CONTROL SYSTEM FOR CHROMIUM RECYCLING TECHNOLOGY FROM TANNERY WASTE

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Abstract: The leather industry uses a by wastes of meat industry, and, as such, significantly reduces the environmental impact. It is therefore evident that term „waste“ is relative. It can be argued that if the "waste" generated in one industry sector can successful be utilised as a raw material in another industry sector for the manufacture of goods, we need to rethink our philosophy on the use of resources. This paper describes a proposed comprehensive computer control and monitoring system for a recycling technological process of both liquid and solid wastes from the tanning industry. The chromium tannery wastes are potential dangerous for the environment. As an experimental laboratory model were built in the Department of Automatic Control Faculty of Technology Tomas Bata University in Zlín an apparatus fully equipped with sensors and actuators. Monitoring and control system was tested on the real equipment.

Keywords: Leather, Tanned waste recycling, DDE server, Real–time process control, microcomputer’s technique, control algorithms.

1. INTRODUCTION

The leather industry is characteristic by a significant production of liquid and solid wastes including chromium, which can be potential highly toxic for the environment. There is a great deal of hard work because of the fact that it is necessary to put among physics – chemical operations machine operations and at the same time there exists a lot of consumption of electrical energy, technological water and other the leather agents.

One of the numerous possible solutions to the problem of chrome-tanned wastes is their enzymatic dechromation, which has been dealt with in detail in Suseela (1986) and Taylor *et al.*(1990). When seeking ways of processing chrome-tanned wastes in the Czech Republic we decided to employ the enzymatic dechromation technology worked out at the USDA in Taylor *et al.*(1990). To fit conditions in the factory manufacturing auxiliary tanning agents where the technology was applied, we modified the American process by using organic volatile bases such as isopropylamine, diisopropylamine, cyclohexylamine, ammonia and others (Kolomaznik *et al.*, 2000). Usage of the mentioned volatile amines has the following advantages:

a) Ash content in hydrolysis products is considerably reduced. (From an initial 25% to a maximum 7% in the first stage of hydrolysis and from 15% to a maximum 3% in the second stage). The reduced ash content gives a higher quality product and in case desalting by ion exchangers or membrane filtration is employed, the working cycle of ion exchanger columns or filtration plants is prolonged.
b) It increases the content of chromic oxide in filter cake, thus facilitating its processing into regenerated tanning salt.

c) When concentrating diluted solutions of protein hydrolyzates, a certain regeneration of organic base takes place. In laboratory and pilot-plant conditions we achieved 60% regeneration, on an industrial scale the regeneration of organic base varied within the range of 20 - 40%.
d) The efficiency of protein yield increases from 60% to 80% and more as we obtained in the USDA laboratory conditions.

2. TECHNOLOGY

The modified technology of enzymatic hydrolysis was then employed in a newly built plant of the TANEX Company, now KORTAN, in Hrádek nad Nisou in north part of Czech Republic, with a daily capacity of 3 metric tons for processing chrome shavings

The most important operation in the whole process of leather manufacturing from pelt is tanning when basic complexes chromium salts form strong coordinating bonds between carboxyl groups of the collagen protein. However, this reaction goes to equilibrium, i.e. some of the available chrome does not link to the collagen protein by tanning reaction and thus, according to the specific technological procedure, outgoing liquid contains 0.2 – 0.4 % of chromium ions. General practice is to use alkaline precipitator to remove chromium from this “spent” liquor. In our process the chromium sludge which is isolated after enzymatic dechromation of tanned solid scraps contains 10-15 % of magnesium oxide (on the free moisture base) and also a small amount of organic base. This fact let us to explore the possible utilisation of chromium sludge to remove and recover chromium ions in spent tanning liquors. Thus, we are suggesting that the sludge from enzymatic dechromation can be effectively used as a sacrificial chrome exhaust agent chrome precipitator for spent tanning liquors.

For reasons application of automatic control of technological processes and computer technique in the leather industry, whose raise can be seen in last years. Proposed model of the technology was used for a simulation test and optimum calculation in the connection of minimum procedural costs of recycling technology (See Fig.1).

A laboratory model of the recycling process – its technological scheme is shown on Fig.2. The main parts are vessels and measuring storage tank with mixer and sensors, which are situated in the technological loop.

The processed wastes are put into it. This equipment is fitted out with necessary sensors and valves for reading physical quantity and control of action elements.

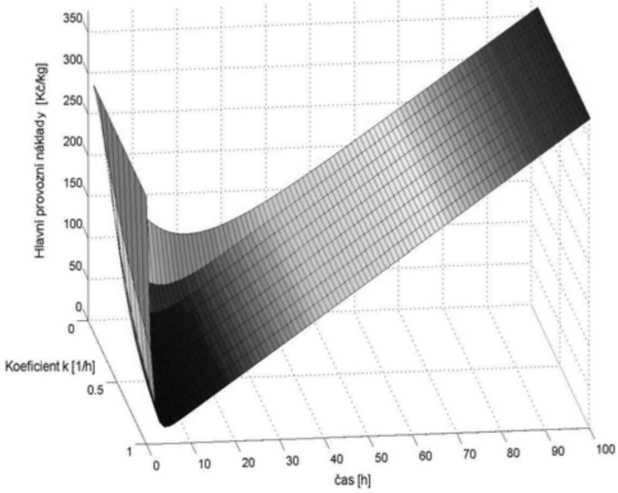

Fig.1. Cost curves for variable speed constant *k*.

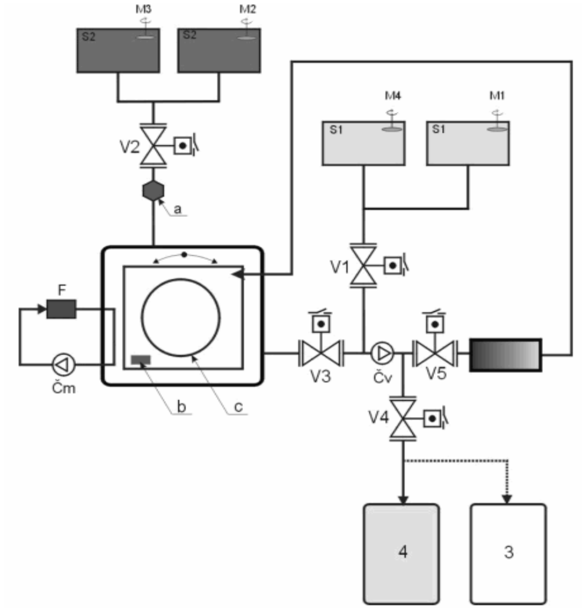

Fig.2.The simplified schema of technological equipments (S1-Vessel with solid wastes Cr^{+++}; S2-Vessel with liquid wastes, V1, V2, V3, V4, V5–Electromagnetic valves, F-Photosensor of concentration, Čv,Čm–Centrifugal pumps, a-Sensor of flow rate, b-Sensor of temperature, c–Washer, 3 and 4-Vessels with finished products.

2. CONTROL SYSTEM AND SOFTWARE

It is necessary to control and display in recycling process (Manh *et al*.,2003):

- Filling process liquid and solid wastes with defined amount.
- Scanning discreet signals defining the position or state individual procedure parts of technological system and taking analogy values prom the process (temperature, pressure, value of concentration etc.)
- Control of the time sequence of individual operation according to technological procedure with controlling of all parameters. Regulation

temperature and activity of the valves and pumps in technological process.

- Communication of the control system and server via the serial link RS 232.

Control consists the checking of equipments and measuring out of chemicals according planed program. Quantitatively higher-level automatic control is the using of backward connection, when action interference is made on the basis of real parameters of the process, which are just going.

The control system is proposed as two level one (Vašek *et al*. 2004). The first – technological – level ensures the technological values measuring, discrete control algorithms processing, technological steps control and manipulated values generating. Second level enables supervising activities. Described technology is now implemented in laboratory conditions in our department by computer control system with a programmable industrial card Advantech PCL – 812/812PG, which has own A/D and D/A converters. Each part of the technology process has its own control subsystem for the direct digital control of the physical values as a temperature, water level in vessel, concentration etc. The software system is built in the C language. For the real time running of the program system there is used special pre-emptive real time operating system RTMON (Vašek, 2001), which was built for the using of monitoring and control system for technological processes. It allows multitasking of defined number of processes. User's programs are structured on the basis of the priority hierarchically. The choosing of the program, which will be running on the processor, is carried out on the basis of its priority level. The structure of an application programs is shown in figure 3.

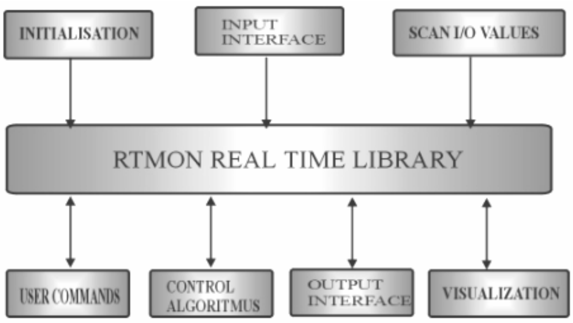

Fig.3 Real time control system

Program system includes the basic part of the real time operating system and the program modules - processes. Initialization process defines data structure of the real time operating system and fills the program variables by the initial values; another process SCAN I/O VALUES reads periodically the binary and analogue input values. The CONTROL ALGORITHMS process calculates manipulated value for temperature control. The process COM ensures the communication between both levels of the control system via the serial link RS 232. It sends and gets back the information and important parameters via the DDE server to software Wonderware InTouch, which is running on the high level of the control system. The VISUALIZATION process allows the basic and simply visualization on the low level of the system. On the supervising level there is running InTouch application where is possible to see the state of recycling process by the help of the animation all its parts and to give supervising commands to control whole the process. The supervising screen is shown on the Fig 4.

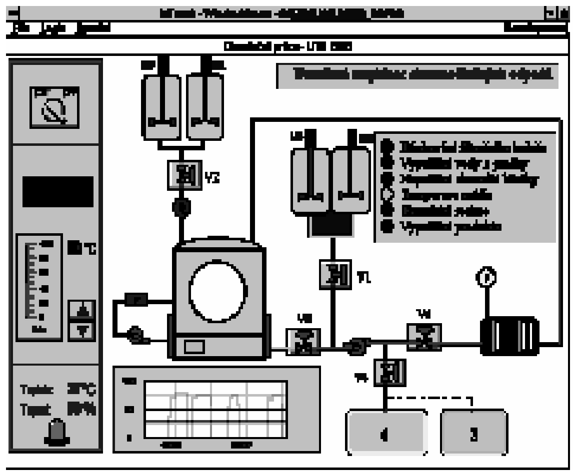

Fig. 4. Supervising InTouch screen.

3. TEMPERATURE CONTROL

3.1. Identification the temperature system

For the identification of the controlled system we have used the step response. The identification was created by means of personal computer. Measured data were calculated by the program in Excel. The transfer function of the thermal system is possible to write as follows

$$G(s) = \frac{1{,}12}{(4610{,}1s+1)(375{,}2s+1)} \qquad (1)$$

3.2. Temperature control system

From the point of view control algorithms the temperature control is not difficult task. We tried several control algorithms. As a result we have used combination of two point controller with the penalization of the manipulated value and discrete PID controller. In the first phases is running two point controller to get quickly required value, then is switched to the discrete PID controller with the better dynamic properties near the required value. The switch point is approximately in the time, when the controlled value achieves 75% required value. The good results give the controllers with the parameters counted by the help of dynamic inversion synthesis method (Vítečková 2000). For the time period

T=700s the transfer function of discrete PID controller is

$$G_R(z^{-1}) = \frac{2{,}9505z^{-1} - 2{,}9916z^{-1} + 0{,}3924z^{-2}}{1 - z^{-1}} \quad (2)$$

The temperature control course is shown in Figure 5. We can see that time of stabilization on the reference value is somewhere 5000s with minimal overshooting. This result is for the recycling process available.

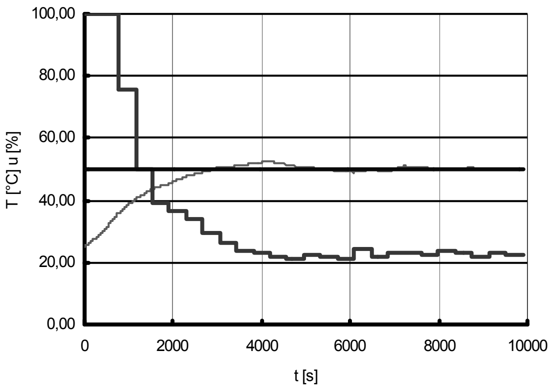

Fig.5. Real temperature control course

4. CONCLUSION

Described method of the computer automatic control in the leather industry realizing by laboratory apparatus is workable and allows on the one hand testing new technological techniques and approach for transform of the natural hide, on the other hand testing new control discreet algorithms for controlling analogue quantities. In this paper presented results of the laboratory experiments are very important step for final industrial application in the tannery waste recycling technology.

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