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Sceptre Application Notes
Camshaft
Automotive Engine Industry

Sceptre 3.0 has recently been enhanced with specialized Analysis and reporting features that aid and simplify the Analysis of measurement tasks found on many camshafts.

The primary data collection mode of Sceptre is the SCAN Command and its ability to measure an unknown free form surface. This makes it ideally suited to the task of gathering data on unknown or known CAM shapes. Data
collection requires no prior knowledge of the shape and thus requires no pre programming. Sceptre has been used quite extensively in the past for reverse engineering specialty or machine tool CAM's which have unusually shaped profiles. These CAM's were developed empirically (on the fly) to cause some type of machine motion. Many of these CAM shapes simply evolved from polishing and filing by machinists.

Sceptre now contains the DISECT feature that can take a point data set from any free form shape and builds
i.e. sizes, isolates and selects geometric segments that best fit the data so that the resultant form lies under a threshold.

CAM Analysis element

A CAM analysis element has been added to the Sceptre package that automatically determines the most frequently inspected features of a class of CAM's used primarily for opening and closing valves in automobile engines. These CAM's are referred to in the industry as "Polydyne" or Polynomial Cam's because the formula for deriving lift, velocity, and acceleration is polynomial equations.

A: **Max Radius**
The angular location at which the cam surface achieves it maximum radius or where it achieves maximum lift.

B: **Max Positive Velocity peak**
The angular location at which the cam surface achieves a maximum (opening or rise) velocity.

C: **Max Positive Acceleration peak**
The angular location at which the cam surface achieves a maximum (opening or rise) acceleration.

D: **Min Radius**

The angular location at which the cam surface achieves it minimum radius or where it achieves no lift. Lies somewhere on the clearance circle.

E: **Max Negative Velocity peak**

The angular location at which the cam surface Achieves a maximum(closing or sink) velocity.

F: **Max Negative Acceleration peak**

The angular location at which the cam surface achieves a maximum (closing or sink) acceleration.

G: **Rise**

Max radius minus Min radius

Not only does it give you the actual dimension but it set's graphic markers that permits the system to pictorially show you where the CAM analysis element decided that these critical measurements occurred. (Fig.1)

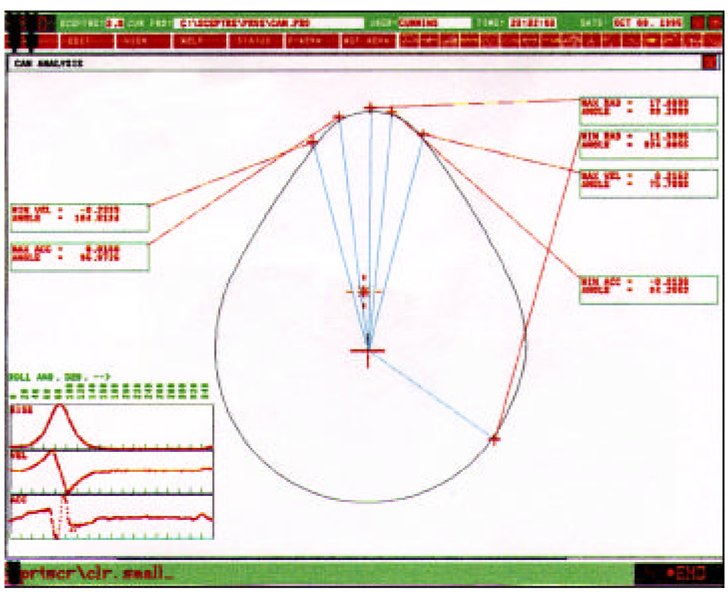

Figure 1 - Screen display after executing CAM analysis command. Routine automatically determines and calculates the MAX/MIN peak radius, peaks velocity and peak acceleration. Lower left charts of rise mm, velocity mm/deg and acceleration mm/mm/deg .

The CAM analysis command can convert the geometric relationships and data set to a rise curve. Classically they can appear as a chart where the abscissa is Angle of rotation and the ordinal is rise.
(See Fig.1 Lower left Top chart)

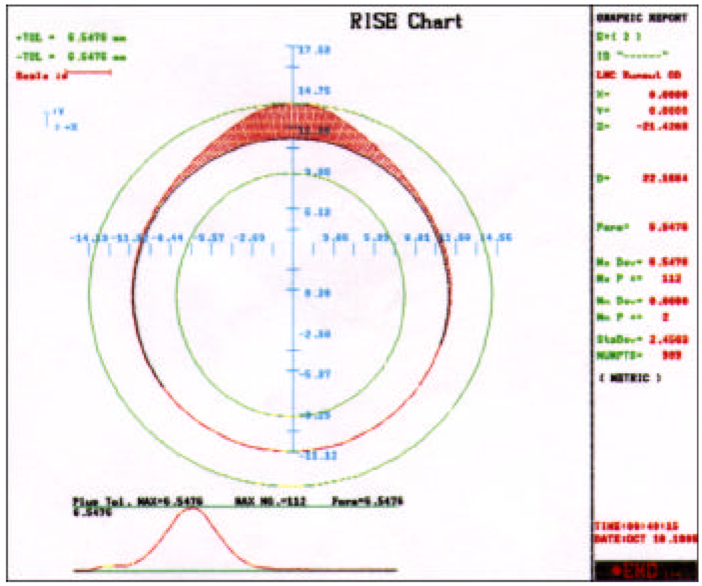

Figure 2 -

cally plot
the data and represent
rise as a curve surface
normal to the geometry.

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The CAM analysis command can convert the geometric relationships and data set to a velocity

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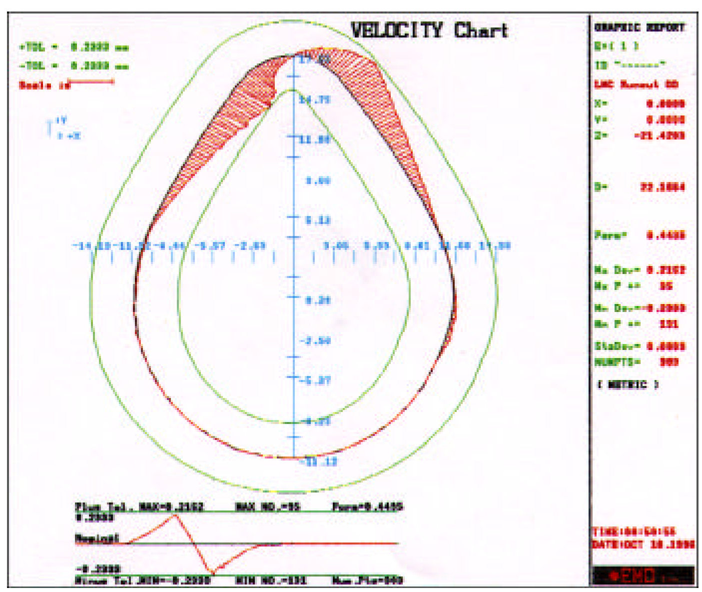


Figure 3
Another method of
representing this
relationship is to
geome

CAM Analysis & Representation of Acceleration

The CAM analysis command can convert the geometric relationships and data set to a Acceleration curve. Classically they can appear as a chart where the abscissa is Angle of rotation and the ordinal is acceleration. see Fig.2 Lower Left, Bottom chart)

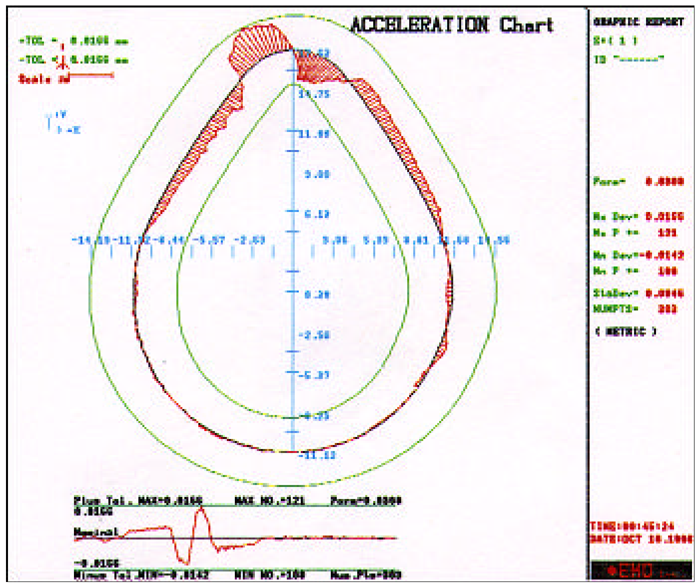


Figure - 4
Another method of representing this relationship is to geometrically plot the data and represent Acceleration as a curve surface normal to the geometry.

Comparison of a CAM to a nominal

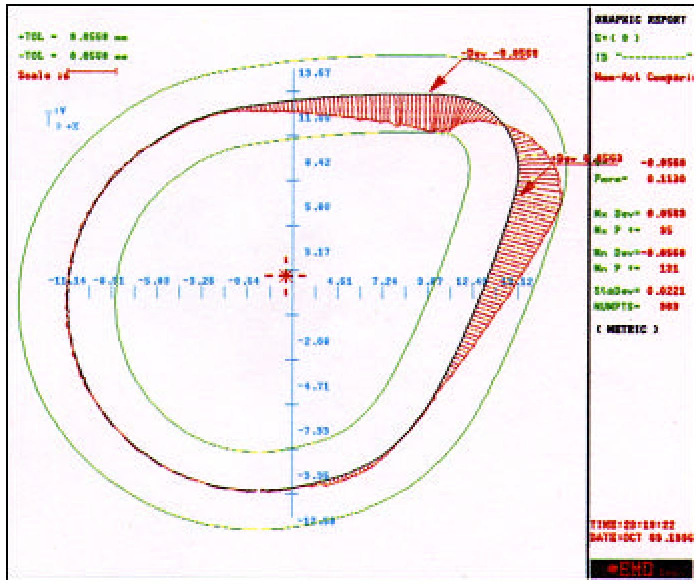
In most cases of designed and defined CAM's there are known nominals. These nominals can be XYZ Cartesian coordinates, Theta-Radius Polar Coordinates or CAD splines. Sceptre has lots of mechanisms for reading files and generating nominal data sets. It can input straight ASCII files where the coordinates are in a table format or it can directly read IGES, DXF or VDE CAD files.

The compare command can then take this nominal data set and compare it to the actual scanned data set. The result is the detected variation in material of the actual to the nominal theoretical profile.

Figure 5 - Comparison of actual scan data against a CAD spline nominal. Variation between these two data sets are magnified.

Note: Distance between nominal (black) and tolerance (green) represents 0.056mm

The two sets are evaluated in fixed reference systems based on defined datum's. In this datum system the misalignment of CAM becomes obvious.

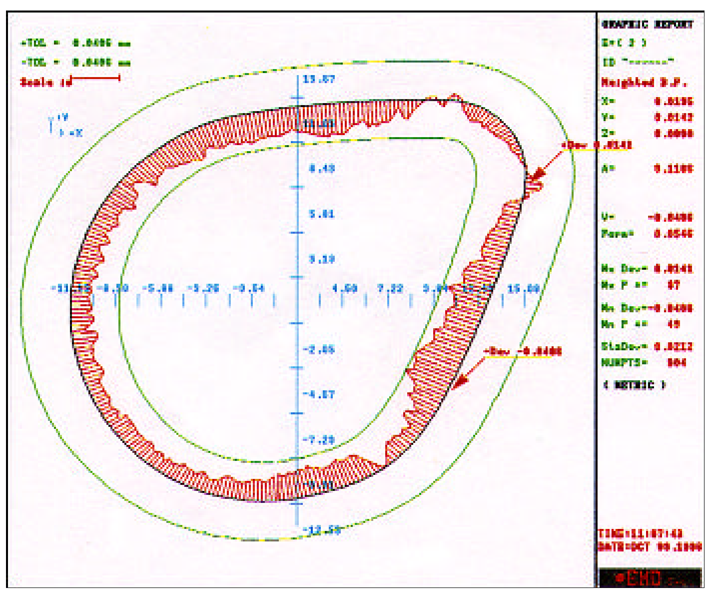


Best Fit

After comparing the Actual to Nominal the result may be best fitted together. In the case of Polydyne CAM it is desirable to restrict best fit shifts and only allow best fit rotations to minimize variations. Other cams may have different fitting criteria based on function. (See Fig.6. Same Data as in Fig.5 but Best Fit)

Figure 6 - Same data as in Fig.5 but Best Fitted for rotation. One result is the rotation angle that now can be used for corrective action in the manufacturing process. Note: That relative to Fig.5 the CAM appears lined up better but still undersized.

Note: Distance between nominal (black) and tolerance (green) represents 0.040mm



Shape Variation

Many CAMS are defined from relative motion or shape variation. After comparing the Actual to Nominal and then best fitting them together we have a absolute set of measurements.

To achieve the relative measurements the Shape Variation command takes the average amount of material deviation and subtracts that from each deviation data set. In this way the data then becomes independent of the size of the cam.   (See Fig.7 Same Data as in Fig.6 with only shape variation)

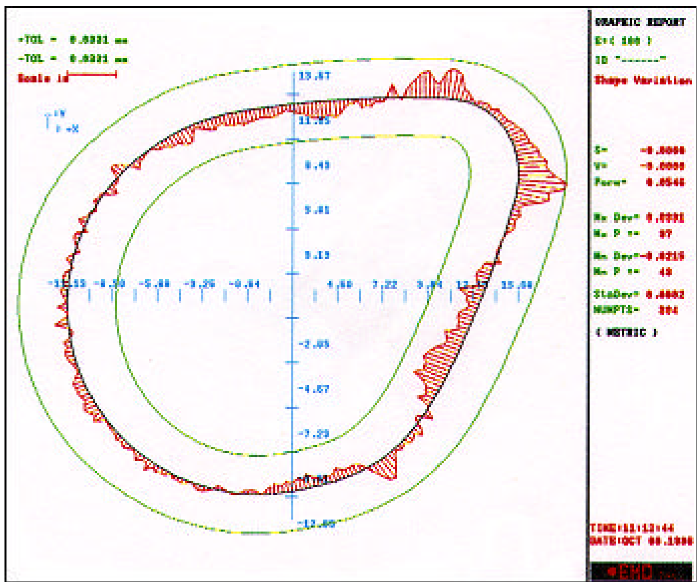


Figure 7 - The shape variation command now has corrected the size of the CAM relative to the nominal data set. That offset size can now be used in the manufacturing process to make the CAM size closer to nominal. The resultant shape is now a true picture of the resulting CAM action motion.

Note: Distance between nominal (black) and tolerance (green) represents 0.033mm