Straightness comparison measurement between an interferometer and a quad detector devices by Optodyne,inc.

Purpose : the purpose of the measurement was to demonstrate the field performance on a medium range machine (3300 mm /10ft) of the measurement done with the quad detector taking in consideration repeatability and accuracy.

Machine and environmental conditions. the machine is a CMM machine and the measurement was performed in a climatic room with air conditioning on, good thermal stability and relatively high air turbulence.
The measurement was performed on the horizontal axis at 1m from the ground floor.
The instrument used as reference is a laser interferometer single frequency with straightness optics, and the testing device an Optodyne LDDM with 8mm beam and quad detector as target.

Measurements:

1) was collected data with the interferometer, 5 runs moving in X direction and collecting data in the z direction and 5 runs collecting moving along x direction again but collecting data in the y direction. The measurements was done moving at step of 100mm with 15sec stop.

2) was collected the data with the quad detector 5 runs moving in x direction and taking data simultaneously in the z and y direction. The x axis was moved at steps of 100mm and with 5 sec stop. (average 30- files opto_1)
3) was collected the data with the quad detector 5 runs in the z and y direction with steps of 100mm and 15 sec stop. average 30 for the first 3 files and average 50 for the last two ,file opto_2).
4) the first measurement with the quad detector was taken too fast with the y axis not completely stabilized, the measurement was done a second time with the same time of stop of the interferometer and the data are more repeatable.

Test Results

The data was analyzed by excel and was plotted. The average and the standard deviation was calculated over 5 runs.

1. Measurement system errors

Fig. 1. Is a plot of the vertical and horizontal straightness measured by Optodyne LDDM with quad-detector and by an interferometer with straightness optics. All the plots are averaged over 5 runs. The maximum difference is about 0.004 mm.

2. Measurement repeatability

Fig. 2, is a plot of the standard deviations over 5 runs for both the Optodyne LDDM with quad-detector and the interferometer with straightness optics. The maximum standard deviations for the Optodyne with quad-detector are 2.4 um for xy and 2.2 um for xz. The maximum standard deviations for the Interferometer with straightness optics are 1.6 um for xy and 1.2 um for xz

Summary and Conclusion

The quad detector is a measurement tool that is easy to use and align, give measurement results of high quality even with large size machine. Based on the above test results, using the Optodyne

LDDM with quad-detector, the system error is less than 4 um and the repeatability or standard deviation is less than 2.5 um.

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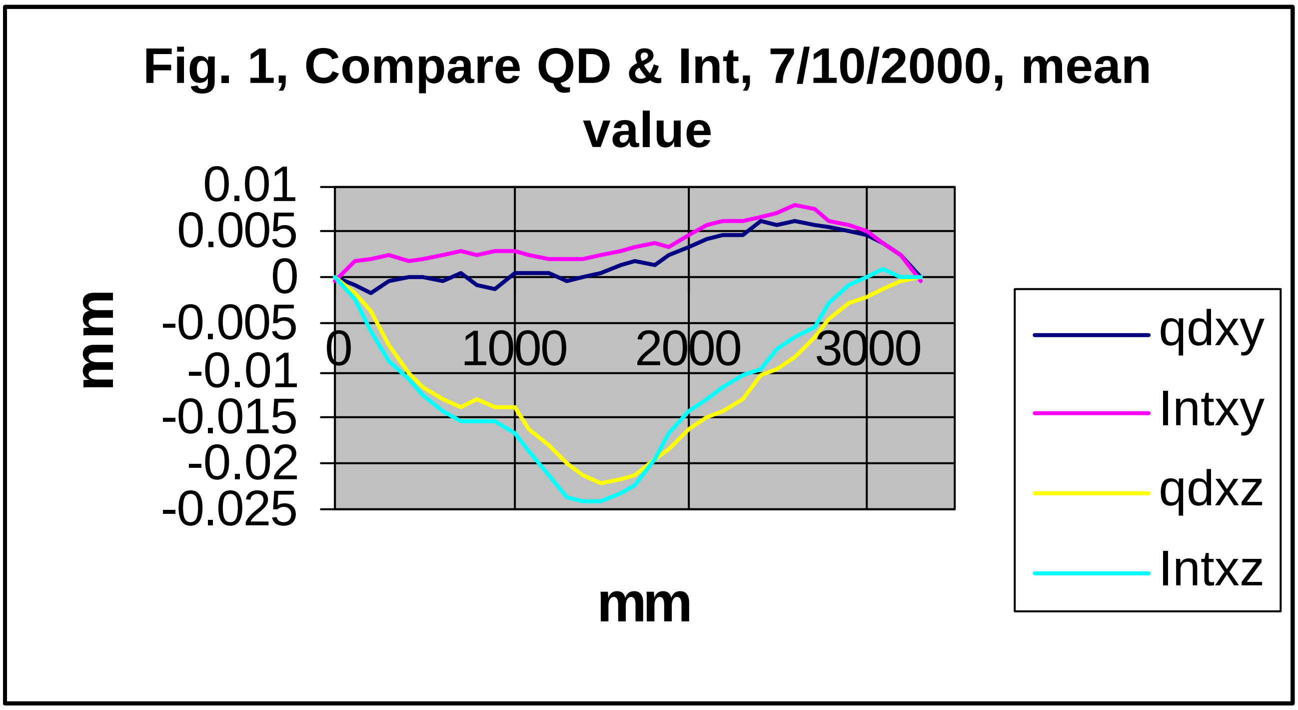

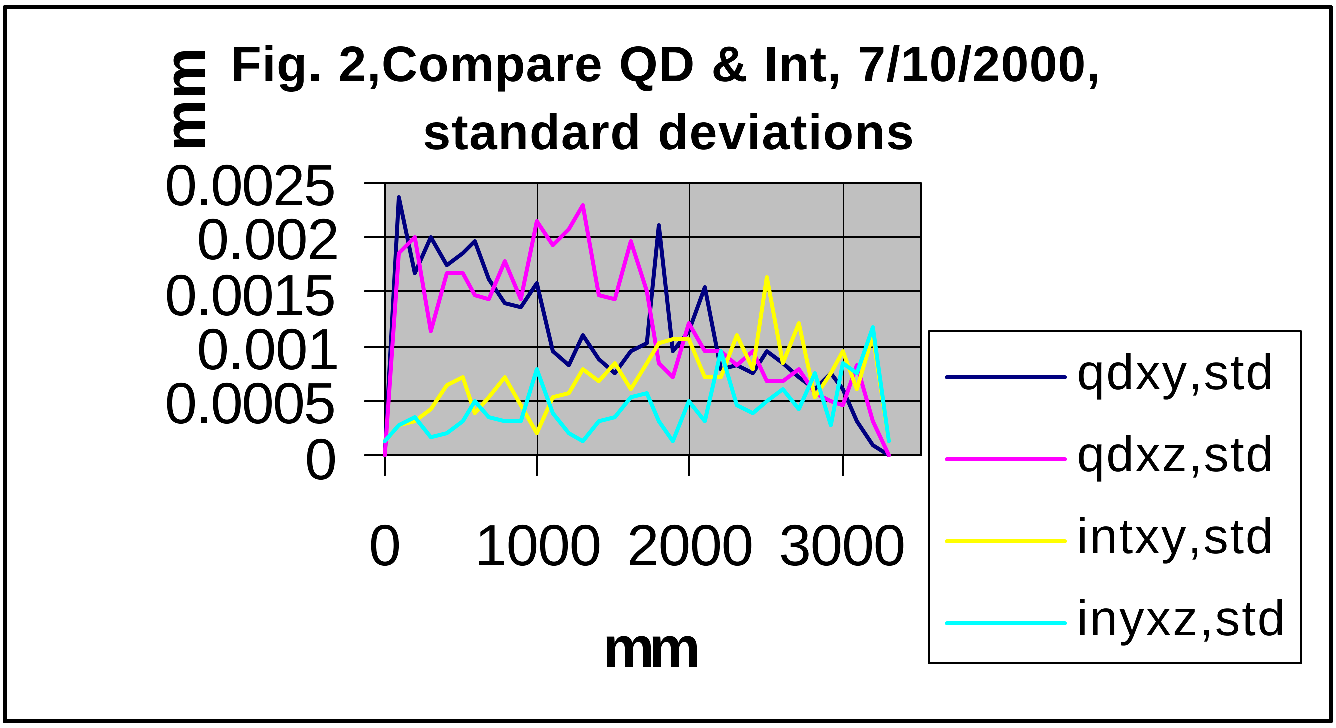

Straightness measurement using LDDM with quad-detector and interferometer with straightness optics

Straightness measurement	LDDM with a quad-detector	Interferometer with straightness optics
Basic technology	Straightness of laser beam and beam position sensor	Straightness of laser beam, prism beam splitter and reflector
Optical arrangement	Single laser beam	Two beams split by a prism
Setup and operation	2 elements for both short and long range	3 elements and different optics for short and long range
Vertical and horizontal straightness measurement	Both straightness in 1 setup and 1 run	Needs 2 setups and 2 runs
Squareness measurement	Using a small penta-prism, easy setup and operation	Using a large penta-prism, difficult setup and operation
Measure vertical axis	Same optics	Needs an additional straightness accessory kit
Measurement time	Short	Long, more than twice
Axial range	0-10 m	0.1-4 m, 1-30 m
Straightness measurement range	+/- 1 mm	+/- 2.5 mm
Resolution	0.1 µm	0.01 µm
Instrument accuracy	Much smaller than beam wandering	Much smaller than beam wandering
Accuracy determined by air turbulence	Yes	Yes
Repeatability due to beam wandering, standard deviation	Single beam, 1 sigma	Split beams, 0.7 sigma