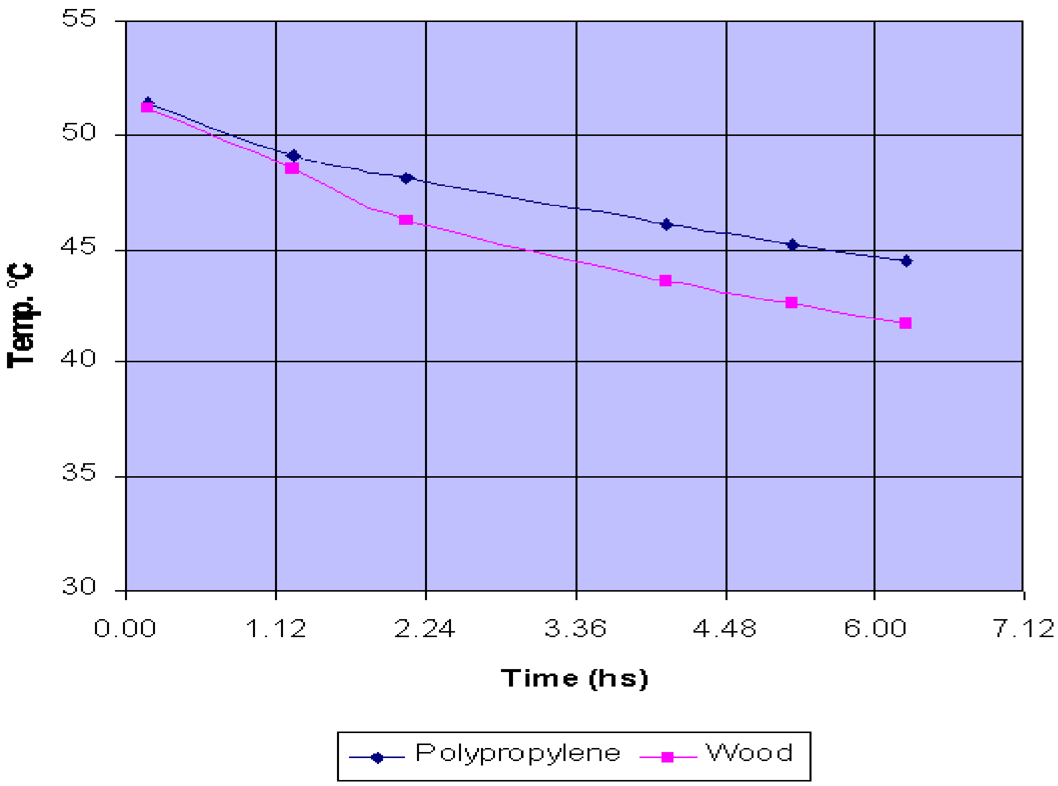
Q = Heat dissipated after one hour.
k = Thermal conductivity constant.
A = Area.
ΔT = Thermal gradient.
Sp = Drum wall's thickness.

This calculation was applied for a 3 x 2 drum, loaded with 7 cubic meters of water at a temperature of 55°C.
Heat dissipated in one hour was as follows:

Iroko wood drum	1154 Kcal / hr
Polypropylene drum	4570 Kcal / hr

To verify these calculations, we made the practical testing of the system:
Two drums of comparative outer dimensions one Wooden, and one Polypropylene were filled with water at 65°C till 40 % of the useful capacity. The temperature of both empty drums was 23 °C and external temperature 22,8°C. After running 10 minutes temperature came down to 51,4°C in the Polypropylene vessel and 51,2 in the wooden one. Temperature was measured every hour and then plotted against time.
The result obtained showed the opposite conclusion of the theoretical considerations, confirming the evident fact of a much higher thermal conductivity constant of the wet Iroko wood (in between the water and dry wood value). New studies are being carried on to determine a reasonable thermal conductivity constant for wet wood to be applied in thermodynamic drum calculations.

In Picture 5, we can appreciate a plot of the temperature dissipation is a Polypropylene drum respect a wooden one:



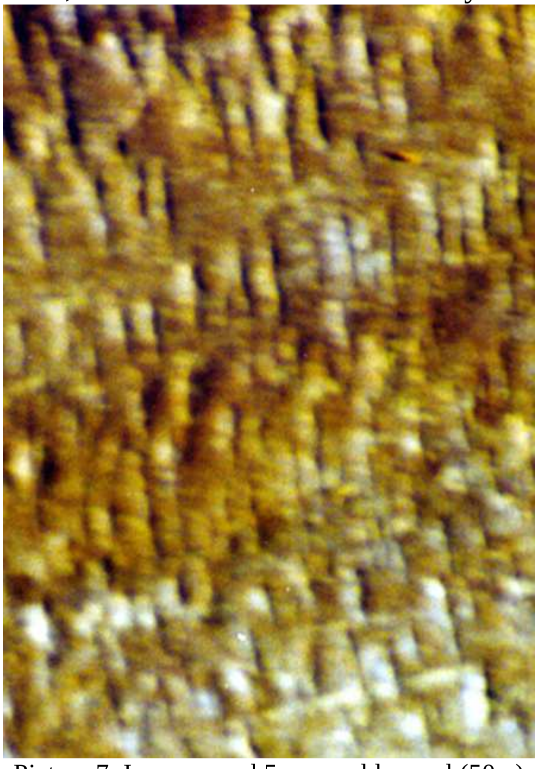
Picture 5 - Comparative Thermal loss (practical experience).

Materials deterioration:

Another interesting point to consider is materials resistance and deterioration.

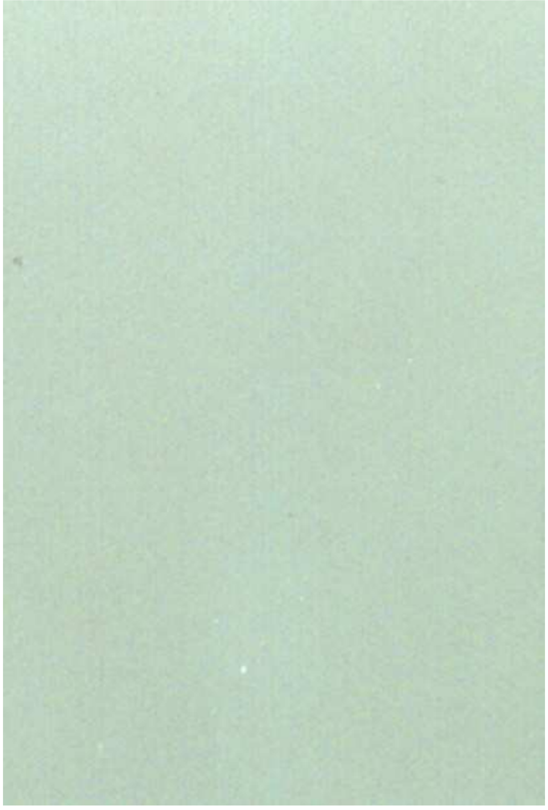
Two retanning drums which worked under similar conditions during five years were compared by microphotography to the same materials in new vessels. The results can be seen in the following pictures. Picture 6 shows the Irocco wood from a new drum, Picture 7 Irocco wood after 5 years:

Picture 6: Irocco wood new vessel (50 x)



Picture 7: Irocco wood 5 years old vessel (50 x)

In this image we can see how wood deteriorates in time. After long use, surface became rougher and thus more aggressive to the skins. In most cases and specially if the drum is used with low or no float, grain layer may be seriously damaged.



Picture 8 - Polypropylene new vessel (50 x)

Picture 9 - Polypropylene 5 year old vessel (50 x)

In the next two pictures we can observe the effect on a Polypropylene vessel. After five years, the inner walls in a Polypropylene drum are flat and smooth. Some minor scratches can be seen in it's surface.

Chemical stability of Polypropylene:

One interesting advantage of Polypropylene respect to wooden drums is chemicals stability. Polypropylene is stable against Hydrogen Peroxide, Sodium Hydroxide, Sodium Sulphide, Calcium Hydroxide, Organic acids, and Ammonia, and Hydrochloric acid at maximum concentrations. Stable to Sulphuric acid, may be slightly attacked by Oleum.
This high stability to Acids and Bases allows to eliminate dye's stains from the vessel even by means of highly concentrated caustic products. This is normally requested in case of a need to dye different colours in the same vessel. Future possibilities are seen for highly oxidative liming processes, were Inox vessels are beforehand discarded, and wood destroyed after short process periods.

Chemicals exhaustion:

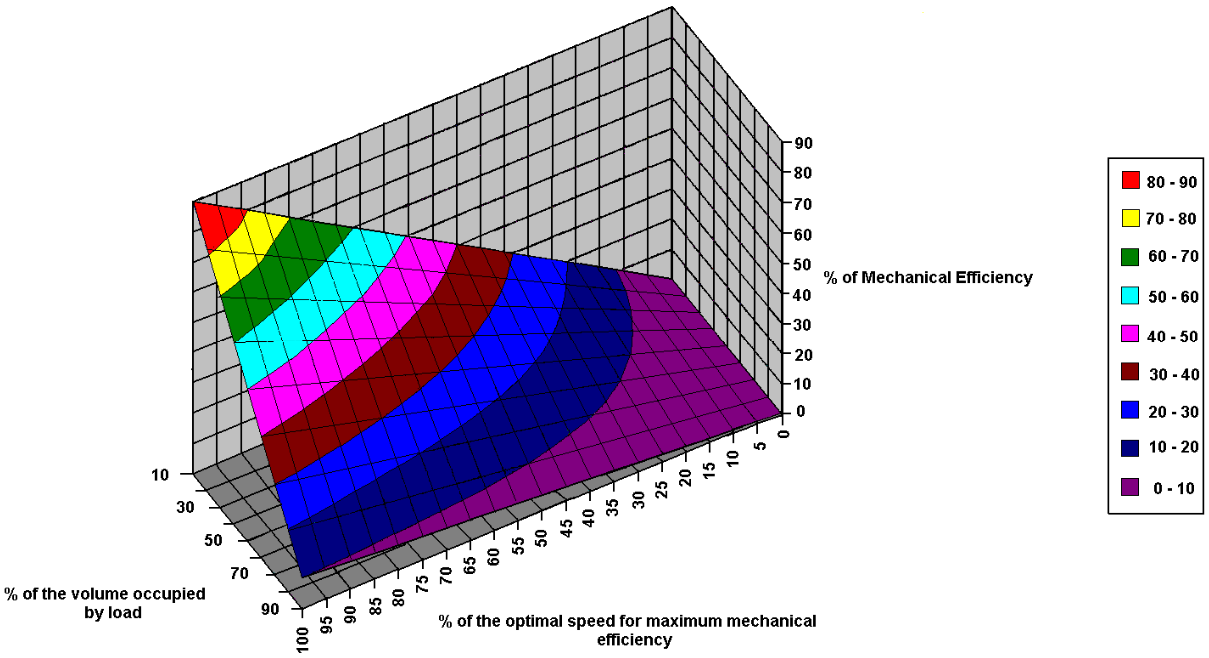
To achieve comparable mechanical action due to speed respect to inner dimensions and load, the following calculation was used. All this supposing that at a same certain percentage of the optimal speed, two drums will have a comparable mechanical action.

$$sD = \frac{42{,}2}{\varnothing} \times \sqrt{2\sqrt{\frac{wL}{\pi \times L}}}$$

where:

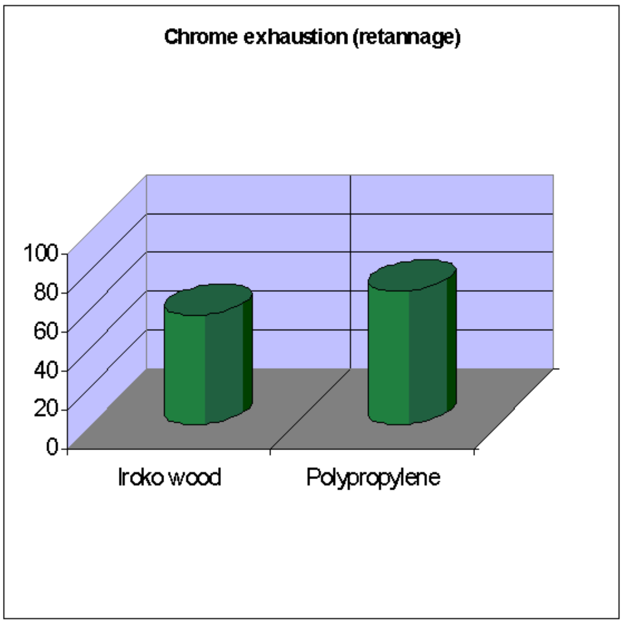
sD = Optimal drum's speed.
Ø = Internal diameter of the drum.
wL = Drum's load in Ton.
L = Drum's inner width.

By means of this calculation is possible to plot a 3d graphic where is easy to see the variables of an ideal drum as we can see in Picture 10:

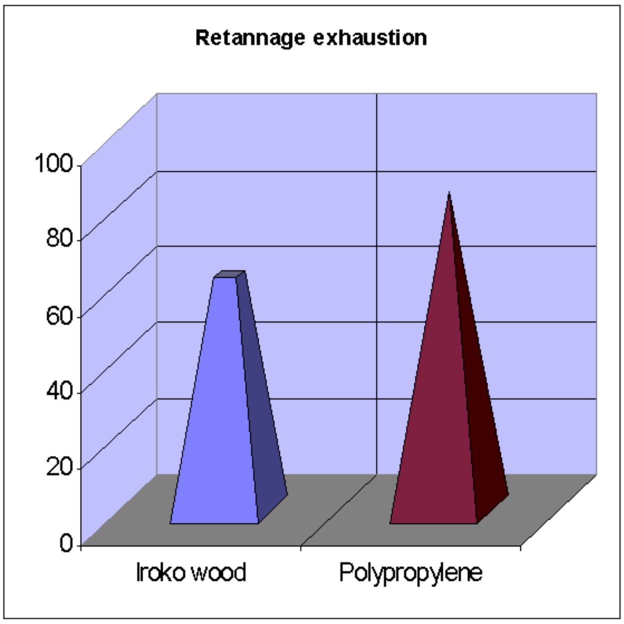


Picture 10 : Efficiency of an ideal drum.

Once calculated the speeds to achieve theoretically the same mechanical action we made different comparisons during bulk processes.
The first testing, was done for chrome exhaustion during rechroming, after 10 minutes process and after 12 hours, without basification (Picture 11). In the Iroko wood drum, ca. 56 % of the chrome was absorbed, while in the Polypropylene drum ca. 65 %. Again we noted a comparative higher temperature in the Polypropylene vessel. We may attribute this effect even to the higher temperature conserved, to the increased turbulent flux of the improved vessel, or what is more likely to both effects combined. For this reason did a similar test during vegetal retanning, were temperature is kept lower. This time the first sample was taken after 5 minutes run, and the next 20 minutes later. The results are reported in Picture 12 where we can see again a higher exhaustion in the Polypropylene vessel.
This time exhaustion went from a ca. 62 % of the tannins in the wooden drum to a ca. 84 % in the Polypropylene one. In this case we may attribute the effect to the highly turbulent flux and not to the temperature, which was similar in both vessels, and which in so short a period of the sampling, remained stable.



Picture 11 - Comparative chrome exhaustion.



Picture 12 – Comparative retannage exhaustion.

Conclusions:
Polypropylene drums showed many advantages in the long term respect to wooden vessels. In the short term shown a higher versatility, combining the cleaning advantages of the Inox drum to the thermal properties of wood and higher chemical resistance. The high turbulent flux recycling system applied to this vessel could only be done because of the mouldability of this material. Finishing is finer specially in recycling holes, improving the flow of small shavings and cuttings, reducing the risk of stains while changing colours.

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Reference:
Perry - Chilton - Chemical Engineer's Handbook.