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Machining Center Pitch Error Measurement and Compensate with Ease Using a LICS-100AP Turn-key Laser System

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1. Introduction

It is well known that better parts build a better product. To machine a better part is very complex. It involves cutting tool, spindle, ball-screw, ways/guides, thermal expansion, coolant, clamping forces and machine positioning accuracy, etc. All these may cause errors and have to be carefully minimized. A well build high accuracy machine is very expensive and also cutting and wearing reduces the machine accuracy. To overcome this and to achieve higher accuracy, the key is to measure and compensate the machine positioning errors.

Recently, Optodyne has introduced a new simple turn-key laser measurement package, LICS-100AP, includes a note book PC using Window 8 OS and pre-loaded with Laser Doppler Displacement Meter (LDDM) software. It is compact, low cost, easy setup and operation. The data collection is automatic and the error table or compensation files for most controllers such as Fanuc, Mitsubishi, Siemens, Heidenhain, Fedia, Fagor, etc can be generated and uploaded to the controller. A 3-axis cnc machine with a working volume of 3 m by 2 m by 1 m can be compensated for all 3-axis linear positioning errors (or pitch errors) in 2 hours. It is extremely compact, easy to operate and affordable.

2. Basic Machine Errors

Machine leveling, thermal expansion and distortion are important to machine accuracy. If the machine is not leveled, the weight of the machine and part to be machined will cause positioning errors. For most shop floors, the air temperature is not regulated. Hence there are large temperature variations. Most machine tools are steel structure. The thermal expansion coefficient is 12 ppm/ºC (6.7 ppm/ºF). That is, an increasing of 1 ºC of material temperature will cause an increasing in length about 12 μm over 1 m (0.0005" over 40"). This is very significant, if the machine is used to cut other than steel material, such as Aluminum. The linear displacement errors are usually caused by the non-uniformity of the lead screw or the scale.

3. Compare Michelson Laser Interferometer with LICS-100AP

Most laser systems are based on the Michelson interferometer. There are two laser beams, the output beam and the return beam, which are parallel but displaced about 25 mm (1"). Hence, large optics is required. Also, the alignment is critical, 3 elements (laser head, interferometer and retroreflector) have to be aligned co-axially. The laser head is large and heavy, and a heavy tripod is usually needed to support the laser head. It is very expensive and difficult to use.

The LICS-100AP turn-key laser system is based on laser Dopplermetry. It is singleaperture and frequency modulated. The laser head includes all data processing electronics. The output beam and the return beam share the same aperture. Hence large optics is not required and a small (0.5" diameter) retroreflector can be used as target. Also, there are only two elements (a head beam and a retroreflector)

to be aligned, the setup and alignment is very simple. As shown in Fig. 1, the LICS-100AP is a complete turn-key calibration system with air temperature, barometric pressure, and material temperature sensors to compensate any environmental and temperature changes. The laser stability is 0.1 PPM, the system accuracy is 1 PPM and traceable to NIST. The compact size and lightweight of the laser head and optics allows the operator to mount the components to the machine directly as shown in Fig. 2. Also, there is no need to dismantle the protective machine enclosure, reducing overall setup and calibration time. The Windows based data collection and analysis software is simple to operate. Hence any machine tool operator or a machinist can use the LICS-100AP for calibration and generate compensation files for the machine with minimum training.



Fig. 1. Components of a LICS-100AP turn-key Compact Laser System and all fit in a small brief case shown in the background.

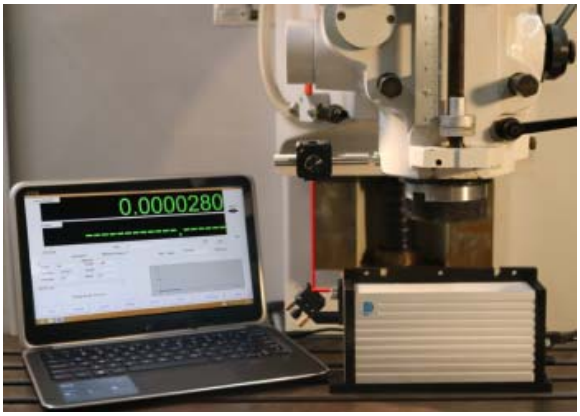


Fig. 2. Shows the LICS-100AP measuring the Z-axis.

4. Major Components, Capabilities and Features

Major components (as shown in Fig. 1) are the following:

Single aperture laser head with processor	LP 100
1/2" DIA retroreflector	R 102
90 degree beam bender with fine steering	LB 100
DC power supply and cable set	IP 100
Carrying case	CC 100
Metrology/Analysis program	W 100
Notebook Computer	LTC

Major Capabilities:

Laser Stability	0.1 ppm
Resolution	1 microinch (0.01 μm)
Range	50 ft. (15 meter)
System Accuracy	1.0 ppm
Slew Rate	40 in/sec (1 m/s)
Power:	90 to 230 VAC, 50 to 60 Hz

The major features are:

- Complete turn-key package fits into a small brief case.
- Single-aperture laser head for easy alignment and setup.
- A machinist can be trained to operate and generate compensation files.
- Using a 90 degrees beam bender to point laser beam in up/down and left/right 4 Directions with fine steering.
- Notebook PC using Windows 8 with preloaded LDDM software.
- Automatic barometric pressure, air and material temperature compensation.
- Automatic data collection and generate pitch error compensation files for most controllers.
- Data analysis based on ISO 230 and ASME B5 standards.
- Ideal for calibrate and compensation machine pitch errors.

5. Measurement and Compensation Lead Screw Pitch Errors

For most CNC machines, there is pitch error compensation capability. Using the LICS- 100A, the linear displacement errors (or lead screw pitch errors) can be measured and the compensation file can be generated automatically. The compensation file can be uploaded to the controller and will result in higher position accuracy.

6. Summary and Conclusion

The LICS-100AP turn-key laser measurement package can perform a quick calibration of the machine's performance based on the ISO 230 or ASME B5.54 standard. The measured errors can be used to generate compensation files to correct errors and to achieve higher positioning accuracy.

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