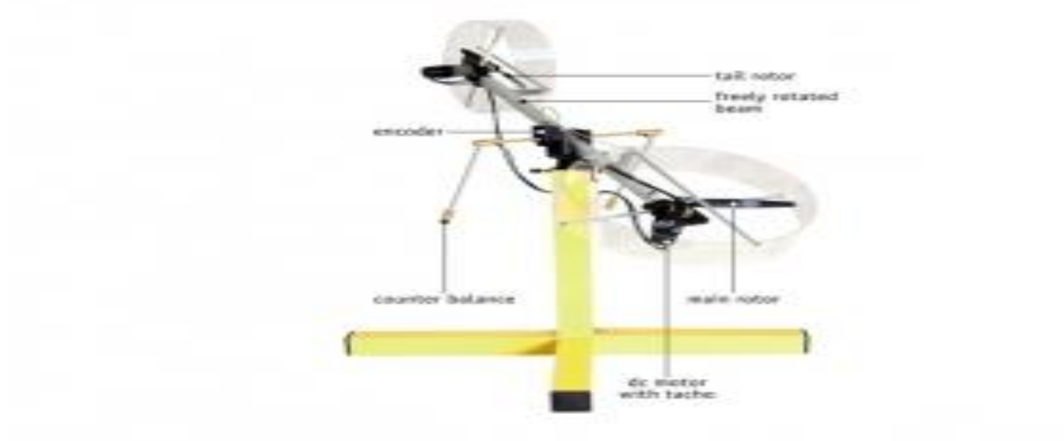
Objectives:

1- To study the (TRAS) under two cases
   - with 1 DOF Azimuth, pitch
   - with 2 DOF Cross Coupled model
2- To study the effects of PID controller on this TRAS in both cases

Introduction:

Two Rotor Aerodynamical System (TRAS) is a laboratory set-up designed for control experiments. In certain aspects its behaviour resembles that of a helicopter. From the control point of view it exemplifies a high order nonlinear system with significant cross-couplings. TRAS consists of a beam pivoted on its base in such a way that the beam can rotate freely both in the horizontal and vertical planes. At both ends of the beam there are rotors (the main and tail ones) driven by DC motors. A counterbalance arm with a weight at its end is fixed to the beam at the pivot. The state of the beam is described by four process variables: horizontal and vertical angles measured by encoders fitted at the pivot, and two corresponding angular velocities. Two additional state variables are the angular velocities of the rotors, measured by speed sensors coupled with the driving DC motors. In a real helicopter the aerodynamic force is controlled by changing the angle of attack. In the laboratory set-up the angle of attack is fixed. The aerodynamic force is controlled by varying the speed of rotor. Significant cross couplings are observed between actions of the rotors. Each rotor influences both position angles. A design of stabilizing controllers for TRAS is based on decoupling. The TRAS system has been designed to operate with an external, PC-based digital controller.



Abstract:

The TRAS was studied under different value of PID controllers, going through 3 trails in each case, with the azimuth case and pitch case, the azimuth case was where the horizontal angle was affected by the controller controlling the tail rotor, while the main rotor controller affected the vertical angle. In both cases the values of Kp,Ki,Kd were adjusted and the response was plotted through MATLAB. Finally in the 3rd case where it had 2 DOF, the response was plotted and PID controllers were at its best in this phase. In the experiment it was clear that the controller was consistently adjusting the value of pitch and

azimuth together to stabilize the system even with disturbance it held very well and stabilized the system again. Tuning the controller variables was done by MATLAB through a code that came with the device. The P controller increased the value of the system making it almost reach a steady state but came with the downside of overshooting, the overshooting was taken care of by the derivative controller, and the elimination of steady state error was taken care of by the Ki controller. However, it was clear that adjusting three parameters together was a very hard task and takes patience and trail and error and much experimentation to get it perfect.

Procedure:

Discussion and Results.

In the first case where the TRAS was studied under 1 DOF, here are the graphs and values of control parameters of Azimuth and Pitch case respectively.

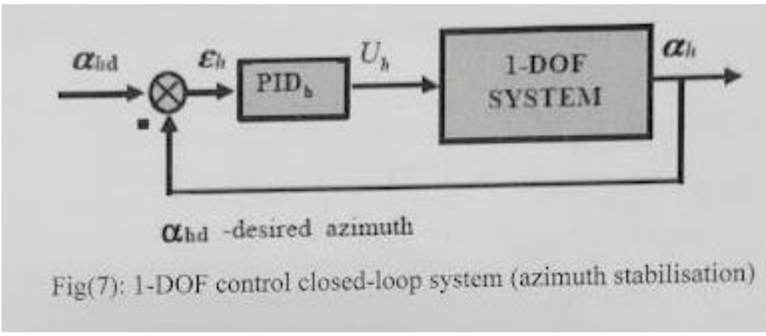


Figure 2: The control loop of the Azimuth case (Horizontal Stability).

Azimuth Control Parameters Value of each trail.

Reading	Kp	Ki	Kd
1st Trail	3	0	5.188
2nd Trail	5	0	5.188
3rd Trail	5	0.2	5.188

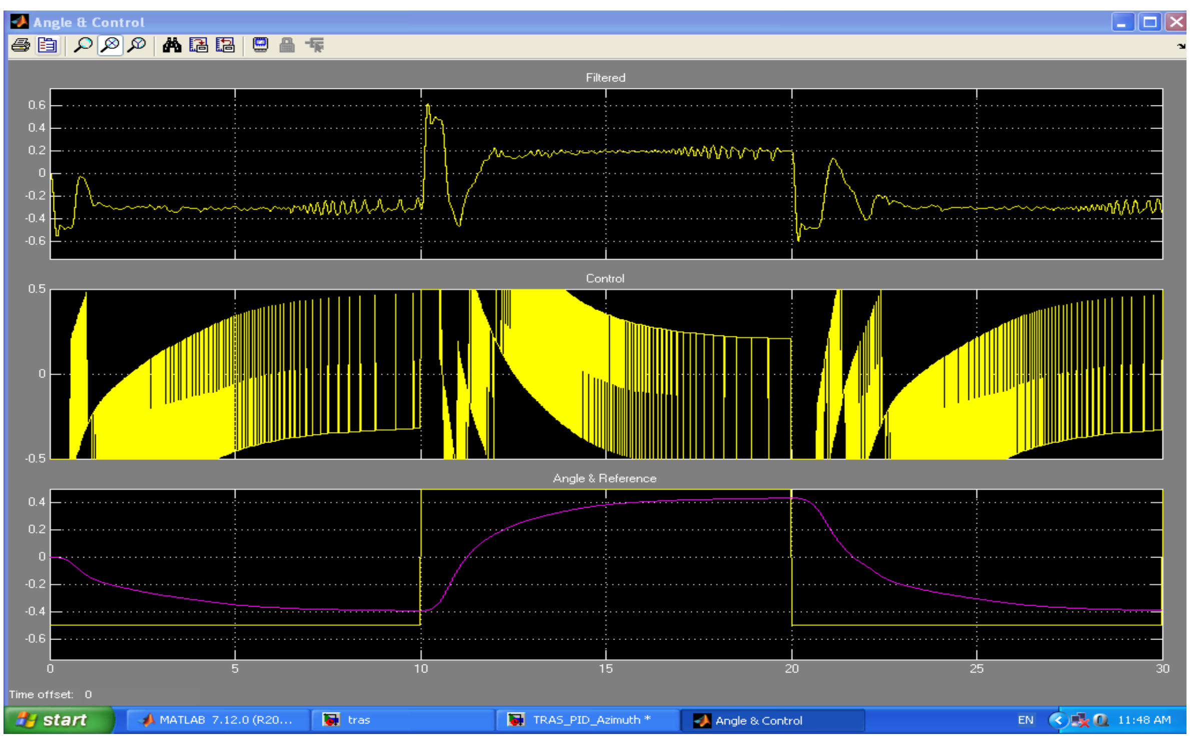


Figure 3: Response of 1st Trail: System hasn't reached a steady state and overshooting is not present.

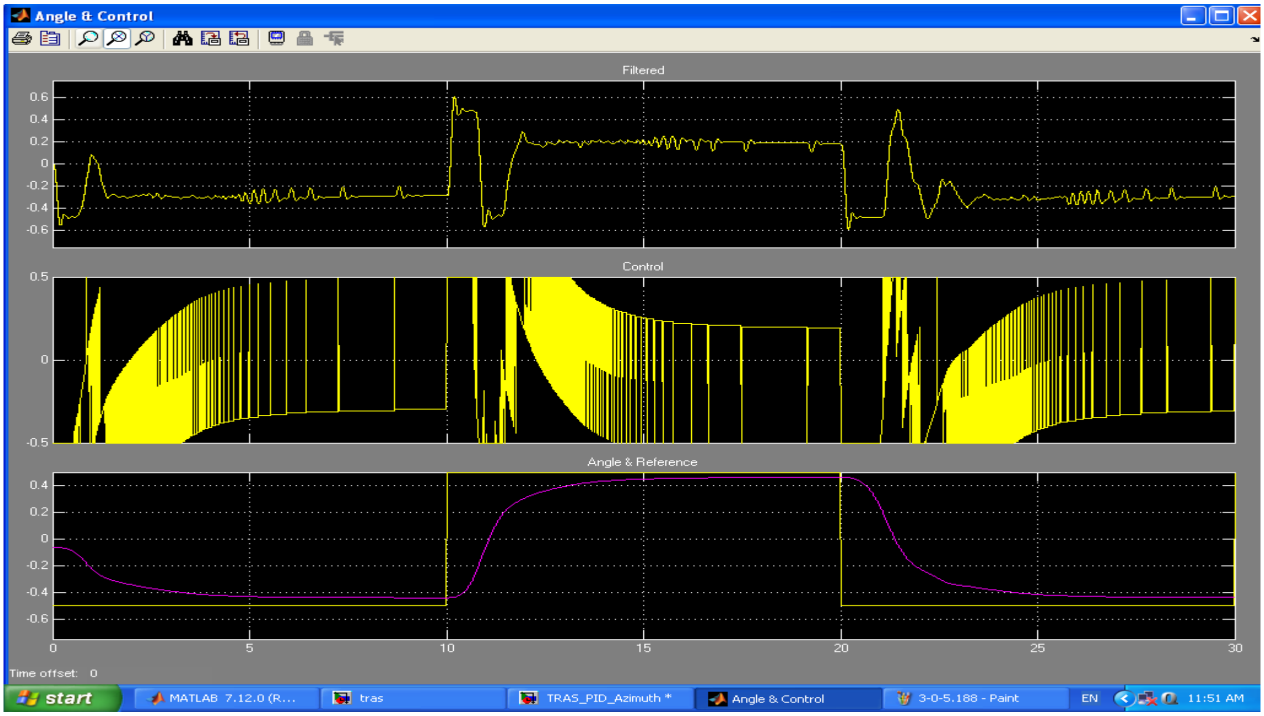


Figure 4: Values of the 2nd trail, with Kp increased system is more stable, but not stable enough.

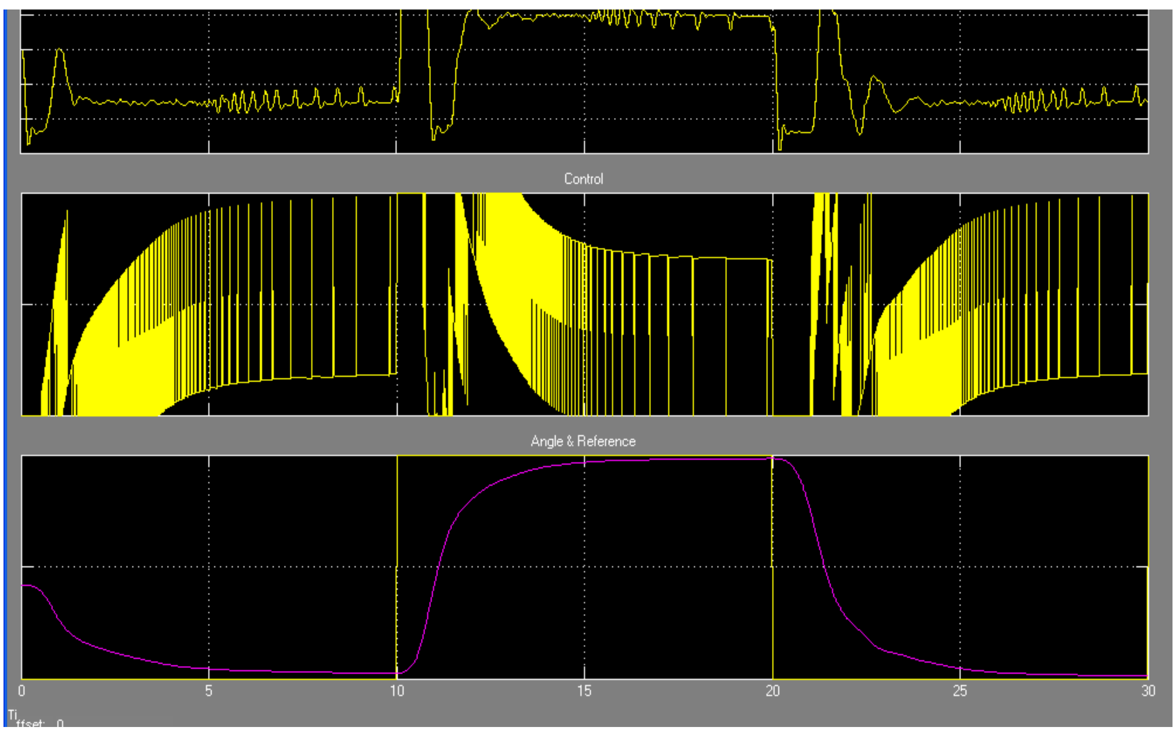


Figure 5: With Kp, Kd kept constant, Ki was increased by a bit and the system almost has a steady state error of zero.

Case 2: Pitch Control (Vertical Angle).

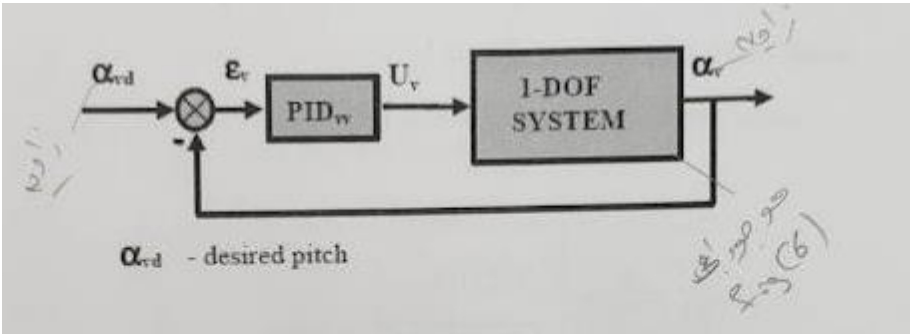


Figure 6: Control loop of the pitch case (Vertical Stability).

Reading	Kp	Ki	Kd
1st Trail	0.81408	0	0.5247
2nd Trail	1.3568	0	0.5247
3rd Trail	1.3568	0.4415	0.5247

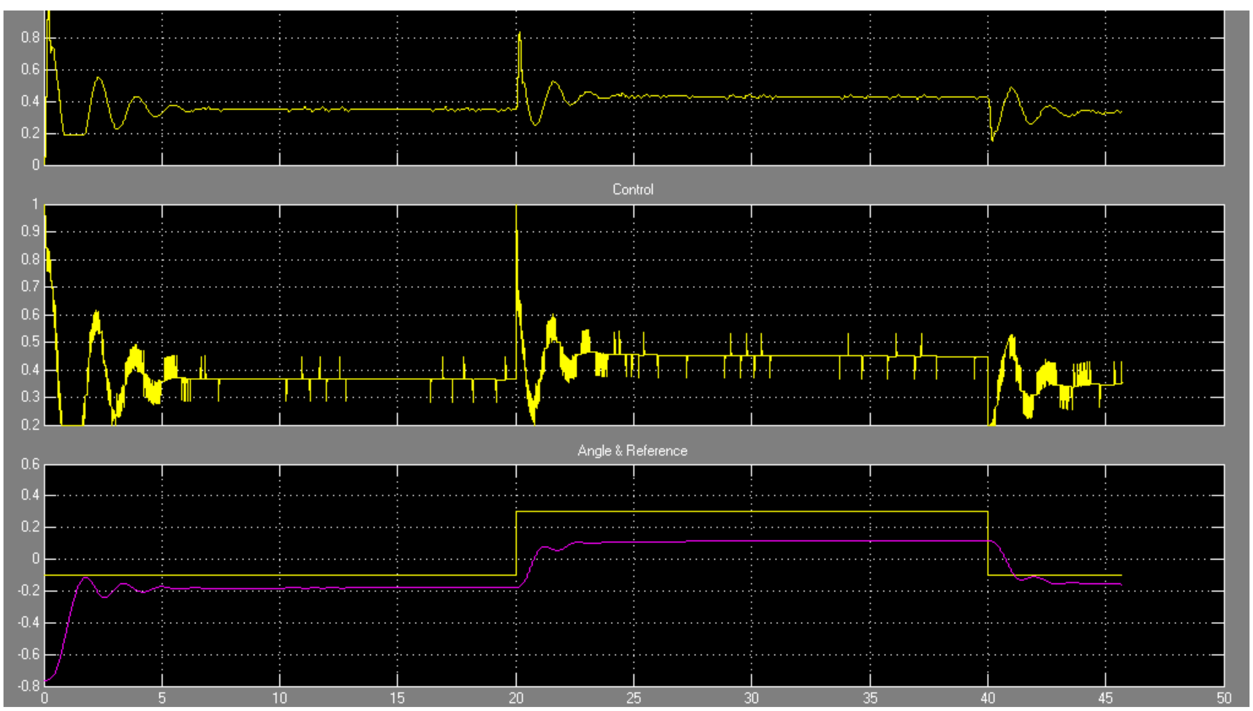


Figure 7: The Response of 2nd Trail with Ki =0, the system has a significant steady state error with overshooting present.

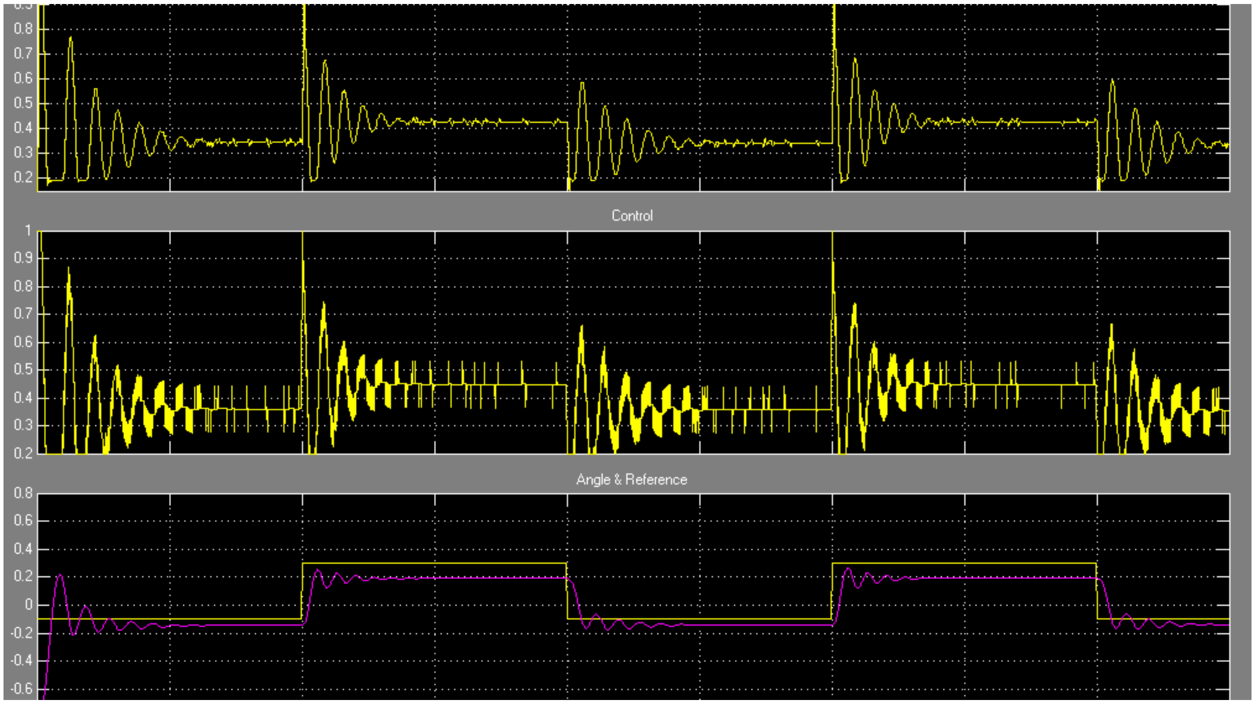


Figure 8: The value of 2nd trail with Kp increased to 1.3568 and Kd, Ki remaining constant, the system has reduced steady state error with more overshooting present than in the first trail.

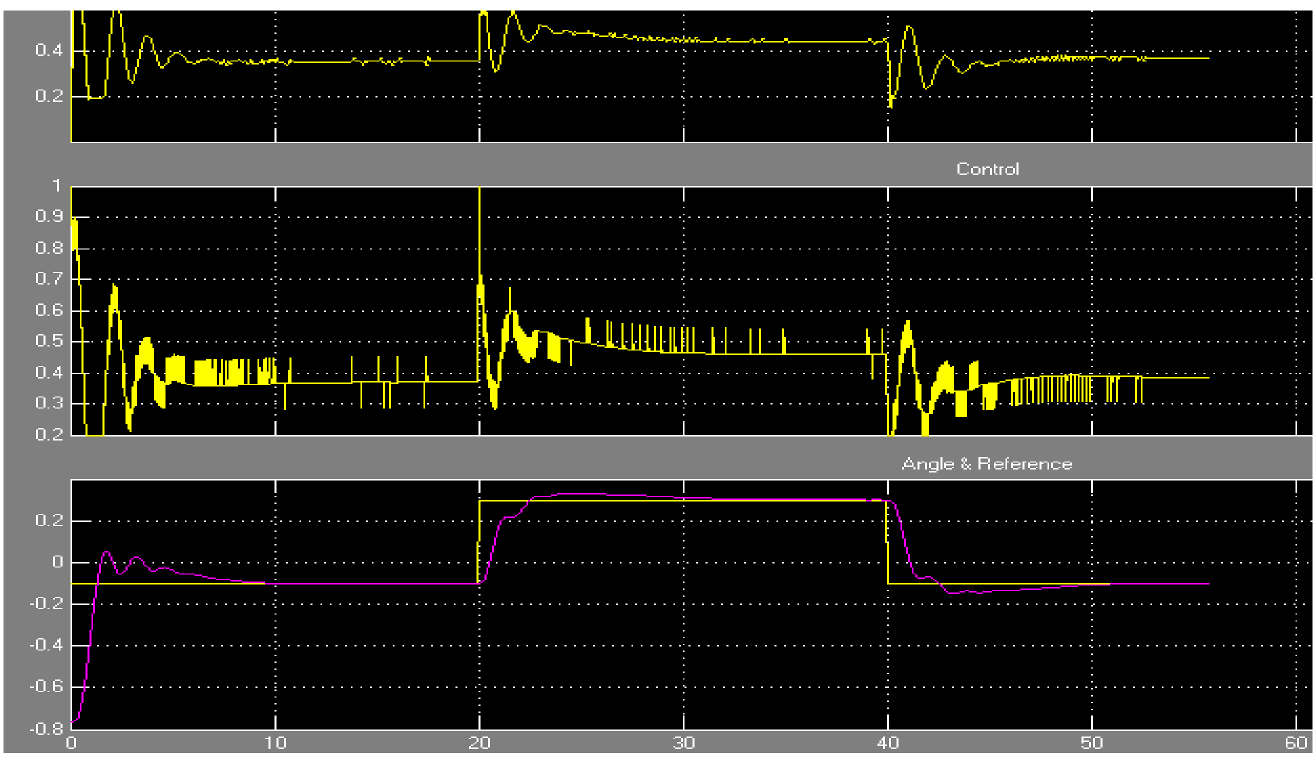


Figure 9: The 3rd trail response, the system has almost eliminated the steady state error since Ki has increased to 0.4415. However, overshooting is still present.

Discussion:

As demonstrated by the figures, adjusting the value of Kp reduces steady state error at the cost of overshooting in both cases of Azimuth and Pitch controller stability. So, the Kd value started to play the role of dampening the system reducing its overshoot. However, both controllers couldn't eliminate steady state error on their own. By adding the integral controller Increasing the Ki value the steady state error was eliminated. While the controllers did the stabilize the system at certain values, as seen in the figures. At other values it didn't reach the desired output. To make the system reach the desired output the system needs to have perfectly tuned PID controller values, in real life application this is actually very hard as controlling two parameters is hard enough, adding a third parameter makes the range of values to be tested much greater than just two parameters. This is what makes tuning the PID controller at times almost impossible. Therefore, It needs careful and repetitive experiments to reach the perfect value which takes a long time and much effort.

Conclusion:

1- When adjusting the gain of the proportional controller alone with other parameters constant it reduces the steady state error at the cost of overshooting
2- When adjusting the Derivative controller parameter Kd alone with other parameters constant it dampens the system and reduces or eliminates overshooting
3- When adjusting the integral controller parameter Ki alone with Kd , Kp kept constant, it eliminates the steady state error
4- To get the perfect result a combination of PID (Kp,Ki,Kd) needs to be tuned perfectly which is very hard to do since 3 parameters have a significant margin of possibilities each with different results.

Conclusion:

1- To reduce steady state error Kp value should be adjusted and