Maestría en Ingeniería en Automatización de Procesos Industriales

Title

Design and construction of an automated deadweight force standard machine prototype

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1. Introduction

The primary mass standards are material patterns. Unlike other primary standards, the mass pattern has no conceptual representation.

The primary mass pattern is an agreement between several countries. These countries defined a primary mass pattern. Each country obtained a prototype. These prototypes are a representation of the original. The mass pattern is transferred to other devices by direct comparison.

The force is directly proportional to the mass. The patterns of force depend on mass patterns.

The primary force patterns are transferred with a deadweight force standard machine to other instruments. These machines are mostly found in the centers of national metrology and calibration and certification laboratories. Most of these machines are manually operated. This generates measurement errors related to manual operation.

2. Objectives

- To identify the basic elements of a deadweight force standard machine.
- To design the parts of deadweight force standard machine prototype in CAD software.
- To develop an electronic system using DAQ device for data acquisition and operation of actuators.
- To develop deadweight force standard machine prototype by virtual instrumentation and DAQ device.
- To calibrate force transducer using the deadweight force standard machine prototype.

3. Method

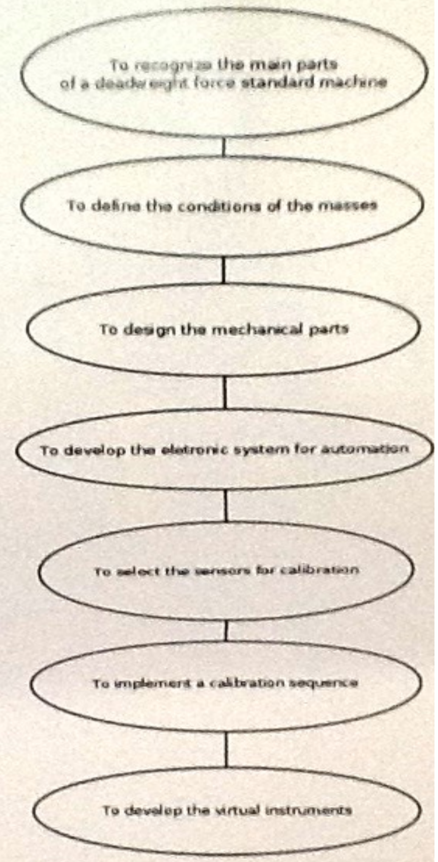


Figure 1. Method for automated prototype.

4. Results

The prototype (Figure 2) consists of a base, a loading frame, a counterweight system, a displacement frame, and a mass change system. The base is a structure that supports the entire machine. The displacement frame supports the transducers. The load frame transmits the force. The force is exerted by the masses towards the transducer. The displacement frame is levitating because of the counterbalance system. This one is a lever system. A mass equals the weight of the load frame. And the mass change system consists of a gripper and a moving frame. The mass rests over the gripper.

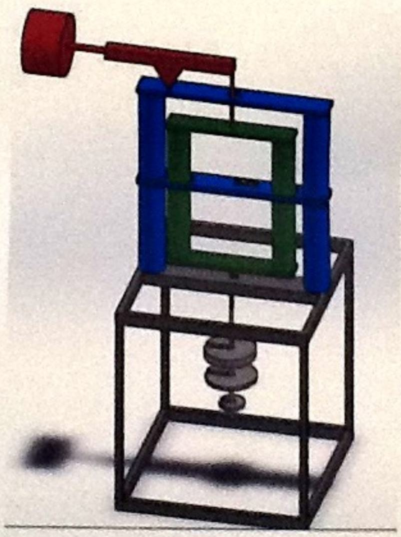


Figure 2. CAD design prototype. The base is in gray, counterweight system is in red, loading frame is in green and displacement frame is in blue.

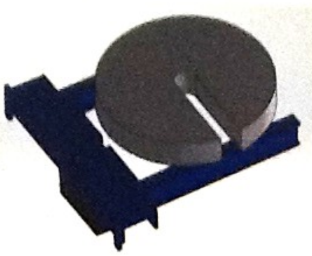


Figure 3. *Gripper and mass.*

Three masses generate the force. The values of these masses are one, five and ten Newtons. The masses generate a force proportional to gravity acceleration. The formula that gives the acceleration gravity for this location is:

$$g = 9.7803181 * (1 + 0.0053024 * (\sin Alt)^2 - 0.0000058 * (\sin 2 * Alt)^2) - 0.000003086 * Lat \ \ m/s^2$$

$$g_{UPPUE} = 9.779007979 \ m/s^2$$

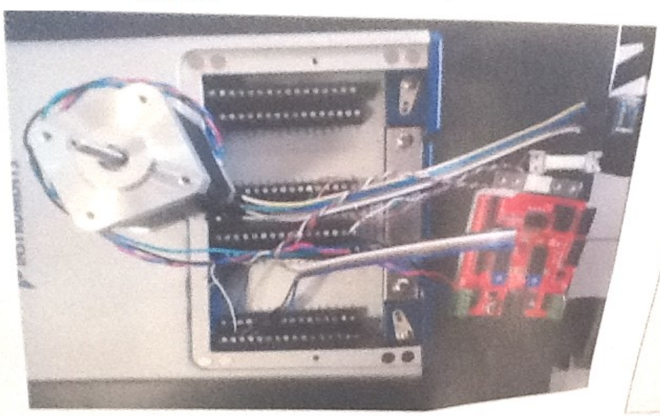
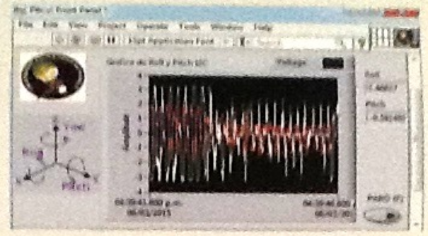


Figure 4. NI USB-6343, electronic system, actuators and force sensors

Two strain gauges were selected as force sensors illustrated in Figure 4. The strain gauges were selected considering the values of the masses. The DAQ is compatible with LabView.

Figure 5. a) Screenshot of virtual instrument that captures the signal of gyroscope.



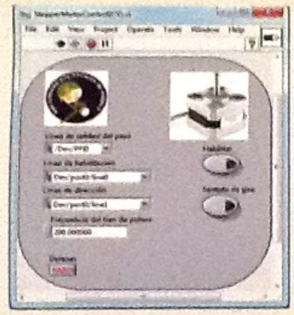


Figure 5. b) Screenshot of virtual instrument that controls the stepper motor.

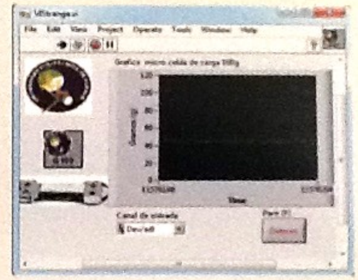


Figure 5. c) Screenshot of virtual instrument that captures the output value of the strain gauge.

Some virtual instruments (VI) are modeled in LabView for signal acquisition and actuators control (Figure 5) . These VIs are modular, each VI is encapsulated in a subVI.

Calibration sequence is based on the ISO-376 standard (Figure 6).

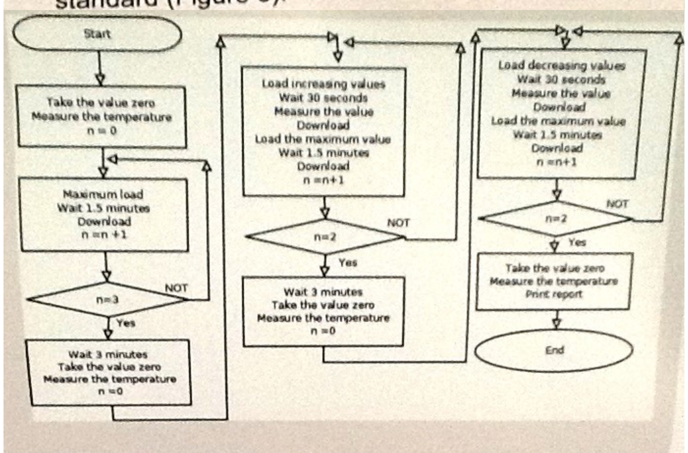


Figure 6. Calibration sequence.

5. Conclusion

Major mechanical systems of the machine were identified. The parts were designed in CAD software. A mechanical system of change masses was designed. This system operated with set of motors. These actuators are controlled by a Virtual Instrument.

The sensors to calibrate were defined in the election of electronic system. The calibration algorithm is based on the ISO-376 standard adjusting it to the number of masses that has the prototype.

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