Design and Development of Computer Integrated Systems for Tea Processing Equipment: A Study

Joli Angu & M. Muralidhar

North East Regional Institute of Science and Technology, Nirjuli, Itanagar, Arunachal Pradesh-791109
E-mail : Jolieangu@yahoo.co.in, mm@nerist.ac.in

***Abstract* - Tea is the most commonly drink beverage all over the world. The manufacturing of black tea involves a lot of energy and workers at garden and skilled personnel inside the factory while processing. Tea market has got good potential of employment generation as well as income generation. There is a good scope to export the tea all over the world, as it is drank by most of the people of the world. In India, tea manufacturing is still practiced in traditional manner. There is not much improvements being done in tea manufacturing and the productivity remains low. Hence, there is a need for incorporating Computer based systems in various sub sections of the tea plant to improve the quality as well as the productivity of the tea. In this paper, there will be discussion of various critical sections in tea manufacturing system and an attempt has been made to design a computer based model to improve the critical sections thereby increasing the productivity of the tea manufacturing system and reduce the human errors The studies carried out includes Three critical sections viz. Withering, Fermentation and Heating/frying sections. Some useful conclusions have been arrived.**

Keyword - Withering, Fermentation, Frying ,E.N (Electronic Nose), Microchip, CCD camera.

I. INTRODUCTION

runachal Pradesh has a lot of scope in tea manufacturing[1] . It has a total geographical area of 83743 sq. kilometers and about 80% of the mountainous terrain is unused lands. Hence there is a very good scope for tea cultivation in these unused lands. The quality of tea in Arunachal Pradesh is very good because of its high altitudes and good climatic conditions necessary for tea cultivation. There are approximately 10 tea estates in this region which is very less in number compared to its unused lands. Most of the tea factories used traditional technologies for manufacturing of tea and their productivities are observed to be very low. One of the tea factories was selected for studies of the productivity by modernization[2] of the plant machineries.

II. SIRU RIJO tea factory: A case study.

The Siru Rijo Tea Estate is located 6 kilometers away from Yomcha circle in West Siang district of Arunachal Pradesh on a big mountain top. It is one of the best tea processing industries in the state. About 40 – 50 tons of black tea is produced every year in this plant. The plant is located in the foothill of the tea garden (Fig.1). The garden is at the altitude of 1100 to 1200 meters from sea level. Hence quality tea is grown here. The plantation area covers about 200 acres.

Fig.1 : Siru Rijo Tea Factory

Tea manufacture process

The starting material in black tea[3] processing is the young shoot, the terminal bud and the two adjacent leaves plucked from the tea plant. The flush is processed in four distinct stages, which are withering, rolling, fermentation and drying. Each stage involves characteristic changes in the physical and biochemical composition of the leaves and the cumulative effect of these changes are ultimately reflected in the quality of

the finished product, namely the black tea. After the drying is over, the leaves are sorted, that is, divided into different grades and made ready for the market. The tea manufacturing process in flow chart form is shown in Fig.2

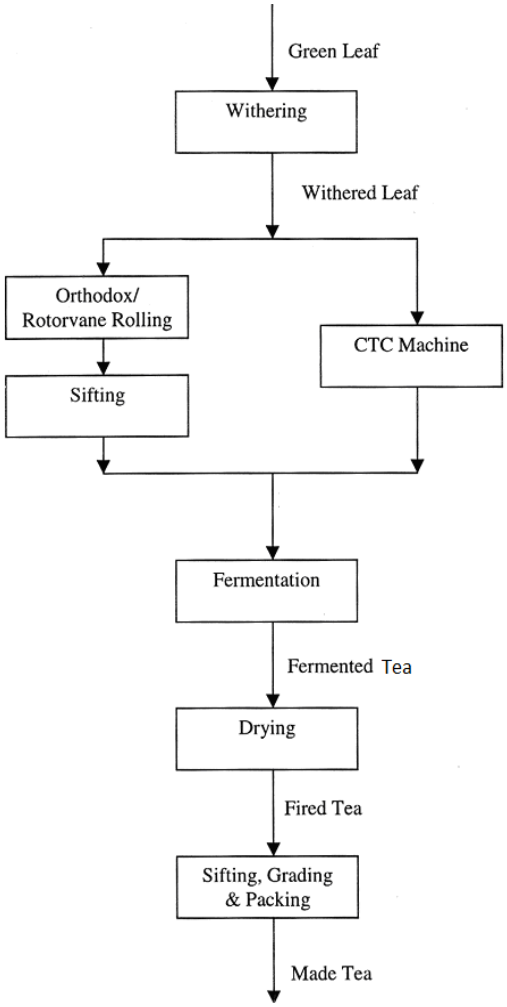


Fig.2: Block diagram of tea manufacturing process

Critical sections of the black tea manufacturing

There are mainly three critical sections in the black tea manufacturing which influence the quality of the black tea. Those are withering, fermentation and heating sections.

Withering:

It is a physical and chemical change to bring down the moisture content[4] of the leaves to 67 to 73% approximately depending upon the nature of the leaves and the weather conditions. The critical part here is that the expert personnel has to decide the moisture content of leaves by human sensory (by hand). It is shown in Fig.3

Fig.3: Withering Trough of Rijo Tea Plant

Fermentation:

It is the process of oxidation of leaves. The mechanical aspect involves spreading out of the leaves macerated by rolling a layer 5-8 cms thick, for 45 minutes to 3 hours, depending on the quality of the leaves. Fermenting machines make the process continuous, that is, every unit of macerated leaf has to be spread out for individual treatment. At the end of the process, the achievement of the right degree of fermentation is judged manually by observing the aroma[5-6] (apple type smell) and colour (copper brown). At present no instruments are used. It is shown in Fig.4

Fig 4.: Fermentation section of Rijo Tea Plant

Drying:

After fermentation, the leaf is dried (Fig.5) either in the conventional chain driers or in fluidized bed driers. Leaf is fed constantly to the chamber on the moving trays and hot air mixed the ambient air is fed as the heating media. The temperature at the inlet and exhaust air has to be constantly monitored[7-10]. At present only the dial type of thermometers are used in some factories. Some experimental work has been reported by the industry towards development of electronic temperature meters but no other parameters are measured and the operation is still totally manual. In this process the moisture content of rolled and fermented leaves are reduced from 45-50%.

Fig.5: Heating section of Rijo Tea Plant

Siru Rijo factory operation:

The Siru Rijo factory (Fig.6) operations from withering section till sorting are either manual transfer or manually operated conveyors. Moreover, all the machineries of the plant are manually operated which includes calibration of the machineries manually.

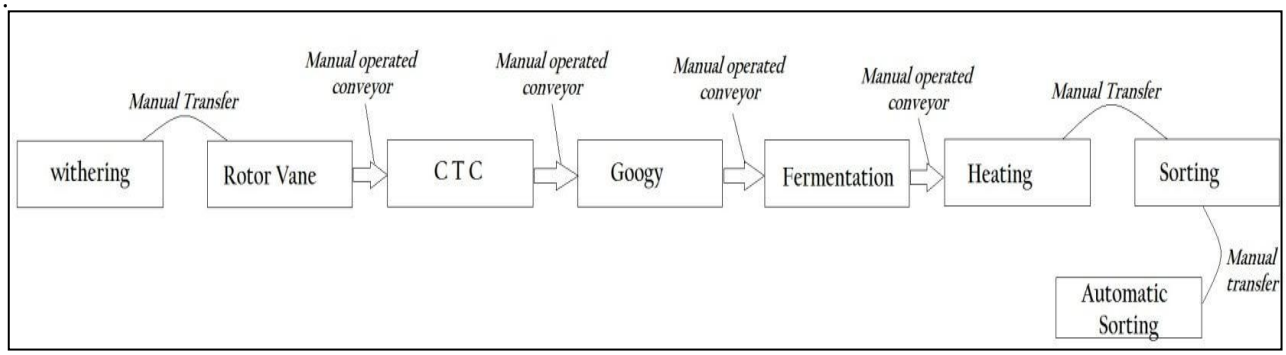


Fig.6: Existing process operation in tea manufacturing of Rijo Tea Plant

Design and Development of CIM system for Siru Rijo Tea Plant

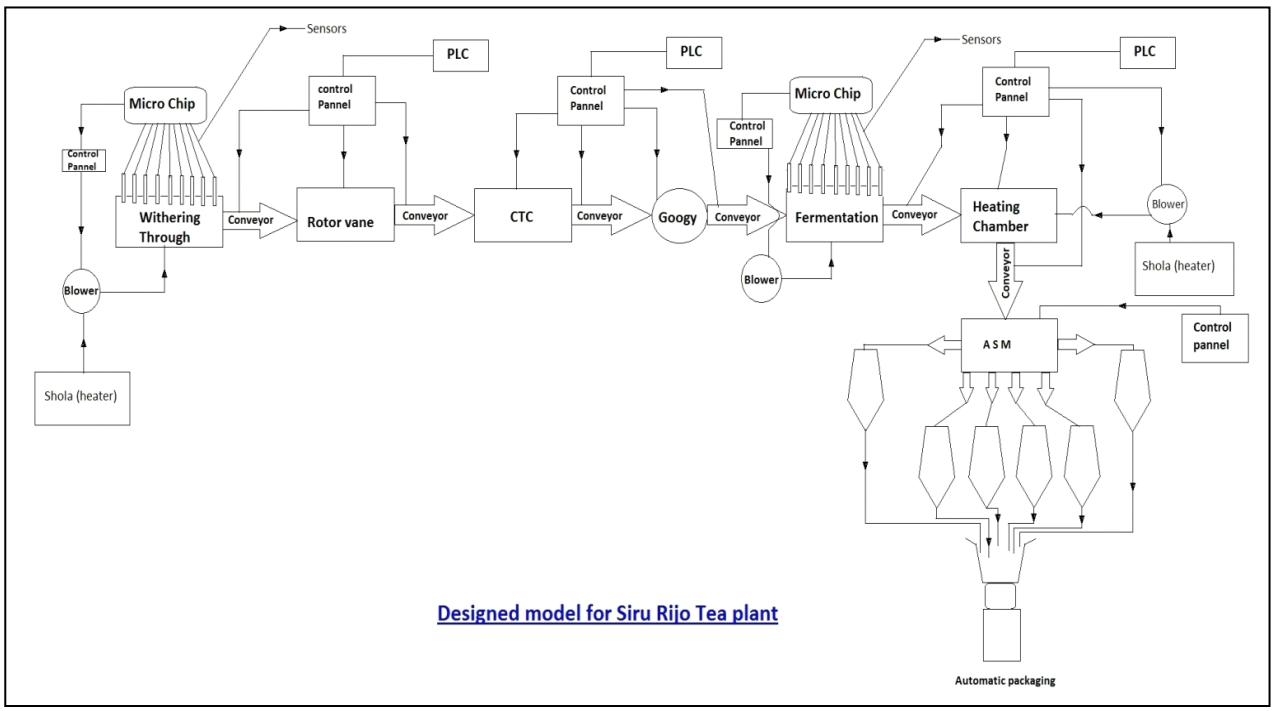


Fig.7: Design proposal for automation of the Siru Rijo tea plant.

The design model (Fig.7) includes the automated system by replacing manual operated system as well as expert personnel. The new designed system includes systems in the (a) Withering section using sensors and micro controller, (b) Automatic transfer using PLCs between every section of the plant, (c) Fermentation section, using Electronic Nose sensors, CCD cameras and microchip, (d) Heating section incorporates thermal sensors and microchip. This design system is a part of M.Tech thesis of CIMA (Computer Integrated Manufacturing and Automation).

Design and development of sub-systems of tea manufacturing for critical sections of the Siru Rijo Tea Plant:

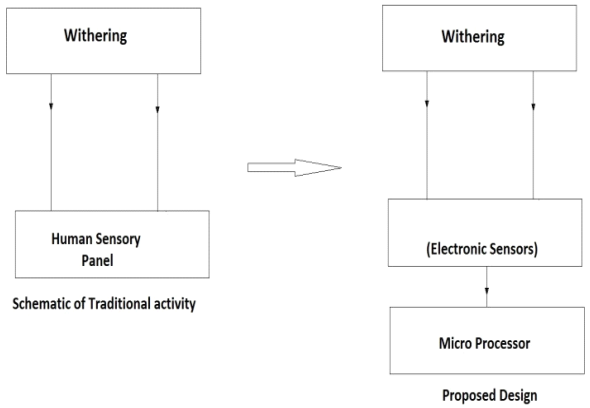


Fig.8: Withering operation

Withering section

As withering (Fig.8) is one of the most critical sections that influence the quality of the made tea. The traditional activity involves human errors most frequently and has to be constantly monitored. Here is an attempt to replace the traditional activity by replacing electronic sensors (Moisture detectors) and microprocessor.

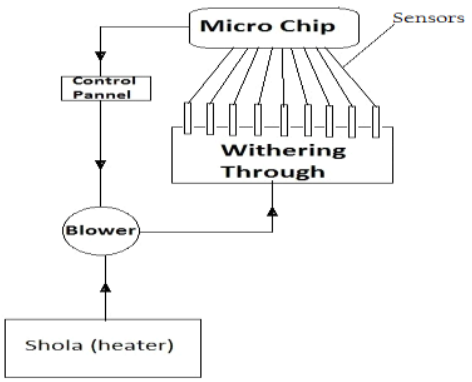
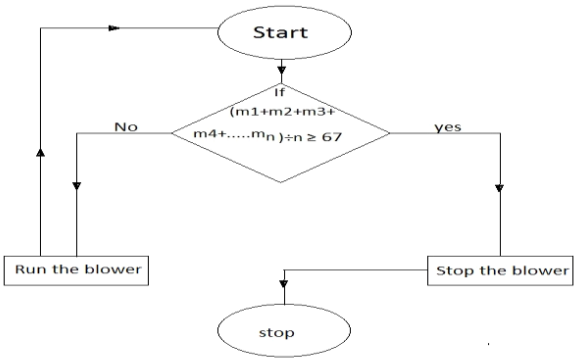


Fig.9: Design of computer based withering system

There will be a number of moisture detecting sensors inserted (Fig.9) in defined positions in a withering trough. The readings of these sensors will be read by the microchip. Microchip will calculate the average of the readings and compares the readings with its database as shown in a flow chart below (Fig.10).



Where: " m " is the moisture content.

" n " is the number of sensors employed.

Fig.10: Flow chart for moisture control

To demonstrate the working of the microchip, a C and C++ programming codes are developed for correct withering of the leaves.

```
#include<stdio.h>
#include<conio.h>
#include<time.h>
#include<iostream.h>
main()
{
time_t start_time;
time_t current_time;
start_time = time(NULL);
current_time = time(NULL);
int n,moist[100],sum = 0,avg = 0,i;
cout<<"enter the nos. of sensors to be implemented in the experiment\n";
cin>>n;
cout<<"*******\n";
while (avg <= 50)
{
for(i=1;i<=n;i++)
{
cout<<i<<" sensor = ";
```

```
cin>>moist[i];
sum = sum + moist[i];
}
avg = sum/n;
cout<<"average = "<<avg<<"\n";
cout<<"sum = "<<sum<<"\n";
while (current_time < start_time + 4)
{
cout<<"blowing\n";
current_time = time(NULL);
}
sum = 0;
start_time = current_time;}
cout<<"\n**********************************";
}
```

When the desired value of moisture content is achieved, the microchip will give an electrical signal to stop the blower and to start the conveyor belt for further processing.

Fermenting section:

It is also one of the most critical sections (Fig.11) that determines the quality of black tea. There are two very important parameters that expert personnel have to constantly monitor which are "Aroma and Copper Brown colour". The computer based model for this system to eliminate the human errors is presented in Fig. 11.

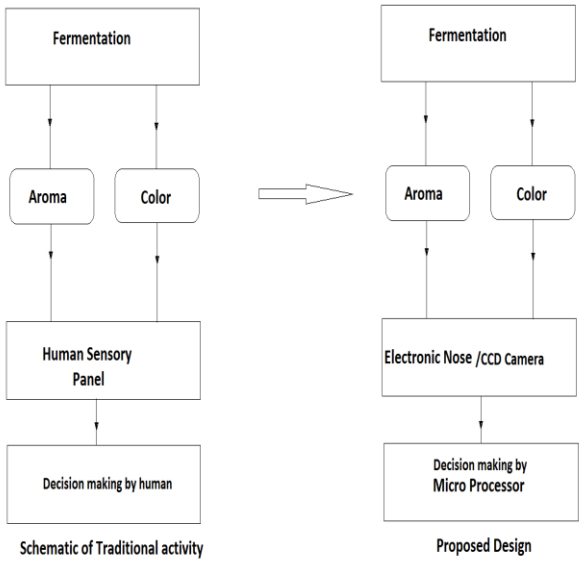


Fig.11: Schematic and proposed design for fermentation.

There will be "n" numbers of electronic nose sensors and at least two CCD cameras employed in the fermentation chamber. The block diagram below shows how the Electronic Nose sensors and CCD cameras will be arranged in the system (Fig12).

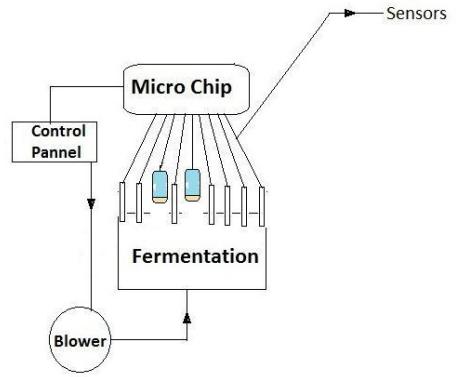


Fig.12 : Sensor based fermentation control

To detect the aroma there will be Electronic nose sensors which will be engaged to sense the aroma of the tea. Electronic nose sensors works on the application as shown in Fig.13.

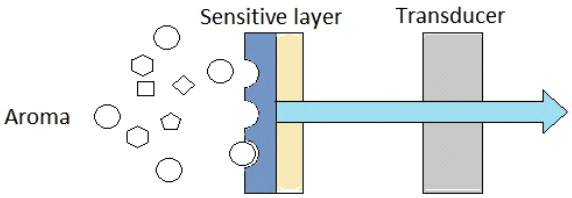


Fig.13: Working principle of Electronic Nose

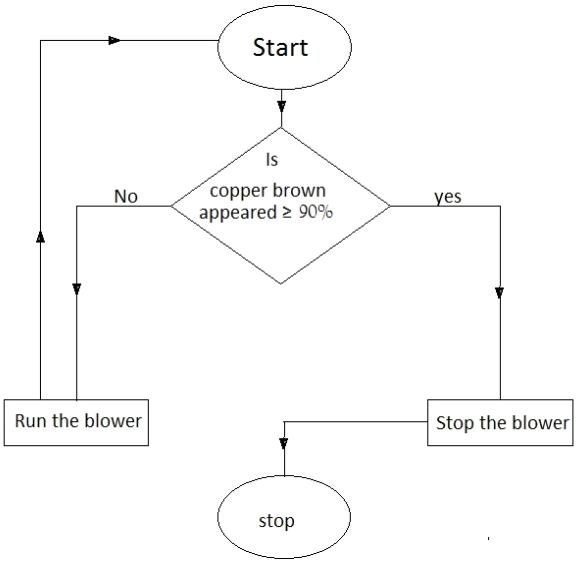


Fig. 14: Flow chart of color and blower control

This sensor will sense the required aroma and will transduce it into electrical pulses. Which will be received by microchip. The flow chart shows the functions of the microchip (Fig.14). The microchip will stop the blower when the required percentage of aroma and colour is achieved.

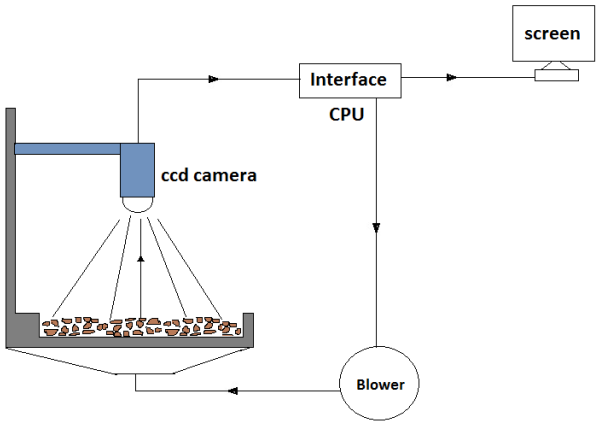


Fig.15 : Color detecting setup.

III. DISCUSSIONS AND CONCLUSIONS:

A study has been made to identify the various critical sections of the tea plant and an attempt has been made to design and develop a computer based system to improve the quality and the productivity of the tea plant in withering and fermentation section at Siru Rijo plant in Arunachal Pradesh. It is expected that by incorporating the computer based systems, the quality of the tea will be improved significantly as it will reduce the human errors usually occur in withering, fermentation and heating sections. Moreover, it is expected to reduce the cycle time of operations at each section. Hence, there will be overall improvement in the productivity and quality of the tea in terms of labor input time, operation cycle time and energy consumption in each section.

IV. ACKNOWLEDGEMENT:

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