Alignment of Parts for Laser Micromachining
(applicable to MM, PM, & custom machines)

A common requirement in laser micromachining as a manufacturing step is to align micromachined features w.r.t. existing structures on the part to be processed.

Example 1:- point-to-point machining of motifs with rotational symmetry;- an array of small circular via holes must be drilled through a dielectric layer to contact lower level metallization tracks. Typically, the precision with which individual parts can be loaded onto the part support,- manually or auto,- is substantially lower than the required machining accuracy.

Example 2:- insulation must be removed from along the long edge of a contact pad, by tracking a large rectangular motif along that edge, firing the laser during part motion. The motion, and motif shape, must be aligned with the part edge.

In both cases the current part position/orientation must be determined. In example 2, a theta axis is necessary to align the long edge on the part with machine X,Y (and more importantly with the edges of the rectangular motif;- a software-based coordinated diagonal move X+ΔY can correct the former, but not the latter!). In example 1, correction using a theta axis can be used, but is not necessary, since the required correction can also be carried out by making the appropriate edits to the via coordinate file.

Either way, the alignment relies on the visual identificiation of alignment fiducials or identifiable features which serve as such. TWO such fiducials are the minimum requirement on a non-distorted part. The fiducials can be situated anywhere on the part, typically(but not necessarily) aligned with one of the major X,Y axes.

Visual CCTV display is in a window on the PC ProcessPower display, with video cursor overlay which can serve to display markers, or add a mouse-controlled crosswire.

Data Acquisition(operator guided)

1) The X,Y coordinates of the fiducials,- which can be anywhere on the part,- are established in a coordinate system(for e.g. of the CAD file), whose origin must be known w.r.t. some mechanical **part reference position**, for e.g. the part corner, whose position can be defined to low precision by locating dowels on the fixture, subject to a **part loading error**. For e.g. the fiducial positions of a particular product, including also complete processing data etc., are strored in a related .fdc file)

2) In turn, that part reference position in the X,Y plane is known w.r.t. a **machine reference position**, which might be X,Y home position or rotation centre, established by prior machine calibration.

3) The vision system used to view & identify the fiducials is either a TTL(Through The Lens) system, or a system mounted at a known **vision offset** position, calibrated w.r.t. processing position. The vision system must have a magnification a) sufficent to ensure the final alignment accuracy required, but b) not so big that part loading errors make it impossible to locate the alignment fiducials in their anticipated positions,- i.e. the fiducial has to appear somewhere on the CCTV display(where there is a conflict between these two requirements, a two-step alignment procedure is used, with consecutive low-mag. & high mag. vision systems.

4) On first launching the alignment software routine, a preliminary step is to record the exact **process position** on the TTL image,- marking & recording this position with a mouse click(A).

5) After part loading, entering the alignment routine causes the X,Y stages to move the part so that the anticipated position of the 1st alignment fiducial is brought into the image field, subject to the part loading error(B). A mouse click acquires the true position of the fiducial(C), and initiates a move to the expected position of the 2nd fiducial, again acquired with a mouse click(D).

Correction by Coordinate Editing

6a) For an application such as example 1 above, the via coordinate file is simply edited to correct for the part loading error determined as above, before launching the process.

Using a Theta Correction Stage

Where a motorized theta stage is fitted, a necessary part of the prior machine cabilbration is to determine the X,Y offset between rotation centre and machine reference position. In many cases the rotation centre is defined as the machine reference position, calibrated w.r.t. X,Y home position determined at power-on.

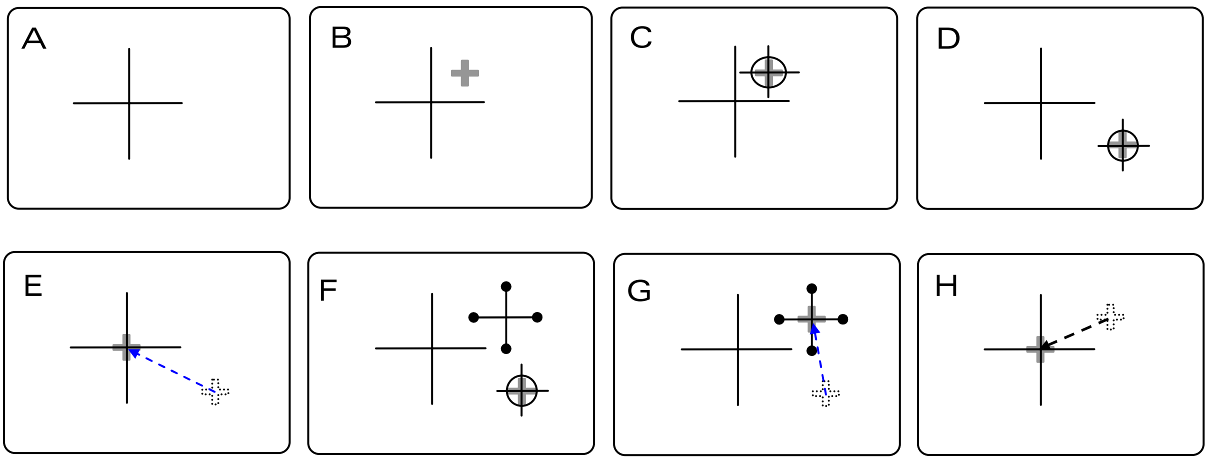
Correction with Motorized Theta Stage

6b) On clicking on the second fiducial, the part automatically corrects in theta, X & Y, bringing the second fiducial to the crosswire marking the process position(E). A brief pause allows the operator to check the correction, then the part translates to bring the first fiducial back to the process marker for checking correction at this point also(E). At this stage the operator can click left to confirm correction(and if appropriate automatically launch a pre-programmed process routine), or click right to repeat the alignment routine from 5,- allowing iterative correction).

Correction with Manual Theta Stage

When only a manual theta stage is fitted, as for e.g. on PM:-

6c) On clicking on the second fiducial, the software automatically generates a new marker on the image display(F), which lies on the locus of points to which the fiducial can be moved by a pure theta displacement. The operator adjusts the manual theta stage to bring the second fiducial to the position of this new marker(G) and presses enter to confirm theta alignment correction and initiate X,Y component of the correction(H). After a brief pause, the part translates to allow cccccchecking of correct alignment of the 1st fiducial,as abovevf.



Automated Procedures using PRS

The procedures above can be further automated using a frame grabber & PRS system to identify and record fiducial postions. This option is most logically associated with automatic part loading, and appropriate for custom industrial processing applications. The optimal techniques used for PRS depend on the image contrast etc., and are studied on a case-by case basis

Deformed Parts

Where parts may be deformed during the manufacturing process, more than two fiducials will be required:-

1) Skew errors, i.e. where X,Y orthogonality is lost, require 3 fiducials, which are also sufficient to cater for anamorphic deformations,- e.g. shrinkage along one axis.

2) Random part deformation may require more fiducials, the number and placing of which depends on the nature of the deformation. Correction of intermediate points via interpolation, linear or bicubic spline.