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STATIC MEASUREMENT OF THE THICKNESS OF THE ABLATIVE COATING OF THE SOLD ROCKET BOOSTERS

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Introduction

1. The Solid Rocket Boosters(SRBs) used to launch the Space Shuttle are coated with a layer of ablative material to prevent thermal damage when they reenter the earth's atmosphere. The coating consists of a mixture of cork, glass, and resin. A new coating(Marshall Convergent Coating, MCC-2) was recently developed that is environmentally complaint. The coating must meet certain minimum thickness standards in order to protect the SRB.

2. The coating is applied by a robot controlled nozzle that moves from the bottom to top, as the rocket part rotates on a table. Several coats are applied, building up to the desired thickness. Inspectors do a limited amount of destructive "wet" testing. This involves an inspector inserting a rod in the wet coating and removing the rod. This results in a hole that, of course, must be patched later. The material is cured and the thickness is measured. There is no real-time feedback as the coating is being applied. Although this might seem like the best way to control thickness, the problems with "blowback"(reflected material covering the sensor) are formidable, and have not been solved.

3. After the thermal coating is applied, a protective top coat is applied. The SRB part is then placed in a oven and baked to harden the surface. The operations personnel then measure the thickness of the layer using the Kaman 7200 Displacement Measuring System.. The probe is placed on the surface. One person(the inspector) reads the instrument, while another(the technician) records the thickness. Measurements are taken at one foot intervals.

4. After the measurements are taken, the number of low readings is tabulated. If more than 10% of the points fall below the minimum value, there is a design review, and the part may be stripped of coating, and a new coating is applied. There is no other analysis.

Goals

Improve the measurement process by speeding up the process, improve analysis of thickness data and to evaluate the utility of the virtual instrument concept for taking measurements

Proposed System

1. HARDWARE:

a. COMPUTER: laptop(WinBookxp) with the following characteristics:

CPU: 486DX
RAM: 8 Meg of RAM

MANUFACTURER: National Instruments
MODEL: DAQCard-700
INTERFACE: PCMCIA Type II
TYPE: 12 bit ADC
CHANNELS: 16 analog/8 differential
DIGITAL: 8 inputs, 8 outputs
SPEED: 100k Samples/second

CONNECTOR: CB-50(50 screw down connector)

2. SOFTWARE:

MANUFACTURER: National Instruments Corporation
PRODUCT: LabVIEW for Windows
VERSION: 3.1.1

3. PROCESS:

The operator places the sensor flush with the ablative coating surface. The instrument is based on the measurement of eddy currents. It measures induced current that is proportional to the distance between a conductive material(the metal surface of the SRB) and the sensor. A set of non-conductive ceramic disks were provided by the manufacturer for calibration of the instrument. The output is in mils, and is accurate to 1 mil. The output of the sensor was available through pins 4 and 5 in the front of the sensor. These pins were connected to pins 2 and 3 on the CB-50 connector.
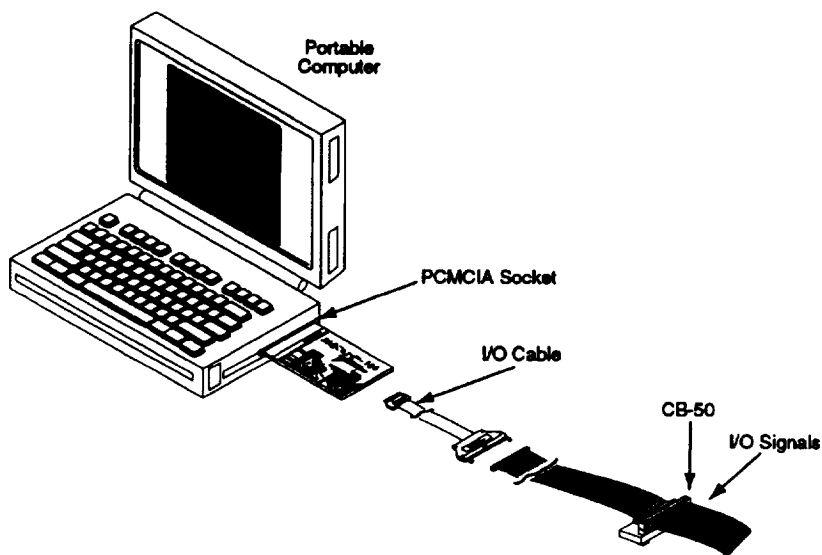
This figure shows how the laptop computer interfaced with the PCMCIA Card and CB-50 Connector. The PCMCIA (Personal Computer Memory Interface Association - a standards group for small credit card sized devices(not limited to memory). The DAQ card is supplied by National Instruments.

4. The Program:

The LabVIEW(Virtual Instrument Engineering Workbench) software represents several revolutionary concepts.

The first is the concept of the virtual instrument. Given the right interfaces, a general purpose computer(PC, Mac, Sun , HP, etc.) can be programmed to perform the operations of an expensive special purpose instrument or to control certain processes. The PC can be easily modified to perform a wide variety of different tasks.

The second concept is called Visual Programming. The displays and inputs are represented by pictures(icons). They are connected together using a roll of wire icon. This is similar to the flow diagrams which are second nature to engineers.
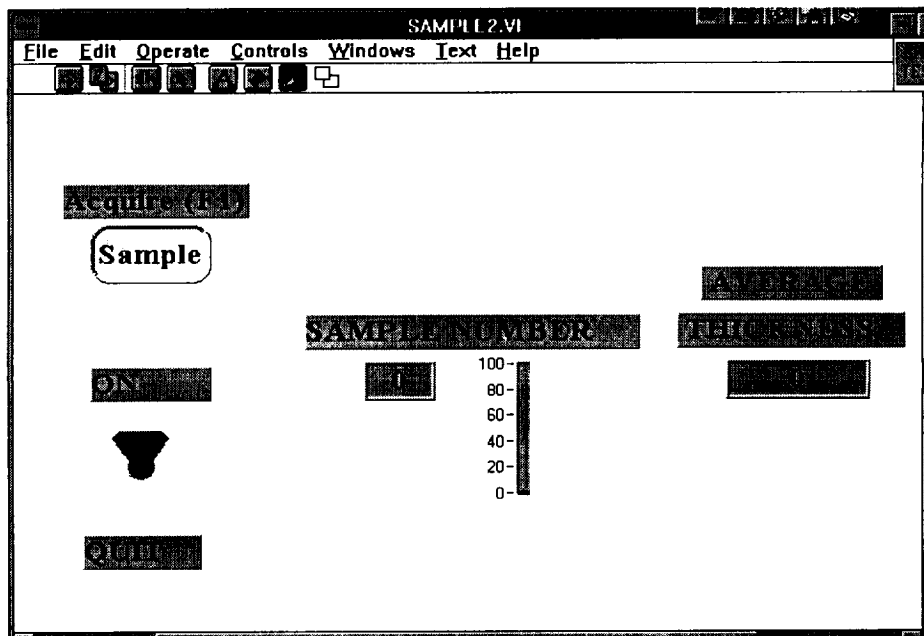

Figure 2. Instrument Panel

This diagram show the panel of the virtual instrument. The user moves the mouse to the operate icon the selects RUN. He then presses F1 when the sensor is ready to be read. A pop up menu appears that prompts him for the name of the file where the data is be stored. The sensor take 10 measurements and averages them. It writes the sequence number of the reading, along with the value of the thickness, in spreadsheet format.

In the figure below, TEST is the data acquisition VI. It is in a Loop that is executed 10 times. The values are multiplied by 1000 to convert them to mils and are fed to the Mean VI. The output of the, along with the sequence number, is written to a file in spreadsheet format(tabs between values, Return at the end of each line.
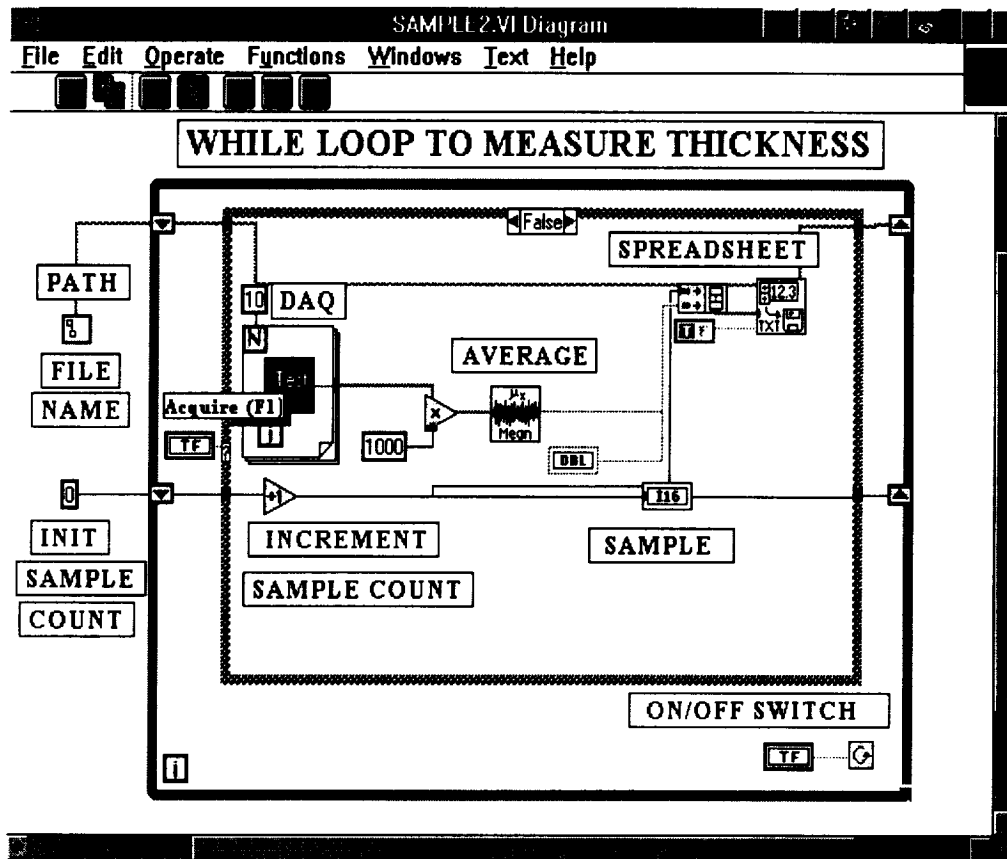

Figure 3. LabVIEW Diagram

LabVIEW Programming

The LabVIEW programs are written in a graphical language called "G". It is a pure visual language. There is no text based part, as there is in visual BASIC. Programming is done by selecting icons that stand for functions, sensors, controls, and displays. The programmer lays out a "panel " that represents the display and controls the user will see. See figure 2. The programmer then switches to the diagram view, where the functions and instruments are represented as icons. See figure 3. The programmer then connects the icons together with a wiring tool.

The data was written in spreadsheet format. The mean and standard deviation can be easily computed. The next step to convert the sequence numbers to grid coordinates(x and y) representing the surface of the SRB section. Now, the thickness could be plotted using color codes. For example, RED would indicate below minimum thickness, GREEN above

thickness. Now the entire surface could be viewed with respect to out of specification areas. The would allow the easy identification of areas that are out of specification, and indicating the need to control the application of the spray.

Conclusions

The project was completed successfully. The concept of using virtual instruments based on a lap top PC is practical and cost effective. It is widely applicable to throughout NASA. It offers significant savings compared to the use of traditional savings. Given the funding forecasts, this approach may be of greater importance than before. The use of virtual instruments should be encouraged throughout NASA.

Recommendations

The handle(gun) for the sensor needs to be fabricated, along with a trigger to activate the sensor. The concept needs to be tested at Cape Kennedy. Some user resistance might expected, as the new process may involve taking the measurements in a different order than was done previously.

The time for laptop data acquisition and instrument control has arrived. Using visual software, it fast, easy, and inexpensive to develop useful applications. A task force or committee should be formed to recommend ways that the use of this approach can be spread throughout the agency. Perhaps guidance and recommended practices need to be published. Videos and training material should be acquired at the libraries.

Bibliography

1. Acquiring Data through Windows, Andy Reinhardt, BYTE magazine, volume 17 page 63-64, Sep 1992.