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Computer Control of Leather Tannery

M.R. Safaieh* and M. Faghfouri[1]

The fundamental step in leather production is "tanning" or "processing" the animal hide. This process is performed in a wooden cylindrical device called a "drum" or a "lanner". The raw hide is processed inside the drum with a variety of mixtures of chemicals and water under certain environmental conditions and controlled temperatures. During the process, controlling the temperature and pH of the mixture is of utmost importance and directly affects the quality of the leather produced. In many developing countries, including Iran, control is exerted manually by an experienced worker. Since the quality of leather is directly linked to the level of control maintained during the process, a numerical approach and a precise computer controller could not only increase the quality of the final product but would also make the process more efficient. In this paper, the benefits of a computer control system will be studied, the required software will be designed and, finally, the required computer hardware will be addressed.

INTRODUCTION

Traditionally, livestock breeding has been one of the predominant occupations in many rural areas of Iran. Leather products, therefore, have been traditionally produced for centuries. Even though the west was highly involved in leather production, studies have shown that tannery originated from the Middle East and, specifically, Iran. After the industrial revolution, the process of leather production was mechanized by the west and several different methods were invented to facilitate mass-production and the rapid processing of leather. These methods, however, have never been transferred to Iran and, as a result, heavy leather made from cow hide is imported from other countries, despite the high volume of livestock bred in Iran. Lack of planning and inefficient policies have weakened the leather industry as a whole and persistent reliance on traditional methods of production has all but eliminated any movement toward automation and mechanization. This, in turn, has led to further dependence on foreign countries as sources of technological advancement in this area [1-3].

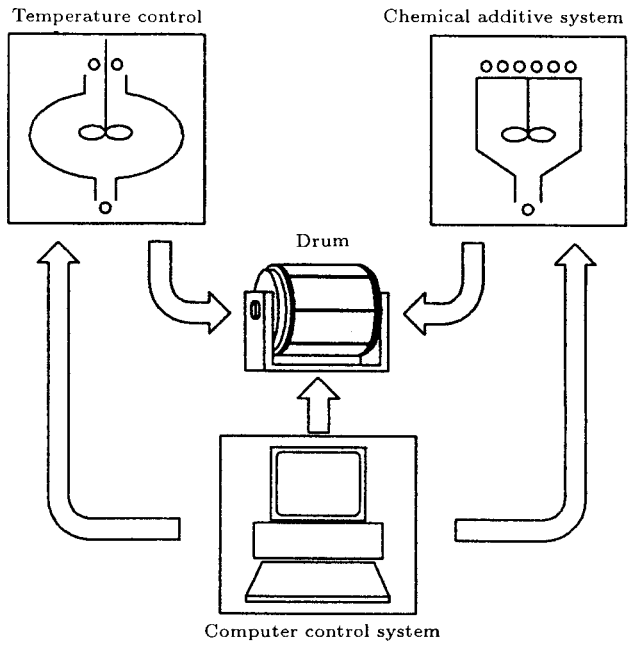

Figure 1. Basic system diagram.

The vital signs to be monitored throughout the process are the temperature and pH of the mixture. According to studies conducted on Moghan sheep leather, these factors change during the process in a fashion similar to that indicated in Figures 1 to 3 and Table 1.

*. *Corresponding Author, Department of Industrial Engineering, Sharif University of Technology, Tehran, I.R. Iran.*

1. *Department of Industrial Engineering, Sharif University of Technology, Tehran, I.R. Iran.*

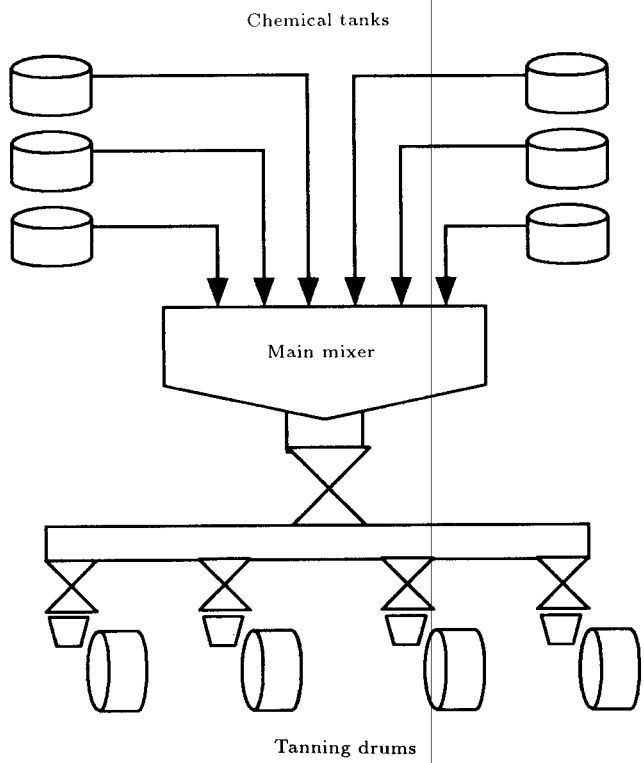

Figure 2. Mixer diagram.

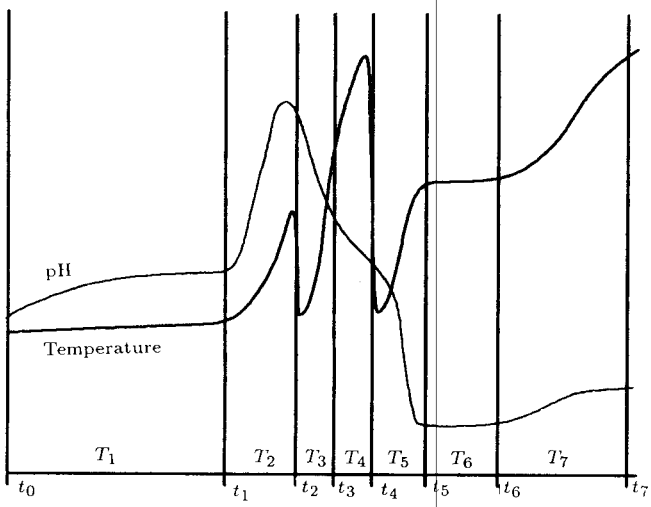

Figure 3. Typical changes observed in temperature and pH of mixture during tanning of Moghan sheep leather.

COMPUTER CONTROL SYSTEM IN LEATHER PRODUCTION

Tannery is a fundamental step in leather production and the process of converting raw hide into leather. A wooden cylindrical apparatus called "drum" is used to mix the raw hide with many different chemicals diluted in water each in its own proportion. Precise monitoring of the temperature and pH of the material inside the drum can effectively decide the quality of the produced leather and, therefore, exact control of these factors is of utmost importance to the procedure. Traditionally, control is exerted by an experienced worker who monitors the gauges and applies the proper changes. Digital and computer control of these components can, not only eliminate human error, but also, make the procedure more efficient by controlling operation timing automatically and reducing total production time, by eliminating the need to stop the process in order to make the monitoring possible. "Drum" is a wooden cylinder in which the raw hide of cow or goat is mixed with water and chemical solutions repeatedly and then turned and rolled until the hide turns into "wet blue". Chemical reactions in the drum occur at many stages and usually involve chrome derivatives. In these stages, various chemicals are passed through the hide requiring different temperatures and pH values. This necessitates the ability to change the drum environment from acidic to basic and vice versa while adding the chemicals in their respective required temperatures [4,5].

Table 1. Description of time periods; time values t_0 through t_7 are empirical.

Start Time	End Time	Period	Description
t_0	t_1	T_1	Fat reduction
t_1	t_2	T_2	Lime addition
t_2	t_3	T_3	Lime subtraction
t_3	t_4	T_4	Enzyme addition
t_4	t_5	T_5	Acid addition
t_5	t_6	T_6	Chrome addition
t_6	t_7	T_7	Base addition

Computer control can be advantageous to manual control in many different respects some of which are listed below [6]:

1. Weight of the mixture of hide, water and chemicals can be monitored without stopping the process;
2. Temperature of the mixture can be controlled without stopping the process;
3. Proportions of the different chemicals can be monitored and controlled without stopping the process;
4. Automatic commands can be sent to hot and cold water valves to control the temperature of the drum automatically;
5. Automatic reservoir valves of different chemicals can be controlled seamlessly by electric signals;

6. The drum can be emptied automatically.

DESIGN OF A COMPUTER MODEL FOR THE TANNING PROCESS

Time periods T_1 through T_7 are essential divisions which will be simulated and controlled on the computer. The flowchart depicted in Figure 4 shows the process as it is controlled on the PC. The computer control software was developed using Delphi computer language. This software was then tested by using a general D/A converter and rows of LEDs as a representation of various valves and gauges used in the system. Further testing, however, required direct access to actual tanning equipment which can only be operated in a functional tanning factory. Implementation of the technique, proposed in this paper requires extensive field tests on the equipment upon which the software should operate [5].

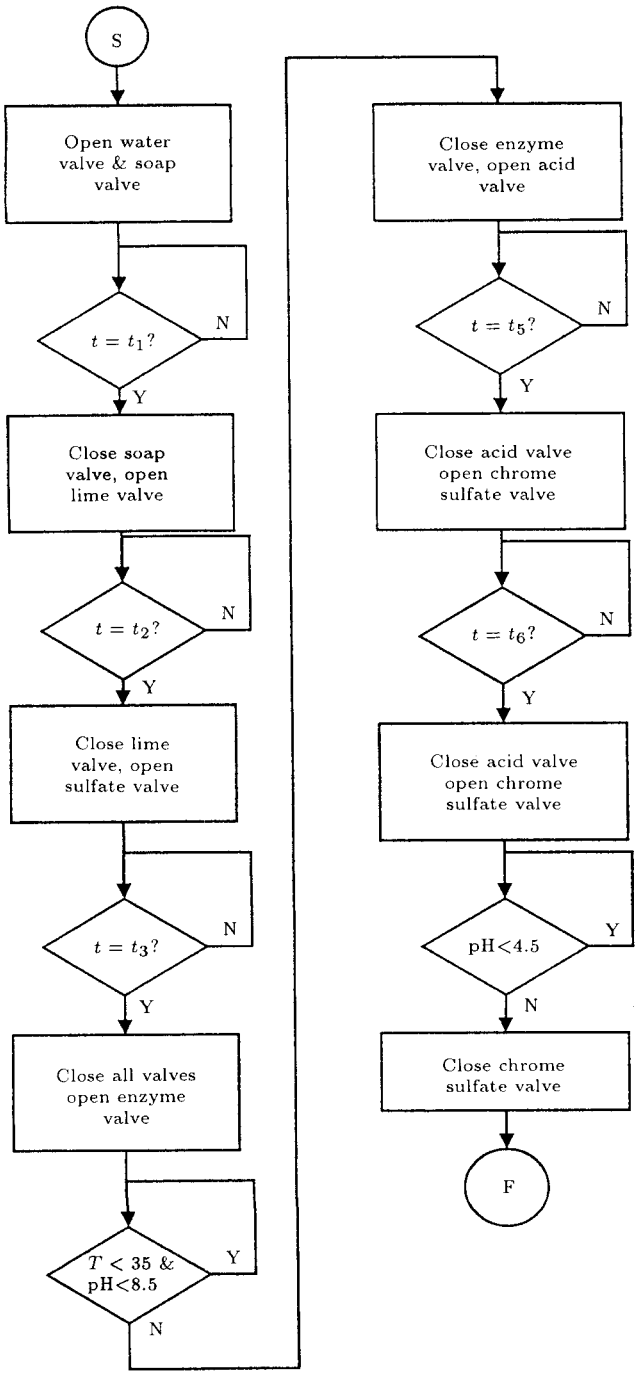

Figure 4. Flowchart of process simulation.

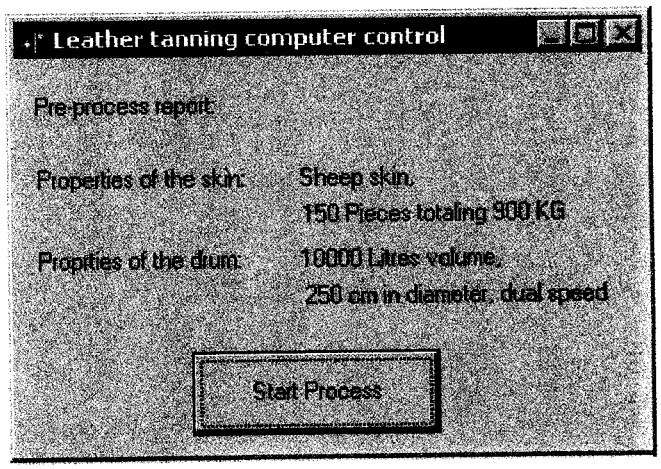

Figure 5. Specification of the raw material and environmental variables, such as type and quantity of the hide, total weight of the raw hide, initial weight and volume of the liquid inside the drum, initial temperature, diameter and volume of the drum, are shown in the program.

In addition to these steps, the ability to monitor the pH of the drum as well as the weight and volume of the mixture, the temperature of the drum and the time elapsed in the process, has been considered and implemented in this model [7].

Simulation results are then printed in Figures 5 through 8.

HARDWARE

To maintain proper control of the process, the variables involved should always be monitored. The temperature and pH of the drum are screened by sensors at all times. The data from these sensors are obtained as weak electrical signals and should be amplified to be readable by computer input ports. This input is then processed by the software and necessary adjustments, resulting either from these readings or a pre-specified schedule, are made. These adjustments appear on output ports as electrical signals. These signals, however, should also be amplified to be usable in an industrial environment to control valves and gauges. To amplify these signals, a special configuration of hardware is used. The process and schematic diagram of the hardware is shown in Figure 9.

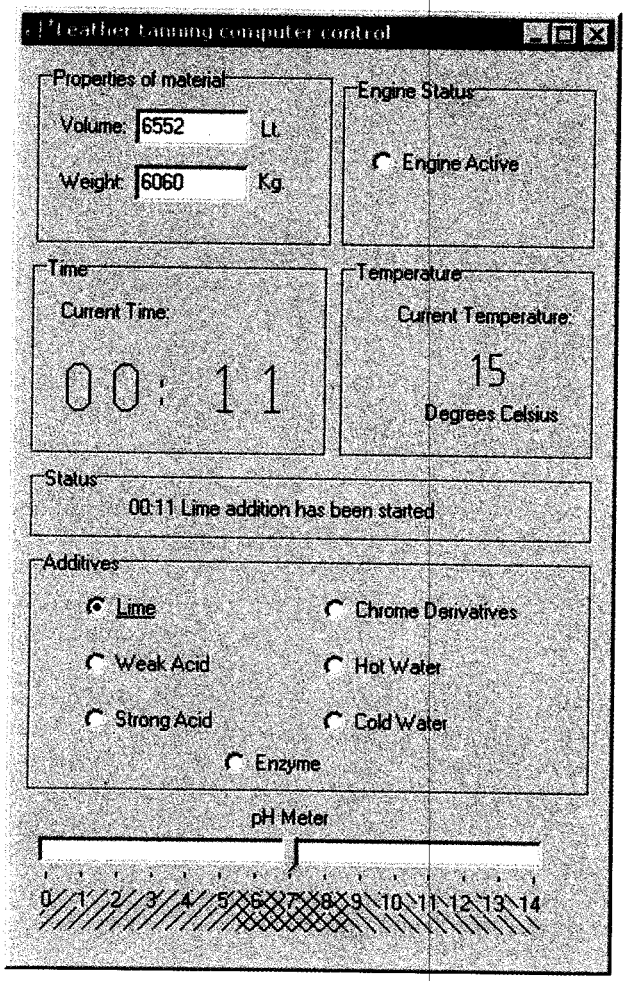

Figure 6. Typical program interface showing neutral environment (with pH meter in the blue area) has been established, drum temperature is at 15 degrees Celsius, mixture weight is 6060 kilograms, mixture volume is 6552 liters and the lime addition has been started.

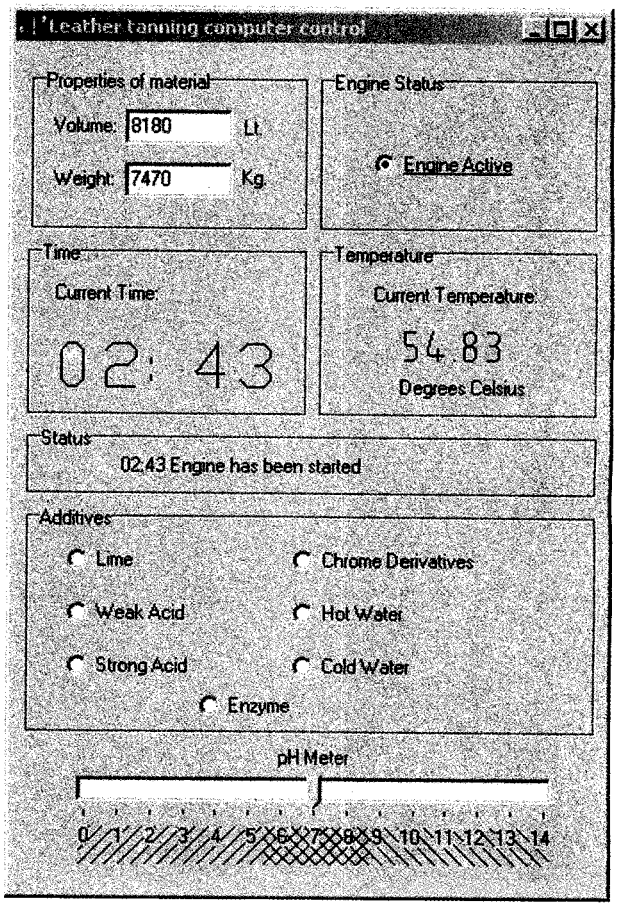

Figure 7. Typical program interface 163 minutes from the start of the process: Neutral environment (with pH meter in the blue area) has been established, drum temperature is at 54 degrees Celsius, mixture weight is 7470 kilograms, mixture volume is 8180 liters and drum rotation has begun.

CONCLUSIONS

The economic benefits of using a computer controlled system for leather tanning are numerous and justify the expenses required to implement such a system. These benefits can be summarized as follows:

1. Reduction of the need for a specialized and expert work force,
2. Reduction of the process time,
3. Enhancement of safety for the workers by eliminating the need to handle chemicals manually,
4. Better leather quality,
5. Ability to control many drums by one central computer station,
6. Better efficiency of the tanning process.

To implement the process of automation simulation described in this paper a team should run

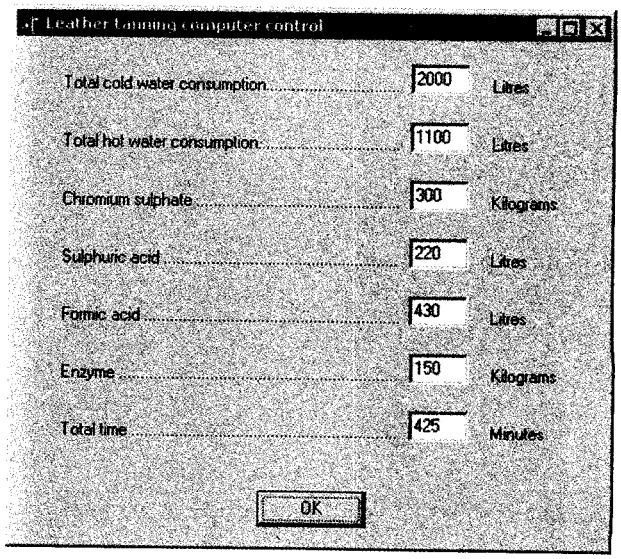

Figure 8. Total consumption of material and total process time of 425 minutes.

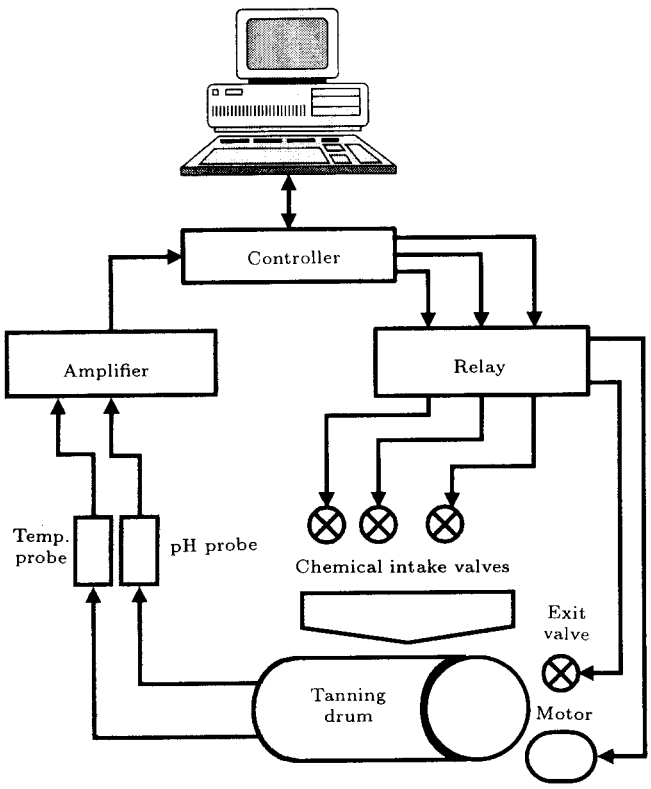

Figure 9. Hardware diagram.

extensive tests on the equipment already existing in the factory to find the exact factors to be used in the software. The software and the technique can then be used in conjunction with the existing equipment with the help of the hardware described earlier.

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