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ANN CONTROL OF PAPER DRYING PROCESS

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Abstract

In this proposed work model for the paper drying process has been designed in Matlab Simulation toolbox for modelling ,the drying section divides into component such as PAPER, CANVAS, AND CYLINDERS. The dynamic model of these component are represented as lumped parameter system and connected to each other to model the entire paper drying process. Matlab simulation helps in developing model for paper dryer. simulation studies are carried out to study the effect of grade change and other process variables on the final moisture of the paper. the novel approach of modelling the paper dryer as lumped parameter system reduced he numerical complexity of the model .than this process is controlled by using classical and ANN control both.

Keywords-Introduction, Development Of ANN Model Of Paper Drying Process, Result And Analysis, Conclusion, References.

1-1.1 Introduction of paper machine:-

Paper drying process is a subsystem of paper making process. Paper is the final product. Paper is used for printing and writing, for wrapping and packaging and for a variety of other applications ranging from kitchen towel to the manufacture of building material , it simply comes in an enormous variety of quantities. Some common types of paper qualities include the following:

- Writing paper
- Newsprint
- Cardboard
- Light-weight coated paper for magazines
- Fax papers

The function of a paper machine is to form the paper sheet and remove the water from the sheet. A paper machine is divided into three main parts, the wire section, the press section and the drying section shown in fig 1.1, when a stock enters the head box in the wire section it contains roughly 1% of fibre or less. The viscous mix is dispensed through a long slice onto the wire. As it travels on the wire, mu of the water drains way by gravitational forces or is pulled away by suction from underneath. As a water disappears, the cellulose fiber starts to adhere to one another by hydrogen bonds and form a paper web. when the paper web leaves the wire section and enters the press section ,the dry solids content around 20%. In the press section, the newly formed sheet is pressed between rotating steel rolls and water is displaced into a press felt. After a few press nips the web enters the drying section with a solid content of approximately about 50%. It now encounters the dryer cylinders. These are large hollow metal cylinders, heated internally with steam, which dry the paper as it passes them, Finally the paper wound up on a big roll and removed from the paper machine .the moisture content is now roughly 5-10%.

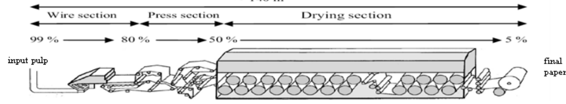

Figure 1.1 Paper machine sub section

1.2 Introduction Of Drying Section:-

Paper dryer is an important equipment in paper making process. The dryer section is the last part of the paper machine which consist of series of steam drums. The most common way to evaporate water from the paper web is to use the latent heat of vaporization in steam. A steam-filled dryer is a cost effective method to transfer heat into the sheet. The moist paper web is rolled on these steam fed drums. Where the steam is used to evaporate the moisture from the web. The heat to the paper web is controlled by the steam pressure in the drum. The drying section consumes 70% of the

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total steam used in the paper mill. During grade transition, the drying section consumes energy without producing desired quality of paper. The paper making dryer has several cylinder configuration, some are described below-

1.3 Cylinder Configuration In The Drying Section:-When the steam enters the cylinder it releases its thermal energy to the cast iron shell and condenses into water. This condensate is drawn off by suction with a siphon and fed back to the boiler house. The steam is typically fed to the cylinder on the back side of the machine, and condensate is evacuated on the front side.

There are mainly two types of dryer arrangement today, The single-tier design and two-tier. The configuration of two-tier and single tier are most commonly used and shown in Fig.1.2 and 1.3 respectively. Here two separate fabrics are used, one is used on the top cylinder and the other on the bottom cylinder.wet paper is transferred unsupported from one dryer to the next, and this can cause problem like wrinkles and sheet breaks. To prevent these runnability problems at higher machine speeds, In single–tiertechnique a single fabric is supporting the web on both the top and the bottom cylinders, as well as in the passage between them. Since the fabric is between the web and the cylinder in the bottom row, no significant drying occurs there.

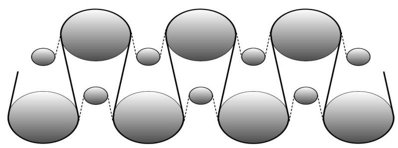

Figure 1.2 two-tier configuration

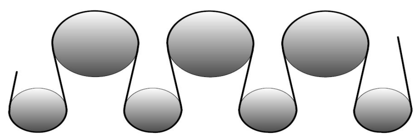

Figure 1.3- single-tier configuration

1.4 Factors Affecting On The Moisture In The Paper :-There are large number of variables that determine the moisture in the paper sheet,shown in **fig1.4.** To indicate the complexity of the problem some of them are listed below.

- **Production speed-** Affects the amount of steam needed, since high production also involves higher vaporization.
- **Dry weight-** A thick sheet is more difficult to dry than a thin sheet at the same production speed.
- **Inlet moisture-** The moisture content of the sheet after the press section is a disturbance variable that normally is unknown.
- **Degree of Refining-** The parameter naturally affects both the freeness and the ability to dry the sheet
- **Air dew point-** A high dew point inhibits effective evaporation.
- **Dryer Fabric Condition-** An old fabric can be clogged and give a higher evaporation resistance.
- **Bulk-** High bulk means that the water inside the web has a longer transport distance to the surface and ambient air.
- **Web Tension-** High web tension increases the heat transfer coefficient and the drying rate.
- **Leakage air-** The air from the machine room is cooler that the preheated supply air and therefore impair the drying condition
- **Ply loading-** In paperboard, different layers consist of different pulps, hence different physical properties. This influences the drying

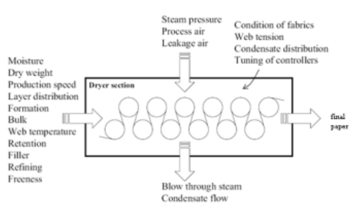

FIGURE 1.4 factors affecting on the moisture in the paper during drying process

2- 2.1 Development Of ANN Model Of Paper Drying Process-Today, a number of different controllers are used in industry and in many other fields. In quite general way those controllers can be divided into two main groups:

a)- conventional controllers

b)-unconventional controllers

As conventional controllers we can count a controllers known for years now, such as P, PI, PD, PID, all their different types and realizations, and other controller types . It is a characteristic of all conventional controllers that one has to know a mathematical model of the process in order to design a controller. Unconventional controllers utilize a new approaches to the controller design in which knowledge of a mathematical model of a process generally is not required. Examples of unconventional controller are a fuzzy controller and neural network or neuro-fuzzy controllers.

2.2)- Conventional controllers-

However, it is known that a good many nonlinear processes can satisfactory controlled using PID controllers providing that controller parameters are tuned well. Practical experience shows that this type of control has a lot of sense since it is simple and based on 3 basic behavior types: proportional (P), integrative (I) and derivative (D). Instead of using a small number of complex controllers, a larger number of simple PID controllers is used to control simpler processes in an industrial assembly in order to automates the certain more complex process. PID controller and its different types such as P, PI and PD controllers are today a basic building blocks in control of

various processes. In spite their simplicity, they can be used to solve even a very complex control problems, especially when combined with different functional blocks, filters (compensators or correction blocks), selectors etc. A continuous development of new control algorithms insure that the time of PID controller has not past and that this basic algorithm will have its part to play in process control in foreseeable future. It can be expected that it will be a backbone of many complex control systems.

2.3)-Unconventional controller-

a)-neural network-Artificial neural networks are an attempt at modeling the information processing capabilities of nervous systems. Thus, first of all, we need to consider the essential properties of biological neural networks from the viewpoint of information processing. This will allow us to design abstract models of artificial neural networks, which can then be simulated and analyzed. Although the models which have been proposed to explain the structure of the brain and the nervous systems of some animals are different in many respects, there is a general consensus that the essence of the operation of

neural ensembles is “control through communication” . Animal nervous systems are composed of thousands or millions of interconnected cells. Each one of them is a very complex arrangement which deals with incoming signals in many different ways. However, neurons are rather slow when compared to electronic logic gates. These can achieve switching times of a few nanoseconds, whereas neurons need several milliseconds to react to a stimulus. Nevertheless the brain is capable of solving problems which no digital computer can yet efficiently deal with

b)-fuzzy logic-Fuzzy logic is based on the theory of fuzzy sets, where an object’s membership of a set is gradual rather than just member or not a member. Fuzzy logic uses the whole interval of real numbers between zero (*False*) and one (*True*) to develop a logic as a basis for rules of inference. Particularly the fuzzified version of the modus ponens rule of inference enables computers to make decisions using fuzzy reasoning rather than exact.

2.4. Proportional-Integral-Derivative (PID) controlPID control logic is widely used in the process control industry. PID controllers have traditionally been chosen by control system engineers due to their flexibility and reliability [3].
A PID controller has proportional, integral and derivative terms that can be represented in transfer function form as

$$K(s) = K_p + \frac{K_i}{s} + K_d s$$

where represents the proportional gain, represents the integral gain, and represents the derivative gain, respectively. By tuning these PID controller gains, the controller can provide control action designed for specific process requirements .
The proportional term drives a change to the output that is proportional to the current error. This proportional term is concerned with the current state of the process variable. The integral term () is proportional to both the magnitude of the error and the duration of the error. It (when added to the proportional term) accelerates the movement of the process towards the set point and often eliminates the residual steady-state error that may occur with a proportional only controller. The rate of change of the process error is calculated by determining the differential slope of the error over time (i.e., its first derivative with respect to time). This rate of change in the error is multiplied by the derivative gain.

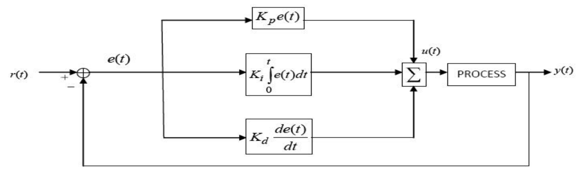

Fig 1.5 PID control unit

2.5)- Introduction of Neural Networks-

Model of Biological Neurons- In general, the human nervous system is a very complex neural network. The brain is the central element of the human nervous system, consisting of near 1010 biological neurons that are connected to each other through sub-networks. Each neuron in the brain is composed of a body, one axon and multitude of dendrites. The neuron model [fig 4.5] serves as the basis for the artificial neuron. The dendrites receive signals from other neurons. The axon can be considered as a long tube, which divides into branches terminating in little endbulbs. The small gap between an endbulb and a dendrite is called a synapse. The axon of a single neuron forms synaptic connections with many other neurons. Depending upon the type of neuron, the number of synapses connections from other neurons may range from a few hundreds to 104. The cell body of a neuron sums the incoming signals from dendrites as well as the signals from numerous synapses on its surface. A particular neuron will send an impulse to its axon if sufficient input signals are received to stimulate the neuron to its threshold level. However, if the inputs do not reach the required threshold, the input will quickly decay and will not generate any action.

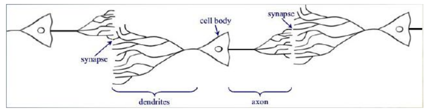

Fig 1.6 biological neuron

Table 1 comparison between biological and Artificial neural network

Parameters	Biological	Artificial
Processing elements	Synapses 10^{12}	Transistors 10^{8}
Memory/CPU	Same thing	Separate thing
Energy use	10^{-12} Watt/neuron	10^{-5} watt/gate
Processing speed	100Hz	10^{9} Hz
Learns	Yes	A little

2.6 Development of model

designing steps for modeling of classical and ANNcontrol model is describe in sec 2.6.1 & 2.6.2

2.6.1 Development Of Classical Controller model The process transfer function suggested by Mr. Nelson[1]. This transfer function is simulated with the help of classical controller. the controller has been trained automatically with the help of Matlab software. Classical control loop system is shown in fig 1.7-

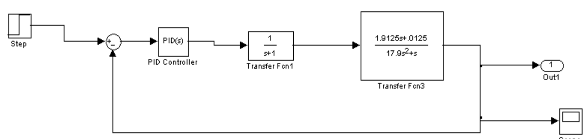

Fig 1.7 model for classical controlling

Step for designing the classical controller closed loop

- Open the window of Matlab software
- Click on simulink icon
- Take different symbols from simulink library
- Connect all blocks
- Run the simulated model
- For this simulated model, collect the input data
- This data can be used for trained Neural Network

2.6.2 Development Of ANN controlled model

There are several controller suitable in the literature. out of them supervised control id most suitable for controlling purpose. In the control ,BPNN has been used. Neural network controlled system is shown in fig 1.8

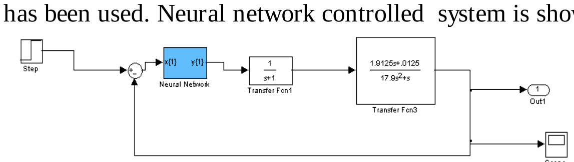

Fig 1.8 model for ANN control

The steps for ANN modelling is as follows

- ➢ Open the window of Matlab software
- ➢ Open editor window, and write a program for SISO system

Unsupervised Program for proposed model

```
net=newff([0 10],[3 1],{'logsig','logsig'},'traingd') % newff-for BPNN feedforword network
net.trainparam.show=100;                          % parameter show every 100 itteration
net.trainparam.lr=.6;                             % learning rate
net.trainparam.mc=.9;                   % momentum coefficient
net.trainparam.epochs=10000;            % no of itteration
net.trainparam.goal=.0001;
p=tout'                     % tout obtained from classical controlled model
\t=yout';                   % yout obtained from classical controlled model
[net,tr]=train(net,p,t);          % trained network
y=sim(net,p)
gensim(net,.001);                        % generate simulation output
```

- ➢ Run this program
- ➢ Get the trained neural network
- ➢ Used this network to design neural network controlled model
- ➢ Get the out put from this network

2.7 Designing Parameters used in proposed work The designing parameters for this proposed work are as follows-

- ➢ Input range-0 to 10
- ➢ No. Of hidden layers-2
- ➢ No of Output-1
- ➢ Activation function- log sign activation function used in proposed network.
- ➢ Learning rate-

Learning rate for proposed network is 0.6

3-3.1 Classical Model Analysis :

The classical model of the system has been developed shown in Fig [1.7] . After modeling the system, this model is tunned automatically. The tuning of controller response is shown in Fig 1.9. It reveals that the closed loop system is stable when the performance parameters of the system are Rise time of the order of 294 sec, Settling time of the order of 3.28e+003 sec, Overshoot of the order of 7.07%, Gain margin of the order of 45.8 @ 0.235 db@ rad/sec & Phase margin of the order of 78.2@ .0054 db@ rad/sec. but the values of performance parameters set manually such as Proportional gain of the order of .4002, integral time or reset time of the order of .00022403 & derivative time time or set time of the order of 62.3227.

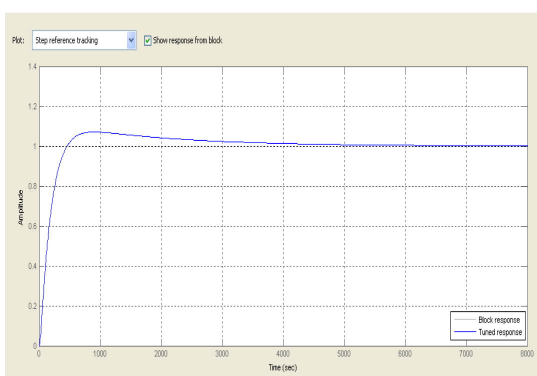

Fig 1.9 result By PID controlling

3.2 ANN Model Analysis:

The ANN model of the system has been developed shown in Fig [1.8] . After modeling the system, this model is tunned. The tuning of controller response is shown in Fig 1.10 to It reveals that the closed loop system is stable when the performance parameters of the system are No. of epochs of the order of 10000,Time taken for tuned the network of the order of .45sec, Performance of the order of .108% , Gradient of the order of .000179.

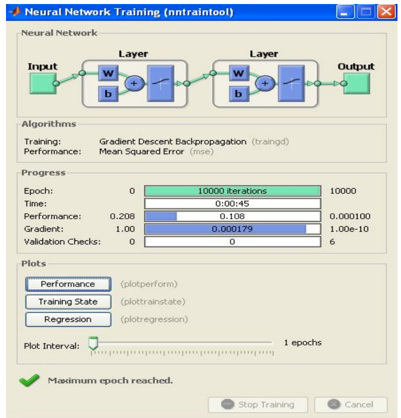

Fig 1.10 neural network training

Thus the best performance of ANN controlled model is achieved after 10000 epches or 10000 itteration and model is trained with Regression Coefficient at .95063 and gradient decent at .00017895 .

Fig 1.11,1.12,1.13,1.14 shows the neural network, hidden layers, updated weight, for layer 1 and layer 2 respectively

fig 1.11 represents the block diagram of neural network in which x{1} input is processed by the neural network to provide an output y{1}

In fig 1.12 there are 2 hidden layers in this proposed model. In which P{1} in input for hidden layer 1 whose output is a{1} which act as an input for hidden layer 2.the output of layer 2 is a{2] which act as input for process output layer

In fig 1.13,1.14,1.15 updated weights are calculated for overall process model , layer 1 and layer 2 respectively to train this proposed model

Updated weights for overall process model are-IW{1,1} and bais b{1}

Updated weights for layer 1- IW{1,1} (1,:)', IW{1,1} (2,:)' , IW{1,1} (3,:)', IW{1,1} (4,:)'

Updated weights for layer 2- LW{2,1} and bais b{2}

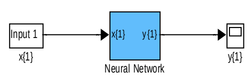

Fig 1.11 neural network

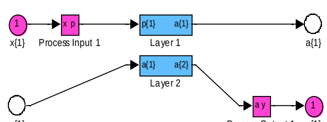

Fig 1.12, hidden layers

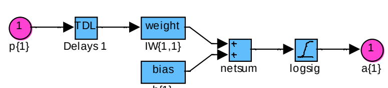

Fig 1.13 updated weight

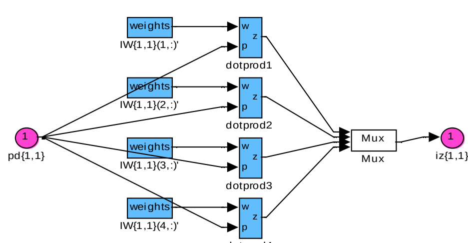

Fig 1.14, updated weight for layer 1

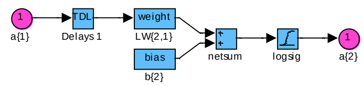

Fig 1.15 updated weight for layer 2

Fig 1.16 is the final process result that shows the steam inflow in dryer section which varies linearly with applied pressure on the valve in the dryer section to evaporate water from paper

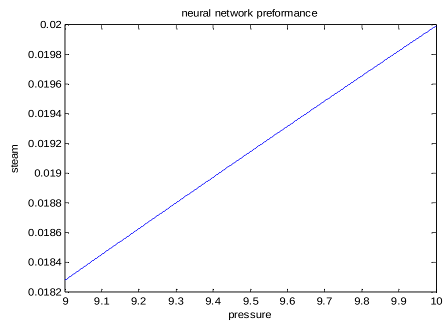

Fig 1.16 Result By ANN controlling

4- Conclusion

This project presents modeling and simulation of a paper drying machine. A SIMULINK model of the drying machine is developed considering the effects of moisture,pressure and temperature. Modification of paper machine SIMULINK model is done to obtain the model of a drying process. The theoretically obtained characteristics of the paper drying experimentally verified for different ambient conditions.

Different drying system parameters were studied and it was concluded as a Matlab model. SIMULINK model was developed for a paper drying process. After that we get the stable system by using different types of controller. which gives the relation between pressure and Steam of the dryer section to get the final dry web.

FUTURE WORK

Our future study will design an improved algorithm for paper machine. The preliminary idea is to use the model equations for temperature and pressure. In future we can also make simulink model for other parameters affecting on paper drying process.and we can also use Neuro_fuZZY system to control this process.

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