International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 5 Issue: 4

ISSN: 2321-8169
251 – 257

Design & Implementation of Motion Controller for Industrial Paper Cutting Machine

Manikandan V. Reddiar[1] , Dr Anil Suthar[2]
[1]PG student,[2]Director,
Dept of Electronics and communication,L.J.I.E.T,A'bad,India
[1]*manikandan.reddiar@gmail.com*,[2]*sutharac@gmail.com*

Abstract— In order to solve a speed control, Speed measurement & synchronization problem, an effective motion controller is design & develop for paper cutting machine of papermaking plant. PID control algorithm was proposed to solve the problem in this paper. The speed closed-loop control was realized after studying & comparing different control algorithm. According to comparison of industrial application results, the applied control strategy to develop a motion controller truly guide, control & can accurately restrain the load disturbance and improve the control effect of synchronization for the cutter speed. This System proves how it can be a low cost solution in the production practice.

Keywords- *Motion Controller, PID Algorithm , Cutting , Synchronization, Encoder.*

*****

I. Introduction

As an important paper artifactitious device, paper cutting machine is mainly used for cutting in paper-making and printing enterprise [1], [2]. The cylinder hob cutting machine is usually adopted in most of domestic small and medium-sized paper-making enterprises, which applying the remote method to synchronous control for the speed, hence, the lower speed and accuracy lead some difficulties for improving the production efficiency, quality and even worse seriously re-stricted the development of enterprises. Under the premise of without changing the cutter mechanical structure, we in this paper proposed an motion controller with improved control algorithm and measure to increase the speed, accuracy and anti-disturbance capability, and via some experimental results to validate the considerable performance of our algorithm.

This paper is organized as follows. Section II briefly describes the background and some related work of paper cutting machine of cylinder hob. In Section III, some de-tailed information for the numerical implementation is clearly outlined. Detailed discussion and analysis are included with respect to industrial application in section IV. We end this paper by a general conclusions in Section V.

II. Technological Mechanism Analysis, Existed Problems & Objectives

A. Technological Mechanism Analysis

The main structure of cylinder hob paper cutting ma-chine [3], [4] is described as Fig. 1, which including: 1. unwinder reel, 2. longitudinal knife, 3. first feeding roll, 4. first revolving knife, 5. second feeding roll, 6. second revolving knife, 7. leading roll and etc. The source paper is drawn from the unwinder reel and then the wide paper is cut through the longitudinal cutter for the sake of satisfying the requirements of a plurality of narrow paper, once this process is finished, the paper is transformed to forward by the first feeding roll, one of them is directly forwarded to the first revolving knife, and the others are delivered to the second revolving knife and was cut into the required paper, finally packaged via the belt conveyor. The position of the longitudinal knife can timely alter and modify the paper width without requirement of speed control. The speed of two feeding roll could be revised according to the requirement of designing, the speed of the two revolving knives are determined by the length of cutting paper and feeding roll. The paper is cutting one time when the two revolving knives circumvolving one circumference. Speed of the cutting knife is necessary to make some relative revision when the paper length is changed or the speed of feeding paper is altered, therefore the synchronous control of the cutting knife determine the accuracy of the cutting paper [5], [6].

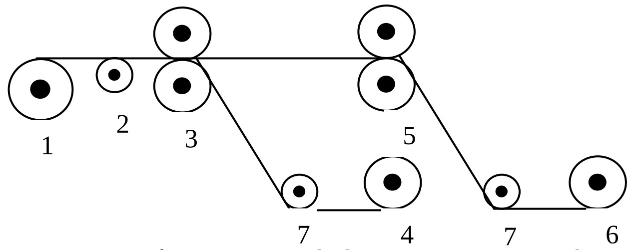


Fig. 1: Description for Structure c. ..linder H... Paper C....g Mach....

B. Existed Problem

Currently, the control systems of cylinder hob paper cutting machine are usually adopted the single-closed-loop plus the ratio control [7], the structure is demonstrated as following Fig. 1.

The disadvantages of the original system are presented:

1. Adopted remote method, weaker anti-jamming capability of the feeding roll speed v, inconvenience param-eters of the control and the parameters can not self-tuning.
2. On account of the outside disturbance, the linear speed of feeding roll is easily variation, so the control of cutting knife belong to servo system control system, moreover the rotate speed n of cutting knife lagged behind and the accuracy of the length L can not be guaranteed.

C. Objectives

1. Objective of this paper is to design the motion controller by briefly studying the PID algorithm, which can control & synchronize the speed of the DC motor of the paper cutting machine in such a way that the required length of paper size can be cut.
2. The paper cutting machines generally available in the market are generally manual and if automatic then it is very costly.
3. Objective is to develop, the kind of motion controller for paper cutting machine which is automatic, user friendly, accurate and less costly.

III. MOTION CONTROLLER

A motion controller controls the movement of some object system. Every now and again movement controllers are actualized utilizing computerized PCs, yet motion controllers can likewise be executed with just simple parts too. Motion controllers require a heap (something to be moved), a prime mover (something to bring about the heap to move), a few sensors (to have the capacity to detect the movement and screen the prime mover), and a controller to give the knowledge to bring about the prime mover to move the heap as wanted. Pretty much everything that is man-made requires movement control amid its produce, bundling, circulation .

Motion control can be essentially characterized as the exact control of anything that moves. The system consists of advance motion controllers, wiring and connectivity devices, motor drive units, software tools and interface to third party devices. Controllers generate trajectories, which the motor follows. Drives then take the signals sent by the controller and change them into signals that will actually move the motor. Feedback devices are used to close the control loop in closed-loop systems. For instance, consider an application that requires high torque, fast, and exact control. Since servomotors for the most part have higher torque at high speeds, a servomotor would be the most proper.

A. Motion Control System:

1. Designed for position and velocity control in variety of electromechanical configuration.
2. Optimized for use in test and measurement automation, laboratory automation, industrial control, Cartesian robotics, material handling, integrated machine vision, machine tool control and OEM applications.

B. Block Diagram & Components Of Motion Control System.

Application Software -You can use application software to command target positions and motion control profiles.

Motion controller -The motion controller acts as brain of the of the system by taking the desired target positions and motion profiles and creating the trajectories for the motors to follow, but outputting a ±10 V signal for servo motors, or a step and direction pulses for stepper motors.

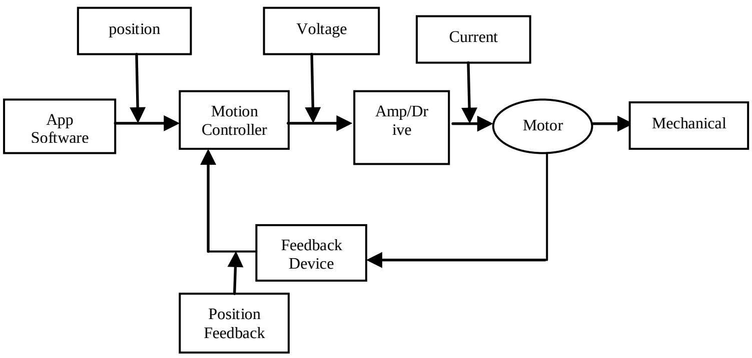


Fig 2. Components of Motion Control Systems.

Amplifier or drive -Amplifiers (also called drives) take the commands from the controller and generate the current required to drive or turn the motor.

Motor -Motors turn electrical energy into mechanical energy and produce the torque required to move to the desired target position.

Mechanical elements -Motors are designed to provide torque to some mechanics. These include linear slides, robotic arms, and special actuators.

Feedback device or position sensor -A position feedback device is not required for some motion control applications (such as controlling stepper motors), but is vital for servo motors. The input gadget, as a rule a quadrature encoder, faculties the engine position and reports the outcome to the controller, consequently shutting the circle to the motion controller.

ISSN: 2321-8169
251 – 257

IV. ALGORITHM USED TO DEVELOP MOTION CONTROLLER

PID (Proportional Integral Derivative)Method

PID controller is proposed for this project due to simplicity, robustness, provide closed loop response characteristics and can regulate time domain behavior of difference type of plants. PID Controller is the combination of proportional, integral and derivative terms.

Each of these terms can be determined by the user. These terms need to be adjusted to optimize the precision of control. The process of determining the values of these parameters is known as PID Tuning. The PID controller includes a proportional term, integral term and derivative term, where the proportional term is to adjust the output of controller according to all of the magnitude of error, the integral term is used to remove the steady state error of control system and improve the steady state response, the derivative term is used to predict a trend of error and improve the transient response of the system. These functions have been enough to the most control processes. Because the structure of PID controller is simple, it is the most extensive control method to be used in industry so far.

The PID controller is fundamentally to alter a suitable relative pick up (KP), necessary pick up (KI), and differential pick up (KD) to accomplish the ideal control execution [7]. Ordinary PID control is broadly utilized as a part of movement control due to its basic calculation and high unwavering quality. Be that as it may, a portion of the controlled protest has no exact numerical model practically speaking, which prompts to set the PID parameters intricately, in addition, the parameters as a rule have poor execution and hard to meet the high accuracy movement control of direct engine. In the event that fluffy calculation is utilized to set the online PID parameters, for example, Kp, Ki, Kd, it can not just hold the benefits of basic standards and advantageous utilization of the routine PID control framework, additionally possess the attributes, for example, adaptability and flexibility of the fluffy control, which can improve execution of the control framework effectively[8]. Over the past half century, analysts have looked for the following key innovation for PID tuning and particular acknowledgment. Many plan strategies can be electronic and, with reenactment bundles generally utilized, the pattern of computerizing simulation-based outlines is picking up force.A reenactment based approach requires no simulated minimization of the control abundancy and enhances drowsy transient reaction without windup. In handling PID issues, it is alluring to utilize standard PID structures for a sensible scope of plant sorts and operations. Modularization around standard PID structures ought to likewise help enhance the cost adequacy of PID control and support. Along these lines, powerfully ideal plan strategies, for example, PID simple can be produced. By including framework recognizable proof methods, the whole PID outline and tuning procedure can be mechanized, and particular code pieces can be made accessible for opportune application and constant adaptation[32].

A PID Controller consists of a proportional (P) element, integral (I) element and Derivative (D) element The PID algorithm is the most popular feedback controller widely used feedback control in industrial control system. The PID method is one of the most feedback control system that has been used more than 50 years ago. One of the most punctual cases of a PID-sort controller was created by Elmer Sperry in 1911, while the initially distributed hypothetical investigation of a PID controller was by Russian American engineer Nicolas Minorsky in 1922. It is a strong effortlessly comprehended algorithm that can provide fabulous control performance despite the varied dynamic characteristics of process plant. This is a kind of feedback controller whose output, a control variable (CV) is generally based on the error (e) between some user defined set point (SP) and some measured process variable (PV). Figure -- shows the general block diagram of PID controller.

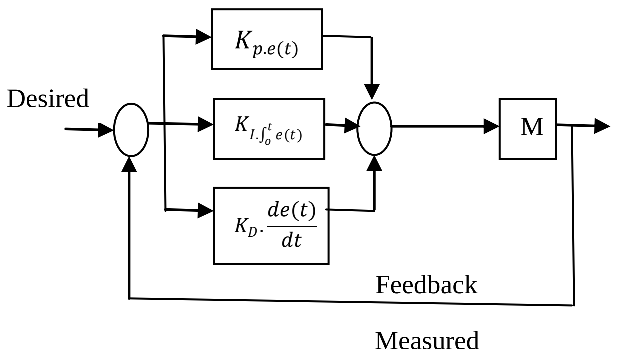


Fig 4. Block Diagram of PID Controller

The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. By defining u (t) as the controller output, the equation form of a PID controller as a continuos function of time is:

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau)d(\tau) + K_d \frac{de(t)}{dt} \qquad (2)$$

Where,

u(t) is a control signal (input to the plant)
Kp is a proportional gain (tuning parameter)
Ki is an integral gain (tuning parameter)
Kd is a derivatives gain (tuning parameter)

e(t) is an error term $\int_0^t e(\tau)d(\tau)$ is a summation of all past error over time $\frac{de(t)}{dt}$ is a rate of change of error term.

For the basic control system, the controller compares the measured value to a set point or reference voltage to get the error value and then the error signal will take the appropriate corrective action. The parameters of PID controller, Kp, Ki and Kd can be manipulated to produce various response curves from a motor controller.

$$e(t) = r(t) - y(t) \qquad (3)$$

where: r(t) is a set point (SP) or reference voltage
y(t) is a measured value or process variable

V. BLOCK DIAGRAM OF PROPOSED SYSTEM.

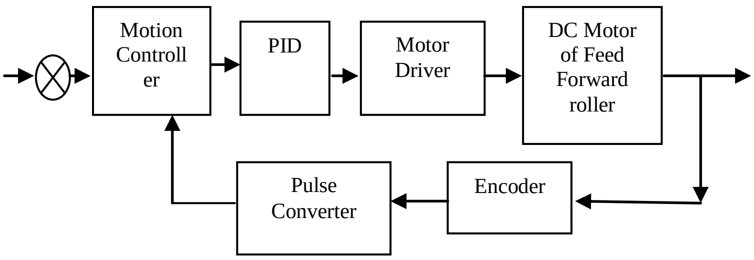


Fig 5. Block Diagram of Proposed Motion Controller with PID

A. DESCRIPTION OF BLOCK DIAGRAM

After Initializing & configuring the parameter of PID, Motion Controller sends the impulse to the motor driver who controls the DC Servo motor. Simultaneously the Position & Speed Control of the Motors are measured by Incremental Encoder & it's feedback is given to the cutter & Motion Controller, if there is a error then with the help of PID Parameters we can estimated & solve the error as per the user input.

Speed control of the DC motor which is attached to the mechanical load or roller is controlled by the value of K_P, K_I & K_D which is attached to the Encoder on the other side of the roller. The feedback of the encoder is given to the steeper motor which is attached to the cutter roller of the machine. As a result, if the user changes the value of PID then speed of the DC motor is changed & the pulse width measurement (PWM) value of the Encoder is also changed which changes the speed of the Stepper motor by its feedback mechanism. The speed response of the Uncontrolled DC motor is shown in fig.7. By implementing PID Algorithm the speed response of the DC motor is controlled which is shown in fig 8. Similary the speed response of the DC motor under load condition with or without PID is also shown in fig 9 & fig 10.

VI. FLOWCHART OF PROPOSED SYSTEM

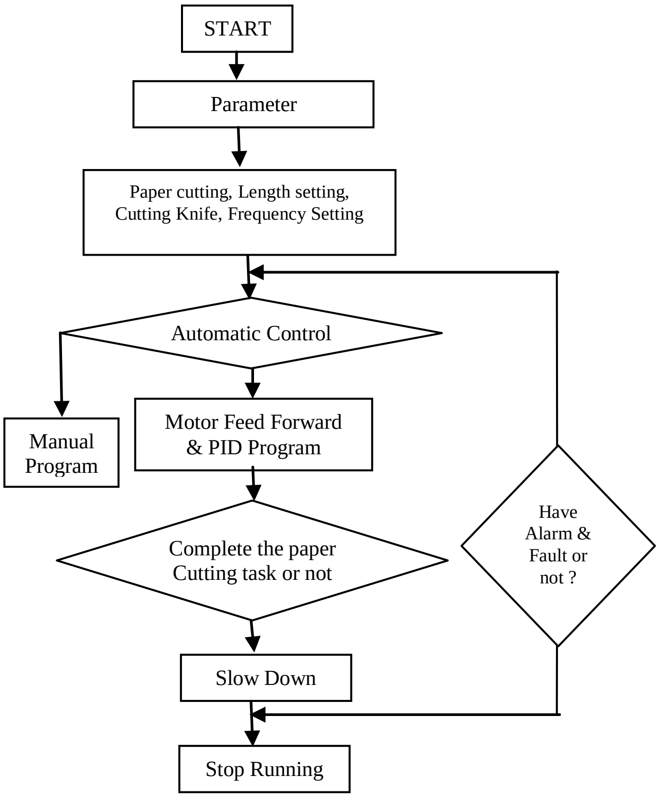
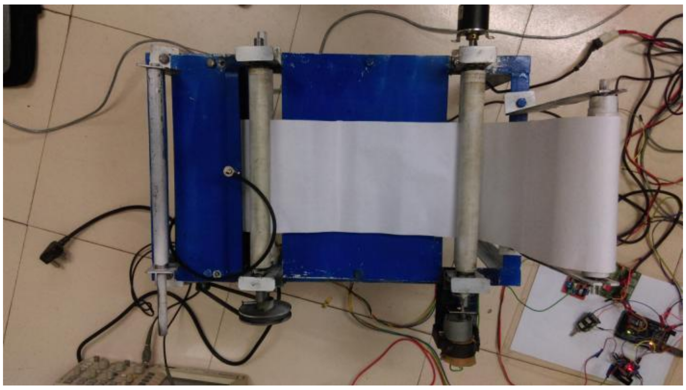


Fig 6. Flow Chart of Proposed Motion Controller with PID

VII. HARDWARE MODEL & SIMULATION RESULTS OF PROPOSED SYSTEM

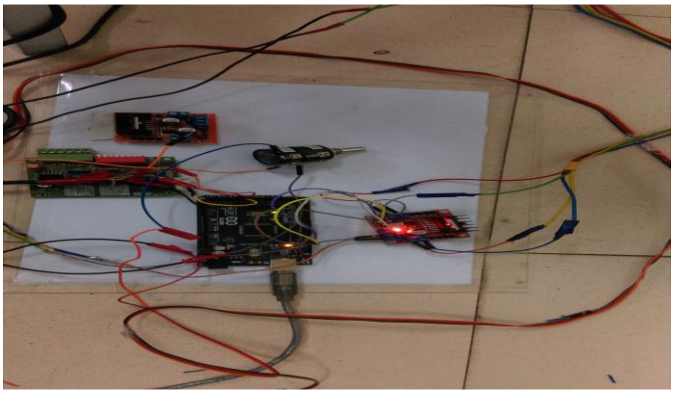
A. HARDWARE MODEL

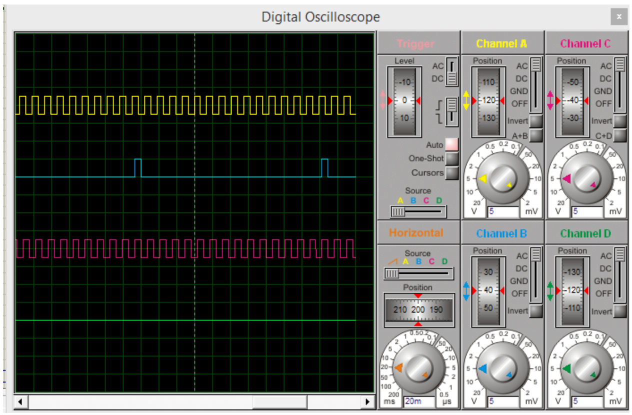
MECHANICAL CONNECTION:



ISSN: 2321-8169
251 – 257

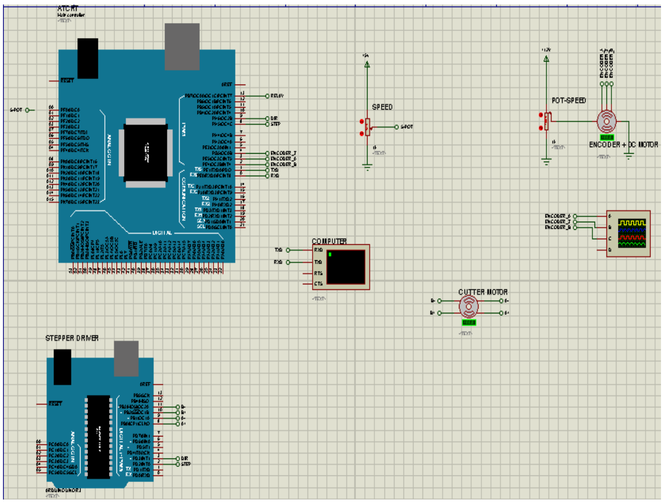
ELECTRICAL CONNECTIONS





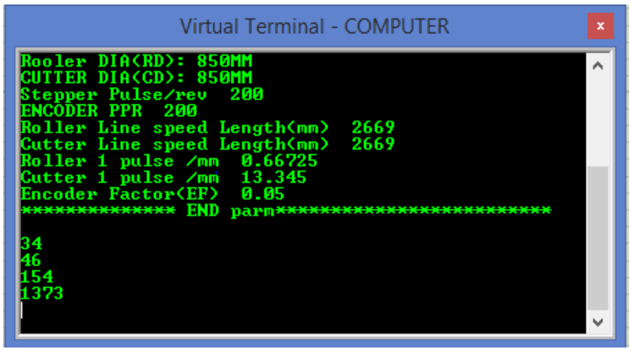
B. SIMULATION & RESULTS

SIMULATION



RESULTS

(1) SETTING THE PARAMETERS



(2) RESPONSE OF THE MOTOR

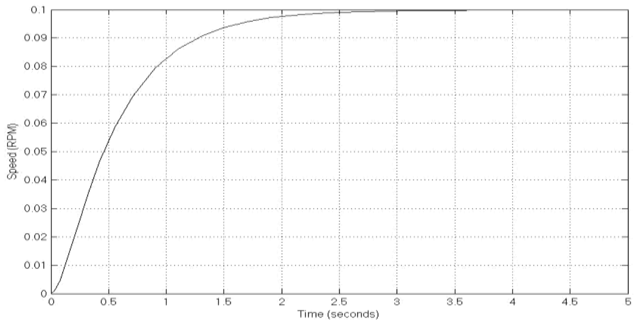


FIGURE 7: Uncontrolled DC Motor Speed Response.

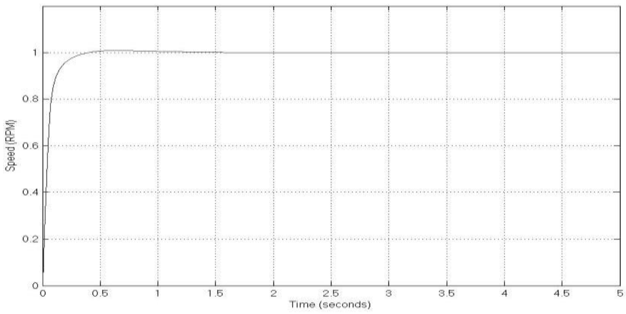


FIGURE 8: PID Controlled Response of DC Motor.

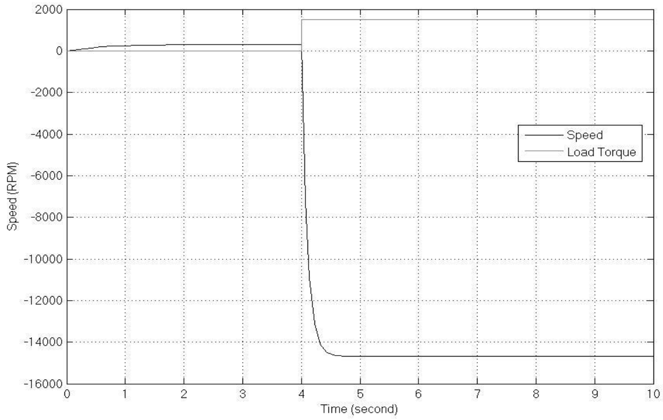


FIGURE 9: Uncontrolled speed response of DC motor under load disturbance.

ISSN: 2321-8169
251 – 257

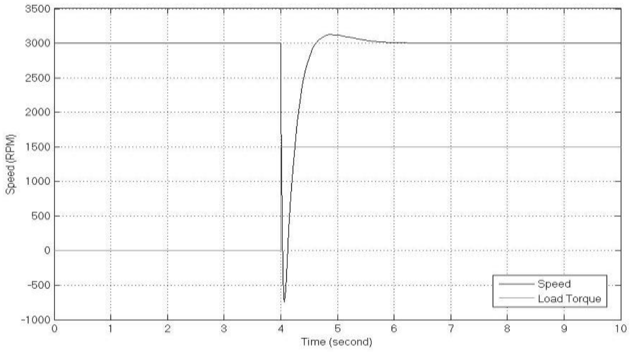


FIGURE 10: Partially Tuned PID controlled speed response of DC motor under load disturbance.

VIII. CONCLUSION

1. The speed control of the paper cutter is a very important process in the production of paper cutting application, it has determined the quality to the whole product. While the paper cutter is working, speed of paper roller and blade roller have decided the length of paper, control the extents of these two velocities, can cut the paper length in trusted.
2. But , the two speeds are time-varying, time-relaying, randomnesses greater, if adopt the traditional method such as operate two potentiometers to control the pace of two directions, is very difficult to realize two paces run in proportion and accurately.
3. Thus the speed & position control is an important process in this application & for this we have to control the speed of the DC Servo motor which is controlled by motion controller.
4. The experiment results validate the considerable performance of our algorithm.

IX. Benefits of MOTION CONTROLLER

1. Increased position and speed accuracy
2. Higher speeds
3. Faster reaction time
4. Increased production
5. Smoother developments
6. Reduction in expenses
7. Integration with other computerization
8. Integration with different procedures
9. Ability to change over coveted particulars into movement required to create an item
10. Increased information and ability diagnose and troubleshoot
11. Increased consistency
12. Improved efficiency

X. FUTURE ASPECTS

From the study of various methods, one can design & develop a motion controller for position and velocity control in variety of electromechanical configuration like various kind of paper products, slice of nonferrous metal, plastic, thin film, leather, etc. & for specific dedicated applications where the speed & motion control of components are necessary. Since, this project is based on intelligence of Human-Machine Interaction, researchers can control & implement this type of systems by processors also. Further Modifications in this device will helpful to interface & control this type of machines. By looking at the current scenario of such technologies, it can be said that these technologies will be more helpful for the world in near future.

XI. REFERENCES

[1] M.Passino Kevin, Stephen Yurkovich. “Fuzzy Control [M]”. Prentice Hall Pearson, 2001.
[2] Chu Qing. “ The introduction for the High Speed Paper cutting System [J]”. Hubei Paper Making, 2005,(2): 25-26.
[3] Shen Jinfei, Yan Wenxu. “Precision Optimum Control Based on PLC Used for the Paper Cutting Machine of Cylinder Hob [J]”.Electic Derive, 2003, 4(6):32-34.
[4] Wenxu, Shen Jinfei Yan. “ Precision Optimum Control Based on PLC Used for the Paper Cutting Machine of Cylinder Hob [J]”. Electric Drive, 2002, 6: 1-7.
[5] Xie, Deyi and Wang, Yuwei. “The Application of PLC in Paper cutting and Paper trimming [J]”. Heilongjiang Pulp and Paper, 2008, 1: 1-11.
[6] V. Ghodke Drmraj, K. Mulalikrishnan. Zvzes, “ Dual, two-transistor for-ward DC-DC converter with Peak voltage of Vin/2High Power Applica-tion [C]”.IEEE PESC, 2002:1853-1858.
[7] Giri R, Ayyanar R, Mohan N. “Common duty ratio control of input series connected modular DC-DC converters with active input voltage and load current sharing” [C]. IEEE APEC, 2003:322-326.
[8] L. Canan Dülger and Ali Kireçci, “Motion Control and Implementation for an AC Servomotor System,” *Modelling and Simulation in Engineering*, vol. 2007, Article ID 50586, 6 pages, 2007. doi:10.1155/2007/50586
[9] Temiz I. and Akar M., “ The Speed Control of DC Servo Motor with Proportional Integral, Fuzzy Logic and Adaptive Neuro-Fuzzy Inference Systems”,World Scientific and Engineering Academy and Society,pp.189-194,İstanbul,2007.
[10] Lee, Y., Lee, J., Park, S., (2000), “PID Controller Tuning for Integrating and Unstable Processes with Time Delay”, *Chem. Eng. Sci.*, vol. **55**, pp. 3481-3493.
[11] Paytra M.J., Mlynek D.M.,1996, “Fuzzy logic implementation and Applications”, John Wiley pres, New York, 317p.
[12] Zadeh,L.A.: “Bulanık Sets,Conformation and Control 8 ”, 339-353
[13] Mohd Fua'ad Rahmat and Mariam Md Ghazaly (2006),” Performance Comparison Between PID and Fuzzy Logic Controller in Position Control System of DC Servomotor”, Jurnal Teknologi, 45(D) Dis. 2006: 1–17
[14] G. Huang and S. Lee, ― “PC-based PID speed control in DC motor,” 2008 Int. Conf. Audio, Lang. Image Process., pp. 400–407, Jul. 2008.
[15] S. Fan and H. Zhu, ―“Simulation of the fuzzy PID control system for brushless DC motors based on MATLAB,”Int. Conf. Autom. Control Artif. Intell. (ACAI 2012), no. V, pp. 1854–1857, 2012.
[16] F. Directions, ―“PID Control Control System System Analysis and Design,” no. February 2006.
[17] Binpeng Wang & Haiying Liu, “Control System of Paper Cutting Machine Based On Motor Feedforward and Fuzzy PID Strategy”, IEEE *International Conference on Information and Automation*, Volume 3, August 2013, ISBN- 978-1-4799-1334-3

[18] Shashi Sahu & Amar Kumar Dey, “Automated Profile Cutting Machine Using PLC”, IEEE *International Conference on Advances in Human Machine Interaction*, Vol. 6, No. 3, 2016, ISBN- 978-1-4673-8810-8
[19] Xianrong Liu, Feng Wang & Lepeng Song “The Fuzzy-PID Application In Speed Control System Of The Paper Cutter”, IEEE *International Conference on Cognitive Informatics & Cognitive Computing*, Vol. 3, No. 4,2011,ISBN- 978-1-4577-1697-3
[20] Jianying Liu, Pengu Zhang, & Fei Wang “Real-Time DC Servo Motor Position Control by PID Controllers Using Labview”, IEEE *International Conference on Intelligent Human-Machine System and Cybernetics*, Volume 1, 2009
[21] Md Mustafa kamal, Lini Mathew & S. Chatterji “Speed Control of Brushless DC Motor Using Intelligent Controllers”, IEEE *Students Conference on Engineering and Systems*, Volume 6, May 2014 ISBN- 978-1-4799-4939-7
[22] X. Shao, D. Sun, and J. K. Mills, “A new motion control hardware architecture with FPGA-based IC design for robotic manipulators,” in Proc. IEEE Int. Conf. Robot. Autom., May 2006, pp. 3520–3525.
[23] T. N. Chang, B. Cheng, and P. Sriwilaijaroen, “Motion control firmware forhigh speedrobotic systems, ”IEEETrans. Ind. Electron., vol.53,no.5, pp. 1713–1722, Oct. 2006.
[24] Y. F. Chan, M. Moallem, and W. Wang, “Design and implementation of modular FPGA-Based PID controllers,” IEEE Trans. Ind. Electron., vol. 54, no. 4, pp. 1898–1906, Aug. 2007.
[25] J. U. Cho and J. W. Jeon, “A motion-control chip to generate velocity profiles of desired characteristics,” ETRI J., vol. 27, no. 5, pp. 563–568, Oct. 2005.
[26] Abdel Azzeh, Richard duke “CAN control system for Electric Vehicle”, ENZCon 2005, the 12th Electronics New Zeland Conference. Manukau City, New Zealand, November 2005.
[27] Kumar, M. A.Verma, and A. Srividya, “ Response-Time “Modeling of Controller Area Network (CAN)”. Distributed Computing and Networking.
[28] A. P. Singh, ―“Speed Control of DC Motor using Pid Controller Based on Matlab,” vol. 4, no. 6, pp. 22–28, 2013.
[29] E. R. De Azevedo, S. Fernanda, M. Brandiio, J. Bosco, and D. Mota, ―“A Fuzzy Logic Controller for dc Motor Position Control,” vol. 00, 1993.
[30] M. S. Microcontroller, ― “Low-cost embedded solution for PID controllers of DC motors,” no. 15, pp. 1178–1183, 2009.
[31] R. G. Kanojiya and P. M. Meshram, ― “Optimal tuning of PI controller for speed control of DC motor drive using particle swarm optimization”, 2012 Int. Conf. Adv. Power Convers. Energy Technol., no. Dc, pp. 1–6, Aug. 2012.
[32] K. H. Ang, G. Chong, S. Member, and Y. Li, ― “PID Control System Analysis , Design , and Technology,” vol. 13, no. 4, pp. 559–576, 2005.
[33] Paulusova, J, Dubravska, M, 2010. “Application of Design of PID Controller for Continuous Systems”. Slovak University of Technology, Faculty of Electrical Engineering and Information Technology.
[34] Gang Feng. “A Survey on Analysis and Design of Model-Based Fuzzy Control Systems.” IEEE Transactions on Fuzzy systems,2007,Volume 14,Number 5: 676-697.