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Optimization and Automatic Control of Chromium Recycling Technology

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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 controlling and displaying 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 with using computer with an industrial card Advantech PCL – 812/812PG and displaying software by Wonderware InTouch. The software of the control system is created in the real time with idea of optimal technology.

Key-Words: - Tanned waste recycling, Enzymatic hydrolysis, Simulation, 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.

2 Problem Formulation

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 publications [1], [2]. When seeking ways of processing chrome-tanned wastes in the Czech Republic we decided to employ the enzymatic dechromation technology worked out at the US DA in Philadelphia [2]. 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 [3]. 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). A reduced ash content gives a higher quality product and in case desalting by ion exchangers [3] 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 a 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. These experiments were realized in US DA laboratory conditions.

3 Problem Solution

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. Prudent practice is to use alkaline precipitation to remove chromium from this "spent" liquor. In our process a chromium sludge was isolated after enzymatic dechromation of tanned solid scraps. It contained 10-15 % of magnesium oxide (on the free moisture base) and also a small amount of organic base. This fact led us to explore the possible utilization 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).

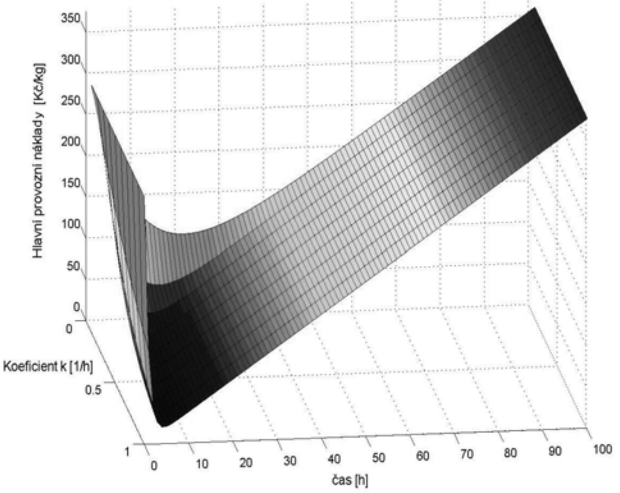

Fig.1. Cost curves for variable speed constant k

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

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.

It is necessary to control and display in recycling process:

- 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 from the process (temperature, pressure, value of concentration etc.)
- Control of the time sequence of individual operation according to technological procedure with monitoring of all parameters. Temperature control and activity of the all valves and pumps which are located in technological process.
- Communication of the control system and server via the serial link RS 232.

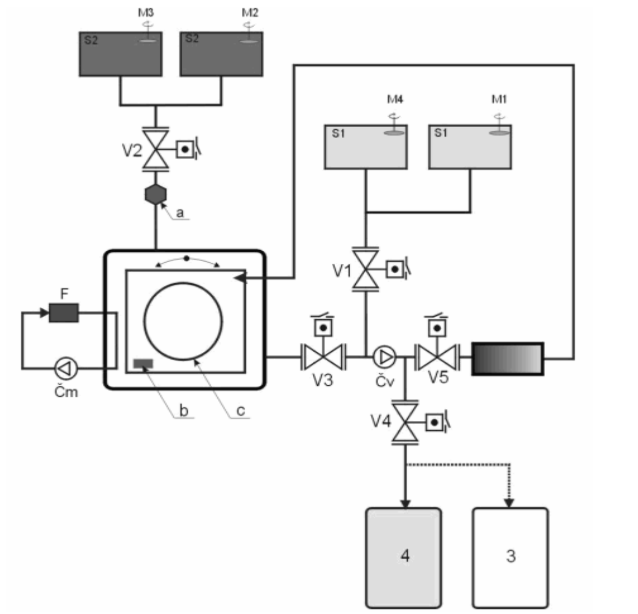

Fig.2 The simplified schema of technological equipments
(S1 - Vessel with solid wastes Cr^{+++}; S2 - Vessel with liquid wastes; V1, V2, V3, V4, V5 – Electromagnetic valves; Čv,Čm – Centrifugal pumps; F - Photosensor of concentration; a - Sensor of flow rate; b - Sensor of temperature; c – Washer ; 3,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

Control consists of the commanding 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.

Programming methods in applied in automation application

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

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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 [4], which was built for the using of monitoring and control system for technological processes. It allows multitasking of defined processes number. 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.

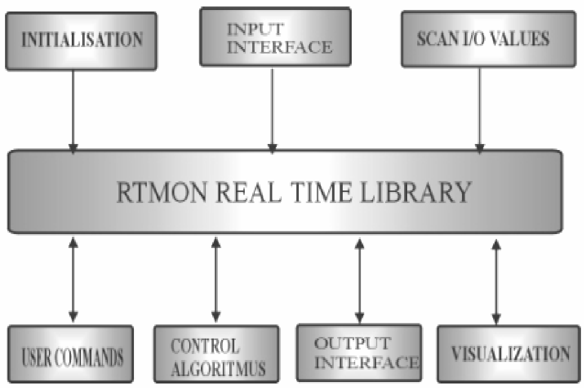

Fig.3 Real time control system

Program system includes the basic part of the real time operating system and several user process modules.
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 reads periodically the binary and analogue input values. The CONTROL ALGORITHMS process calculates optimal time to filling it into the bath from the measured values of temperatures, value of turbidity. In the range of this process is running also sequence control of the valves (open/close) and the pumps. The main processing pump in the recycling circle and the measuring pump located in bypass for the recycling quality bz the help of color liquid waste measuring. The process INPUT INTERFACE ensures the communication between both levels of the control system via the serial link RS 232. The VISUALIZATION process allows to send and to get back the information and important parameters with DDE server and Wonderware InTouch application, screen of the visualization is shown on Fig 4. Process OUTPUT sends physical action signals to the actuators – valves, pumps and heating system. By the help of USER COMMANDS is there the possibility to manipulate with the whole technological system.

4 The Temperature Control

4.1 Temperature System Identification

For the identification of the controlled system we have generated inputted unit signal. Reaction of this signal is the step response. The identification was created by means of personal computer. The program was written in C language. This program archived the measured values, which can be in next step calculated by means of another program. For this function was used known program system Excel.

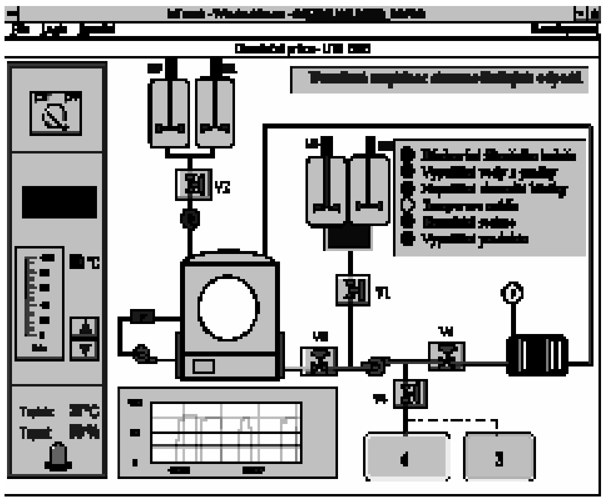

Fig. 4 The process control in InTouch background

On the basis of the described identification we can write the transfer function of the thermal system as

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

4.2 Temperature control system

We designed different controllers for the temperature control. The good results give the controllers with dynamic inversion method calculated [6]. For the time period T=700s the transfer function of discrete PID controller

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

The controlled temperature course is shown on Figure 5. We can see that time period to stabilization on the reference value is somewhere 5000s practically with no overshooting.

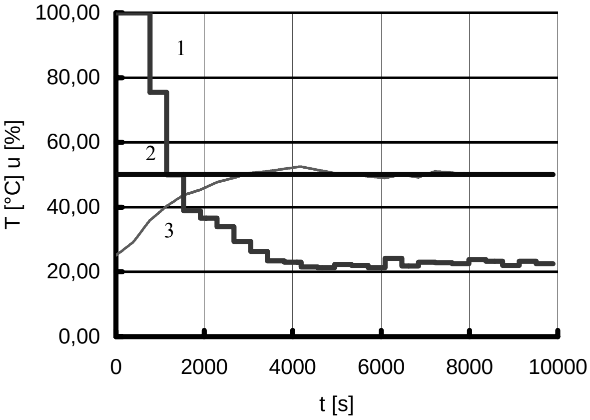

Fig. 5 Real measuring. Controllers designed by dynamic inversion (1-manipulated value, 2-reference value, 3-controlled value)

5 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 control discreet algorithms for controlling analogue quantities. By the present experiences it can be told that the important factor affecting a lot of working results is right choice of a value of temperature to ensuring optimal reaction speed constant.

References:

[1] Suseela, K., Parvathi, M.S., Nandy, S. C.: Leder, 37, 45, 1986.

[2] Taylor, M. M., Diefendorf, E.J. et all: J. Am. Leather Chem. Assoc., 85, 264, 1990.

[3] Kolomazník K, Mládek M, Langmaier F, Janáčová, D. et al. Experience in Industrial Practice of Enzymatic Dechromation of Chrome Shavings J AM LEATHER CHEM AS 95: (2) 55-63 FEB-MAR 2000

[4] Vašek, V.: HC11 Control Unit Applications, IFAC WORKSHOP on Programmable Devices and Systems PDS 2001, Gliwice, Poland. 2001

[5] Manh T. P., Vašek, V., Kolomazník, K.: Best practices scrap leather recycling, II. workshop US Asia Environmental Partnership - Ho Chi Minh university - Nike - UTB, Ho Chi Minh City, Vietnam, January 2003.

[6] Šulc, B., Vítečková, M.: Teorie a praxe návrhu regulačních obvodů. Vydavatelství ČVUT, Praha 2004, ISBN 80-01-03007-5

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