International Journal of Scientific & Engineering Research,Volume 5, Issue 4, April-2014
ISSN 2229-5518

Wind Tunnel Instrumentation System

Karthigeyan S, Jai Bhavani K S, Jenifer Z

Abstract— The measurement and control applications for wind tunnel testing typically include the wind speed measurement and control, pressure profile measurement and model balancing with respect to the wind in the tunnel. These measurement and control applications are difficult as well as time consuming hence needs to be automated. This paper presents the implementation aspects of a reliable and automated wind tunnel instrumentation system using LabVIEW and performance analysis using MATLAB. The automation is done by controlling the tunnel wind speed control, model balancing, auto switching of the wind tunnel at critical temperature.

Index Terms—Automated testing, Drag,LabVIEW, Lift,MATLAB, Model balancing, Thrust,Tunnel wind speed control, Virtual instrument,Weight, Wind tunnel instrumentation.

1 Introduction

Wind tunnel testing facility is an aerodynamic test facility used to study wind flow patterns around bodies and measure aerodynamic forces (lift, thrust, drag, weight) on them. A typical wind tunnel consists of a test section in which the space/road vehicle model is mounted, a contraction cone of the settling chamber before the test section, and a diffuser after the test section. A fan after the diffuser or before creates the wind. This setup exactly simulates relative motion between model and wind. The measurement and control applications for wind tunnel testing typically include the wind speed measurement and control. Static and dynamic force measurement, pressure profile measurement and model balancing with respect to the wind direction. These applications are repetitive as well as time consuming hence needs to be automated. This paper presents the implementation aspects of a reliable and accurate automated wind tunnel instrumentation system integrated with model attitude control function which combines power and precision to deliver flexible, economical, user-friendly wind tunnel test and measurement solutions. The system presented here has been implemented using virtual instrumentation technique and Simple Instrumentation architecture which enhances the productivity and reduce the cost through easy-to-integrate LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) software. LabVIEW from National Instruments (NI),.In this paper, we have presented a LabVIEW-based instrumentation system, which provides users the wind speed measurement and control and motion control functions to automate the wind tunnel testing.

2 System Description

Wind Tunnel Facility has a closed circuit or open circuit wind tunnel to evaluate aerodynamic performance of flight and road vehicles as well as wind effects on civil structures. The system features an open loop or closed-loop control system integrated with the control system for repeatable and efficient conduct of testing. In order to implement the automated wind tunnel instrumentation system, the system is implemented with the tunnel wind speed control, test model balancing control, auto switching of the wind tunnel at critical temperature and measuring the tunnel temperature and forces acting on the model are shown in the Figure 1.

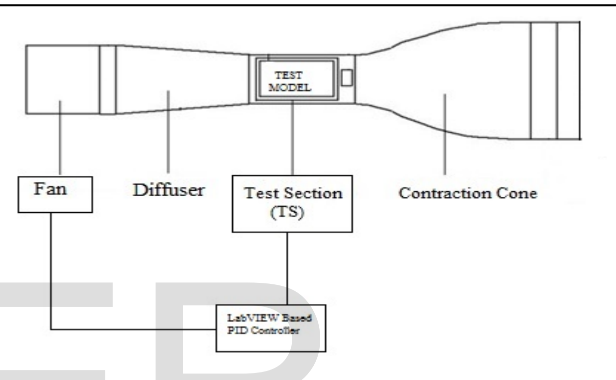


Fig. 1.Schematic Diagram of Automated Wind Tunnel System.

3 System Formulation

For controlling the tunnel wind speed and the model balancing are controlled by controlling the DC motor speed and the DC motor position. This system is modeled by summing the torques acting on the rotor inertia and integrating the acceleration to give the velocity, and integrating velocity to get position. The speed and the position are controlled from the electrical and the mechanical equivalent of the DC motor.

$$\Theta = \int \frac{D\Theta}{DT} = \iint \left(\frac{1}{J}\left(K_T I - B\frac{D\Theta}{DT}\right)\right) \quad (1)$$

$$I = \int \frac{1}{L}(-I_A R_A - E_B + V) \; (2)$$

SHere θ in equation (1) is the angular displacement (angular position), and the derivative is the speed of the DC motor. Here the current i in equation (2) is obtained by applying the Kirchhoff's law to the electrical equivalent and the θ is obtained by applying the newton's law to the mechanical equivalent. The test model is controlled in both the x axis and the y axis for these two axes control is done with the same method for controlling the angular displacement. The controlling is done with the LabVIEW simulation tool. The tunnel auto switching is simply using the conditional loop

International Journal of Scientific & Engineering ResearchVolume 5, Issue 4, April-2014
ISSN 2229-5518

control for the whole system. The tunnel wind speed control block diagram is shown in the Figure 2.

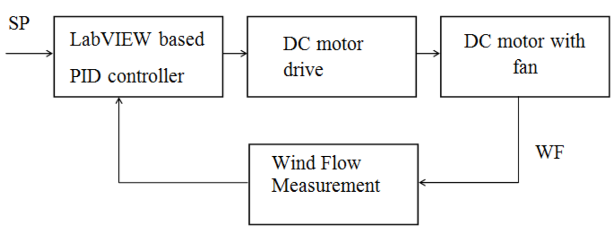


Fig. 2.Schematic Diagram of Tunnel wind speed control.

During testing the wind speed in the tunnel changes in accordance with the geometry of the test model and the position of the test model, but the speed of the wind is to be constant for the good test results. To maintain the wind in the constant speed, the current speed of the wind is measured in and around the test model and is fed back to the controller to maintain the constant speed.

4 Model Balancing

In the wind tunnel the model is balanced continuously for the testing, the model balancing is difficult to done by manually, and it is controlled by DC motor position ,the DC motor position is controlled continuously by PID controller designed in the LabVIEW. The position of the motor is measured by potentiometer, x-axis and the y-axis position are controlled by the same principle and the multi-axis balancing is also possible if required. Here the model balancing is controlled in x axis and y axis. The current position of the model is measured with potentiometer or the Synchro and is fed back to the controller to set to the required position is shown in the Figure 3.

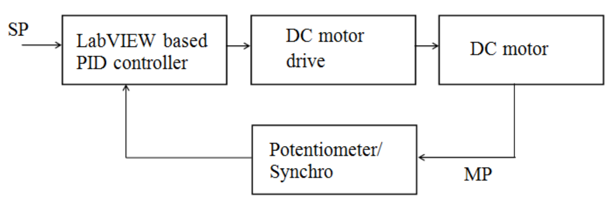


Fig. 3.Model balancing block diagram.

5 Auto Switching Of The Wind Tunnel According To The Critical Temperature

Critical temperature is defined as the threshold temperature at which ice will no longer accrete on the structure. Many factors determine the critical temperature, including airspeed, geometry of the test model and attitude of the body relative to airflow direction and thermal history of the body. Here the control is done depending on the temperature, if the tunnel temperature is below the threshold value the tunnel will shut down and returns to the working condition if the temperature returns to the threshold value.

6 Performance Analysis

The tunnel wind speed and the model balancing are controlled with controllers like PID controller, IMC controller, MPC controller, Fuzzy logic controller and the performances are analyzed to get the better control.

7 Results

The following three main controls are used, Tunnel Wind speed control, Model balancing, Auto switching of the Wind tunnel at the critical temperature, and their results are shown in the figure 4 and figure 5.

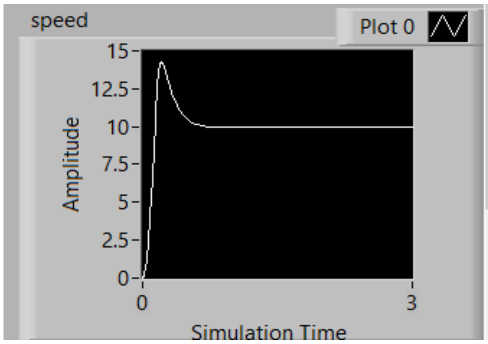


Fig. 4.Tunnel wind speed control.

The tunnel wind speed is shown in the figure 4,here the set point is achieved after the overshoot due to the proportional action in the PID controller used, by the same way the model balancing is controlled and achieved as shown in the figure 5.

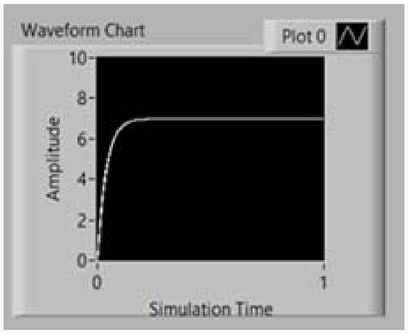
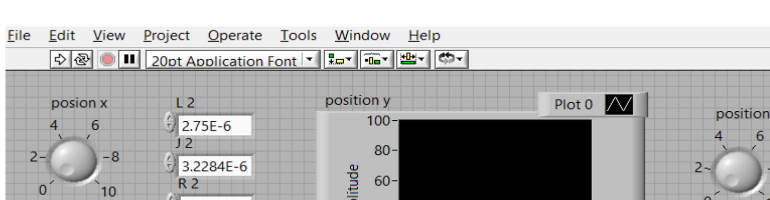


Fig. 5. Model Balancing control.

The figure 7 shows the auto switching of the wind tunnel the threshold value is 2°c.if the tunnel temperature is above the threshold value, the tunnel works normally and if the temperature gets below the 2°c c, the tunnel shut downs automatically and it restarts if the normal condition is back and the conditions are shown by the LED's present in the front panel.



International Journal of Scientific & Engineering ResearchVolume 5, Issue 4, April-2014
ISSN 2229-5518

the complete front panel of the wind tunnel instrumentation system is shown in the Figure 6.

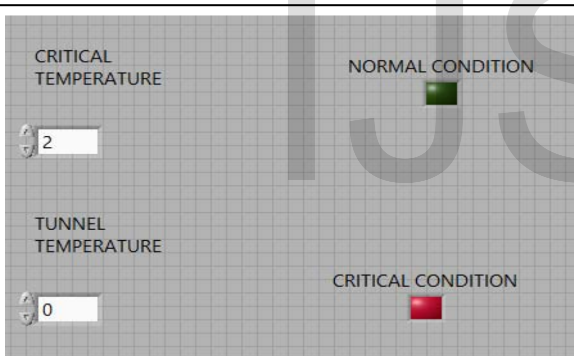


Fig. 7.Auto Switching Of the Wind Tunnel.

8 Conclusion

Thus the LabVIEW based automated wind tunnel instrumentation system presented in this paper has been implemented using simple simulation techniques enhances the productivity and reduces the cost through easy way of integrating LabVIEW based application software. This makes low cost, high performance instrumentation, automated test systems, industrial automation. and the performance is analyzed using the MATLAB.

References

[1] Chautri singh and k.poddar, *Implementation of LabVIEW based automated wind tunnel instrumentation system*,978-1-14244-2746-8/08/2008 IEEE.
[2] M.T. Boyle,*Low Speed Wind Tunnel Testing*, 2530-4/88-0000-0031/1988 IEEE.
[3] A.Ferri& S.M. Bogdonoff, *Design and operation of intermittent supersonic wind tunnels*, NATO, May 1954.