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Design and Simulation of PID Controller based Pressurized Head Box in Paper Machine

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***Abstract*: The head box in a paper machine is a critical component. Head box control is required for quality paper formation. Stock level and Total pressure in the paper machine head box determines the quality of the paper. This paper determines the design of PID controller for the pressure type head box. The stock level and pressure are the parameters taken into consideration.**

***Keywords*: Head box, Paper machine, PID controller, Pressure and Stock head.**

I. INTRODUCTION

The production of Paper and pulp is increasing despite the growth of Information technology. Paper plays a major role in day-today life. Paper production sector is one of the high demand sectors in Industrial production. First paper was invented in China [1]. Many research and developmental process have been concentrated for the improvement of paper quality. The quality of the paper depends on the paper machine process which has many sub processes. One of the most crucial process involves the control of stock and pressure in head box. The head box distributes the pulp evenly to the wire section.

Control of head box is essential for the production of quality paper [2]. This paper involves an air cushion pressurized head box for designing a controller [3]. The paper machine head box is represented in Figure.1. The goal of this paper to design a PID Controller based pressurized head box.

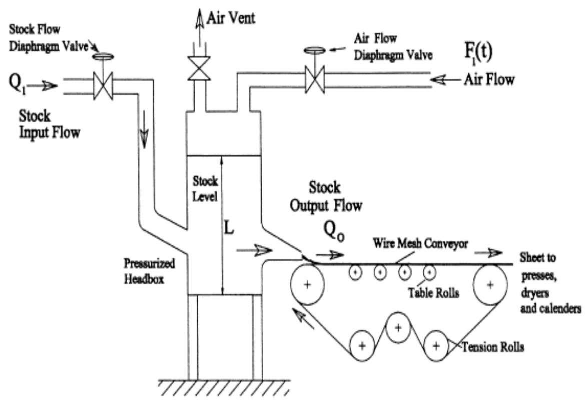

Fig. 1 Paper machine Head box [4]

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II. MODELLING OF HEADBOX

The head box model is considered from [4,6] as follows:

$$\begin{bmatrix} y_1(s) \\ y_2(s) \end{bmatrix} = \begin{bmatrix} \frac{0.528e^{(-0.6s)}}{(2.2s+1)} & \frac{(1.2539s+.063}{(30.051s^2+17.79s+1)} \\ \frac{(0.0205s+.000149)e^{(-1.5s)}}{(43.6s^2+s)} & -\frac{(0.0007)e^{(-2s)}}{s} \end{bmatrix} \begin{bmatrix} u_1(s) \\ u_2(s) \end{bmatrix} \quad \text{----(1)}$$

The model is approximated to,

$$\begin{bmatrix} y_1(s) \\ y_2(s) \end{bmatrix} = \begin{bmatrix} \frac{0.528e^{(-0.6s)}}{(2.2s+1)} & \frac{0.081}{(1.89s+1)} \\ \frac{(1.49\times10^{-4})e^{(-1.5s)}}{s} & -\frac{-7\times10^{-4}\,e^{(-2s)}}{s} \end{bmatrix} \begin{bmatrix} u_1(s) \\ u_2(s) \end{bmatrix} \text{------ (2)}$$

$$P_{Headbox}(S) = \begin{bmatrix} \frac{0.528e^{(-0.6s)}}{(2.2s+1)} & \frac{0.081}{(1.89s+1)} \\ \frac{(1.49\times10^{-4})e^{(-1.5s)}}{s} & -\frac{-7\times10^{-4}\,e^{(-2s)}}{s} \end{bmatrix} \text{------- (3)}$$

Where,
y1 – Pressure level in the head box
y2 – Stock level in the head box
u1 – Speed of the feed pump
u2 – air valve position.

The controlled variables in head box taken into consideration are pressure and stock level where the manipulated variables are speed and the air valve position. For the design of controller, a decoupled model is obtained [6]. A static decoupling method is used for the design purpose.
The decoupled models are:

$$P_{11}(s) = \frac{-0.288s^2 + 0.8825s + 0.5452}{1.247s^3 + 5.365s^2 + 4.39s + 1} \qquad \text{------ (4)}$$

$$P_{22}(s) = \frac{5.421s^2 + 1.693s - 7.229}{s(7500s^2 + 17500s + 10000)} \qquad \text{------ (5)}$$

where $P_{11}(s)$ represents the pressure of head box and $P_{22}(s)$ represents the stock level of head box. The above models are taken into consideration for the design of PID controllers.

III. DESIGN OF PID CONTROLLER

PID controller is simple in configuration and its ease to design; it is widely used in most of the industrial processes. The tuning techniques brings out the massive performance of the PID controller. Proportionality constant (kp), integral constant (ki) and derivative constant (kd) are the three basic parameters of PID controller. The dynamic response of the system is improved by tuning of these parameters.

Elimination of steady state error and reduction in overshoot increases the stability and performance of the system [7].

$$C(s) = U(s)/E(s) = kp + ki/s + kds$$

Total Pressure of head box

By the tuning of the controller for the pressure of head box eq. (4), the response is obtained by MATLAB Simulation as shown in figure 2. The controller values are considered as Kp = 9.68, Ki=12.05, kd = 1.86.

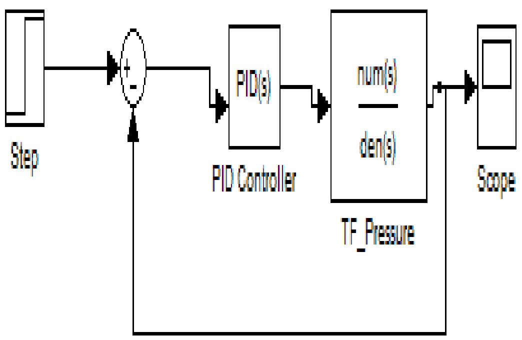

Fig. 2 Simulink SISO model of Head box Pressure

Total Stock Level of head box

By the tuning of the controller for the stock level of head box eq. (5), the response is obtained by MATLAB Simulation as shown in figure 4. The controller values are considered as Kp = -836.35, Ki=-264.32, kd = -645.69.

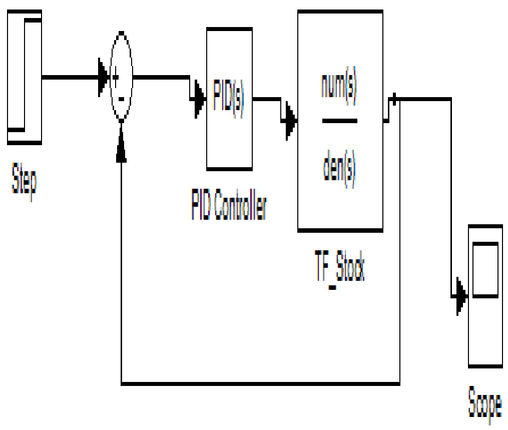

Fig. 3 Simulink SISO model of Head box Stock Level

IV. RESULTS AND DISCUSSION

This section deliberates the analysis performance of controllers designed for the head box in paper machine. The step response analysis of the SISO models of Pressure and Head box are shown in figure 4 and 5. The response parameters are shown in Table 1 and 2.

The step response of Pressure in Head box of a paper machine is obtained as:

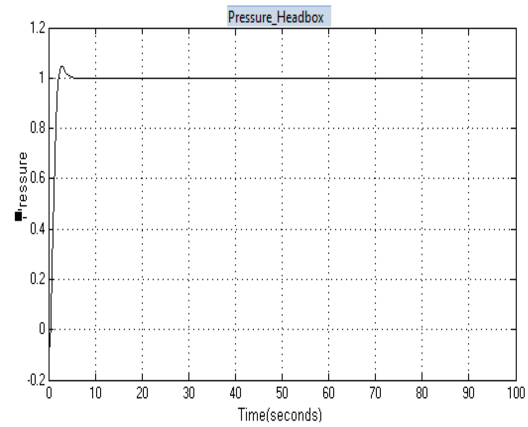

Fig. 4 Step response of Head box Pressure

Table. 1 Response of Pressure

Rise time (sec)	1.17
Settling time (sec)	3.83
Overshoot (%)	5.14
Peak	1.05

The step response of stock level in Head box of a paper machine is obtained as:

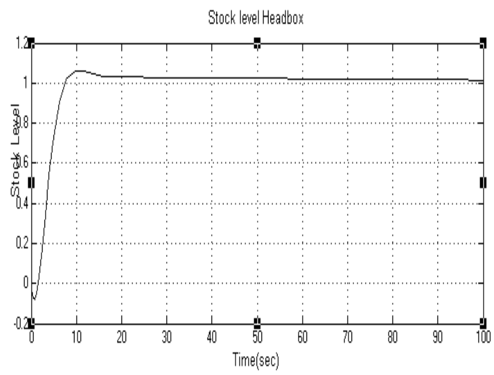

Fig. 5 Step response of Head box Stock Level

Table. 2 Response of Stock Level

Rise time (sec)	5.47
Settling time (sec)	69.3
Overshoot (%)	6.07
Peak	1.06

V. CONCLUSION

From the results it is evident that the design of PID controller with step response analysis yields optimum results for SISO model.

The future scope of this work will be the comparison of performance on the basis of performance indices with different soft computing techniques.

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