How to achieve higher volumetric positioning accuracy and cut more accurate parts with your existing machine tools

I. Introduction

For lean manufacture, it is import to improve the volumetric positioning accuracy of the existing machine tools and to cut more accurate parts without the purchase of new machine tools. The key to achieve that is the new revolutionary laser vector measurement technique developed by Optodyne. With this laser vector measurement technique, the volumetric positioning errors, including 3 displacement errors, 6 straightness errors and 3 squareness errors, can be measured in a few hours instead of a few days by a conventional laser interferometer. The measured volumetric errors can be used to generate lookup tables or compensation files to correct the machine positioning errors in 3 D.

For the existing machine tools, as long as they are repeatable, the volumetric positioning accuracy can be improved up to the positioning repeatability of the machine. There are 3 types of existing machine tools, namely, 1. manual machines with or without numerical display of 3-axis positions, 2. CNC machines with pitch error compensation capability only, and 3. advanced CNC machines with volumetric compensation capability such as Fanuc 15, 16, and 18 with straightness compensation capability and Siemens 840 and 810 with sag compensation capability.

II. Laser vector measurement technique (patent pending)

The laser vector measurement technique is developed by Optodyne for the calibration of volumetric positioning accuracy of a machine tool. It uses a single-aperture laser head and a flat-mirror as target.
Similar to the ASME B5.54 standard body diagonal displacement measurement, the laser beam is pointing in the body diagonal direction. However, instead of move x, y, and z-axis together along the body diagonal direction, stop and collect date, now move x only, stop and collect data, then move y only, stop and collect data, then move z only, stop and collect data, and so on until the opposite corner is reached. Hence, 3 times more data can be collected. For 4 body diagonal measurement, a total of 12 sets of data can be collected and the volumetric positioning errors determined. The measurement time

is short, the equipment is compact, the setup and alignment is simple and the cost is low.

III. For manual machines

For a manual machine, higher accuracy can be achieved by numerical display the volumetrically corrected position. Install a rotary encoder and a home position switch for each axis. Use a desk top PC with 3 counter cards, and volumetric positioning error lookup tables to display the machine coordinate or parts coordinate. The software will display the 3-axis positions corrected with the volumetric positioning error lookup table. The software can also record the actual 3-axis position during the laser vector measurement. For large temperature changes in the shop floor, material temperature sensors can be installed to compensate the machine thermal growth. A block diagram is shown in Fig. 1.

IV. For CNC machines without volumetric compensation capability

For CNC machines without the volumetric compensation capability, such as Fanuc 0, Siemens 802, etc, the machine can only compensate the pitch errors of each axis. First use the laser vector technique to measure the volumetric positioning errors and generate an error compensation lookup table. A software, such as Shadow Map, will use the error compensation lookup table to correct the x-, y-, and z-axis coordinates in the parts program (G-code). Enter the corrected parts program to the controller to cut a more accurate part. A block diagram of off-line error compensation is shown in Fig. 2 and a block diagram of on-line error compensation is shown in Fig. 3.

V. For advanced CNC machines with volumetric compensation capability

For advanced CNC machines with volumetric compensation capability, such as Fanuc 15, 16 and 18 with straightness compensation, Siemens 840 and 810 with sag compensation capability, first use the laser vector technique to measure the volumetric positioning errors and generate a volumetric error compensation file. Then download the volumetric error compensation file to the controller. The CNC machine after the volumetric error compensation will cut more accurate parts. A block diagram is shown in Fig. 4.

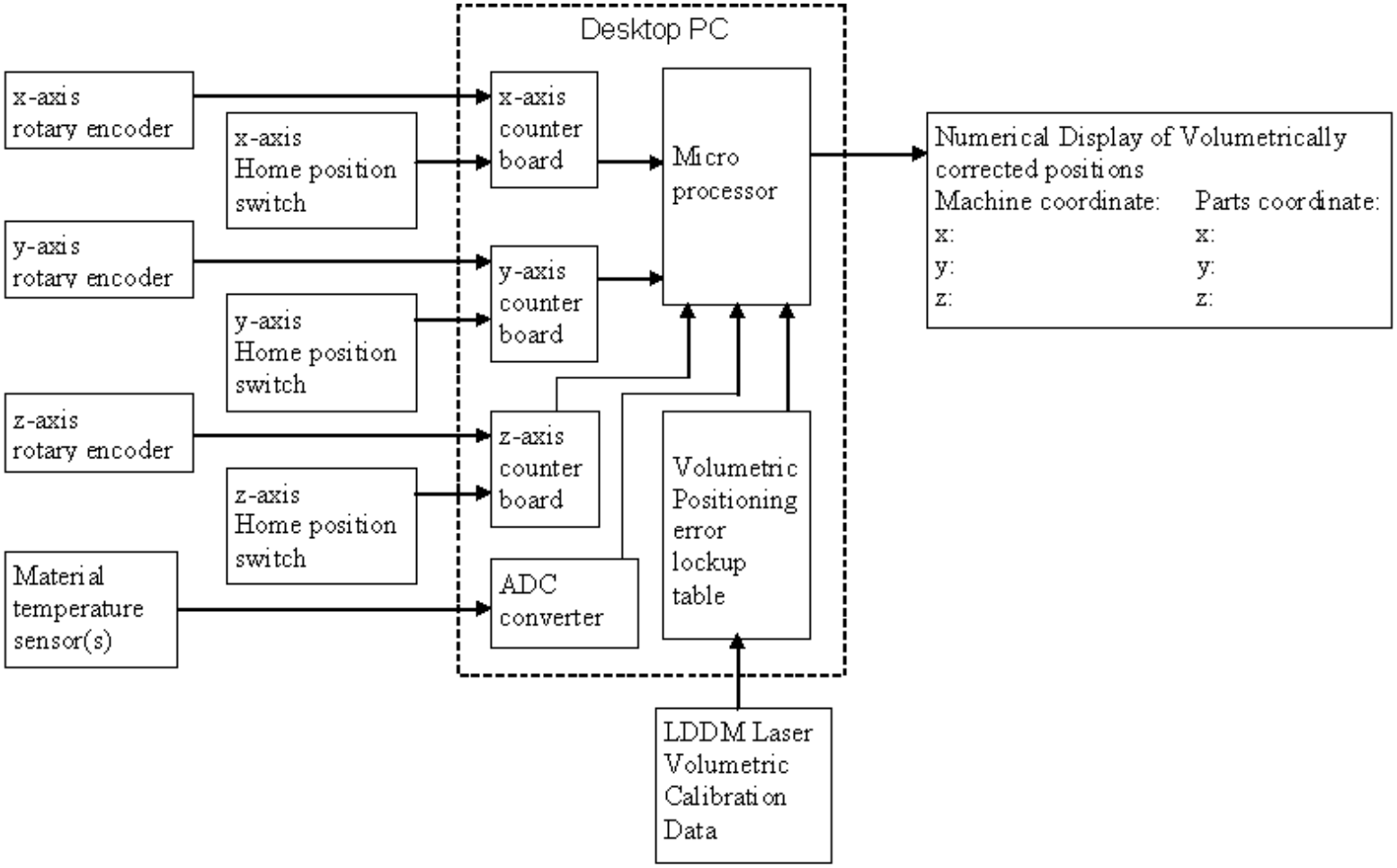

Fig. 1, Block diagram of display the volumetrically corrected position of manual machine

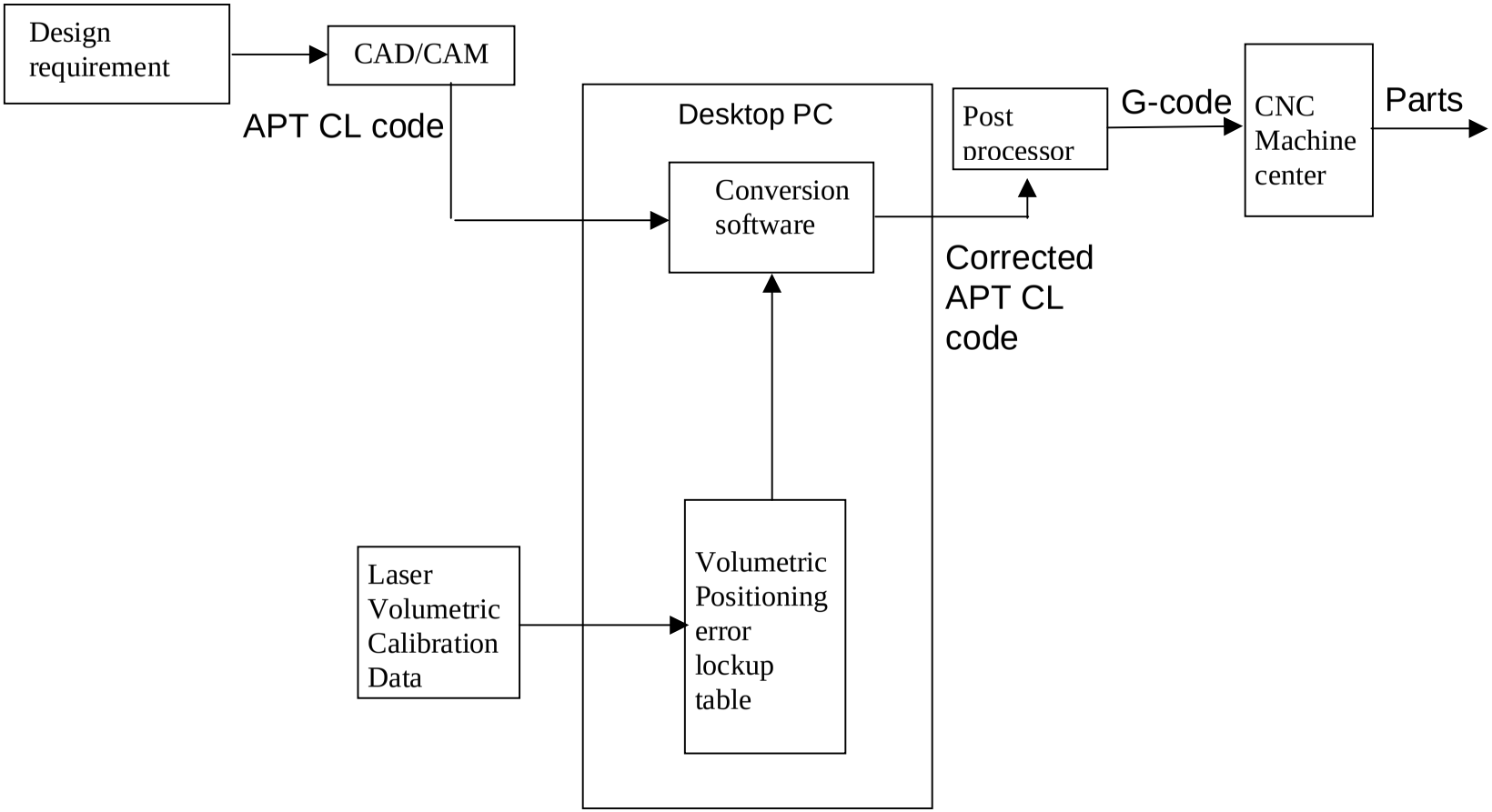

Fig 2, Block diagram of off-line volumetric positioning error correction

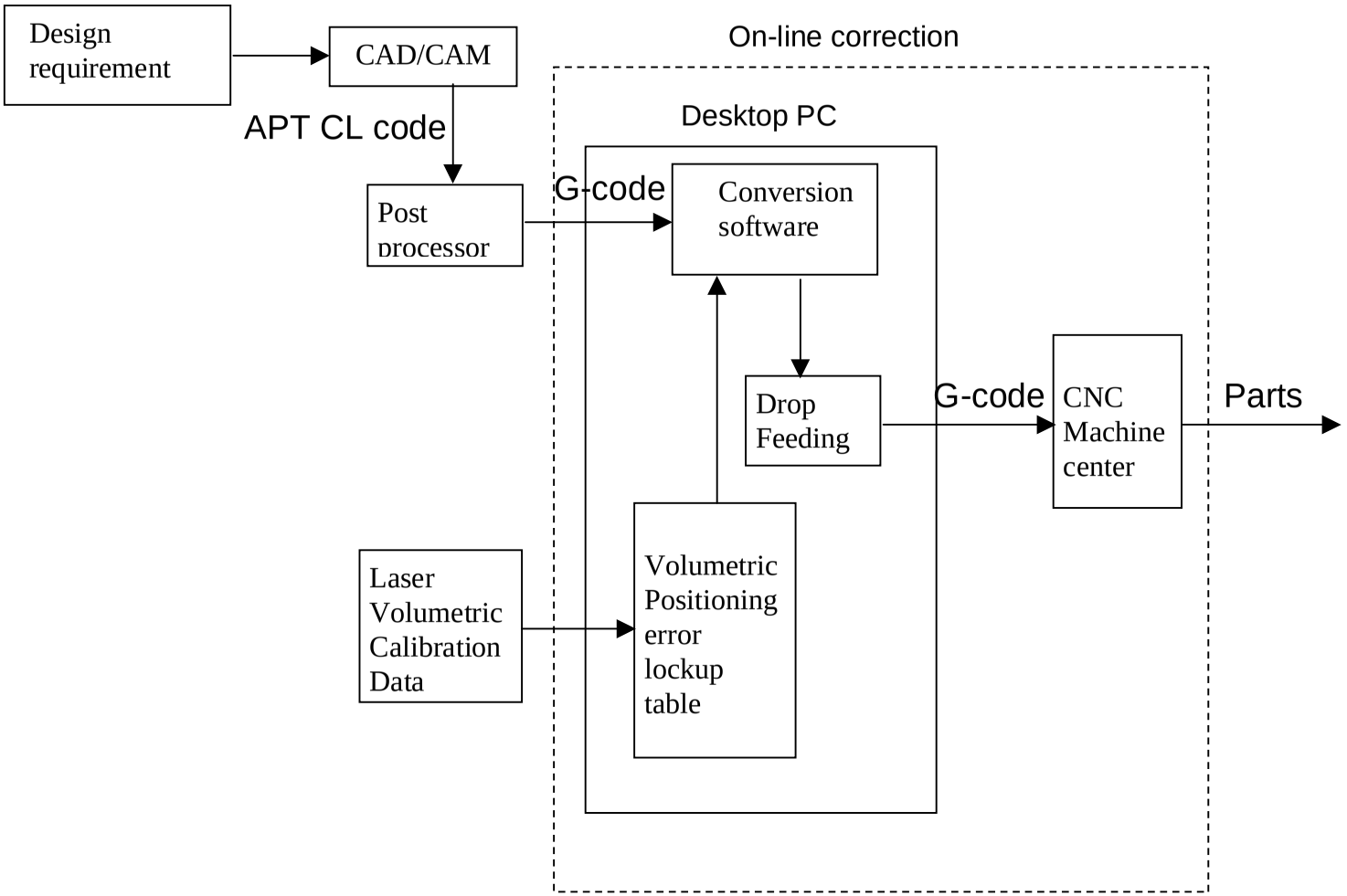

Fig 3, Block diagram of on-line volumetric positioning error correction

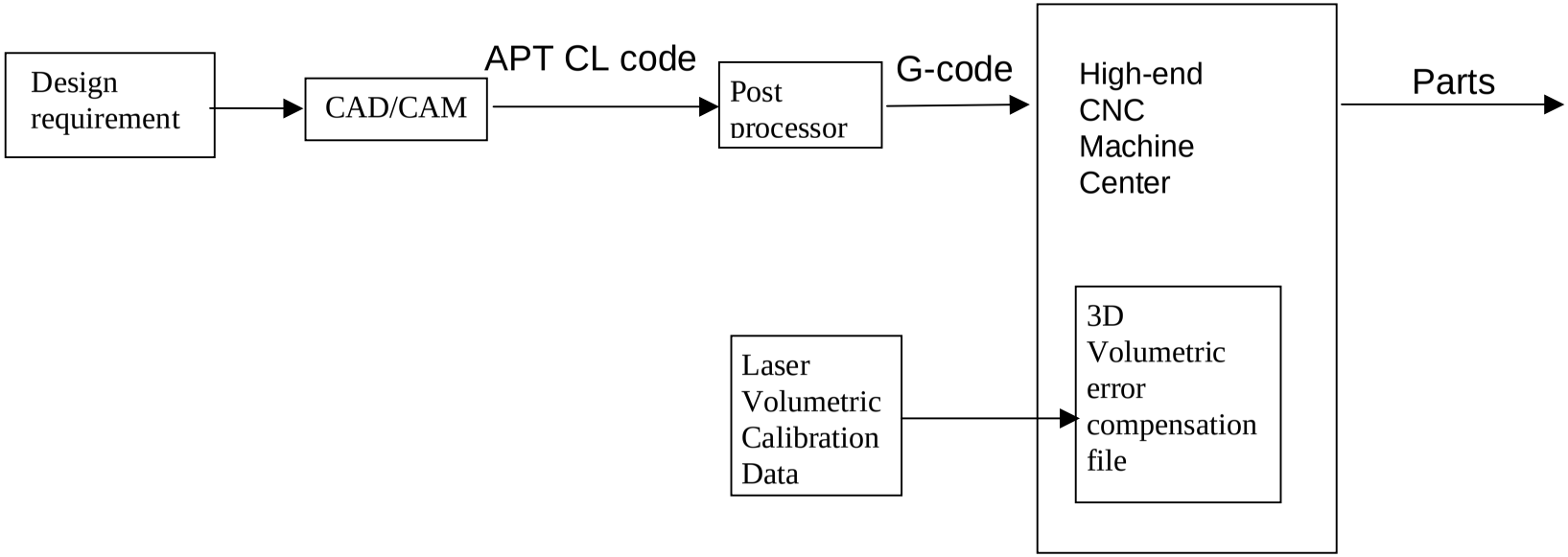

Fig 4, Block diagram from design to manufacture with 3D Volumetric error compensation