

CURVE ANALYZER – APPLICATION PACKAGE FOR ANALYSIS OF 2D POINT SEQUENCES

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Summary. The “CurveAnalyzer” package allows fast and intuitive way of both curve analysis and graphical reporting. It implements a simple interface covering all basic curve analysis functions – building geometric elements from the curve, constructions, dimensioning, wide range curve calculation functions etc. The package can be also used as basis for development of customized solutions.

1. PREFACE

The 3 coordinate measuring machine is a powerful tool for fast and precise acquisition of points on geometrical parts. The measuring software used to elaborate this data (as for example PC-DMIS and QUINDOS) already provide generic solutions for evaluating of the requested characteristics and representation of the results. In the specific case of general 2D profile inspection, this solutions, even being powerful, require rather good knowledge of the functions available in the measuring software for both curve analysis and graphical reporting. The “Curve Analyzer” package presented here has been developed to allow fast and intuitive way of solving this tasks. It implements a simple interface covering all basic curve analysis functions – building geometric elements from the curve, constructions, dimensioning, wide range curve calculation functions etc. The package can be also used as basis for development of customized solutions.

2. PROGRAM STRUCTURE AND ALGORITHMS

2.1. General

“Curve Analyzer” supports unlimited number of objects of the following types : “Curves” (point sequences), “Points”, “Lines”, “Circles”, “Dimensions”. All objects are shown in a “tree” structure that can be condensed or expanded, Fig. 1. Each object can be individually selected and the user has direct access to the most used properties, shown always on the left bellow the tree. For the curves it is possible to set various flags defining the appearance – those showing single points, showing normal vectors, showing numbering and others. Each curve has also set of flags that control how the deviations are to be shown and the way of applying the tolerance band. All the names of the objects are freely selectable, and can be changed in any moment.

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In the graphic area the objects are shown. It is possible to zoom any area of the screen or to pan the image. The printing function will print in a report the visible area. It is also possible to fix the print scale to be one of the pre-defined fixed values.

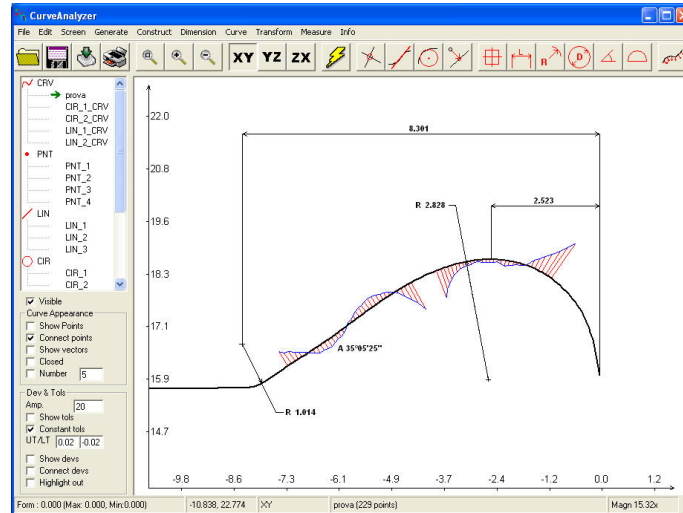


Fig. 1. Graphical use interface of Curve Analyzer package

The axis position and divisions can be automatic or user defined. It is possible to work in any plane of the co-ordinate system. For the evaluations the user can use the points as they are, or can “align” the profile in the plane (2D alignment). Normally this alignment is done after constructing some geometrical elements and then using them as reference. It is also possible to include some theoretical offset or offset rotation to the alignment.

Depending on the activated function, it will be possible to interact with the graphical area, selecting elements or indicating areas, so that it becomes easy to have visible control on the operations performed.

2.2. Curves (point sequences)

All curve computing functions are based on third order constrained spline calculations performed on point sequences and are executed by a dedicated library (calculation of the normal vectors, curve comparison, curve offset, curve intersections), Fig. 2. There is also a special “sorting function”, based on the position of the points on the plane. This function is extremely useful when importing DXF files. The best-fit algorithm of the library allows to limit the best-fit to only rotation or any of the two possible translations. Fourier filter can be used as “low pass” for generic form evaluation or as “band pass” filter for waveness evaluations. All standard transformation as mirroring, shift and inversion of normal vectors or order are possible. Collecting or splitting a curve is also possible.

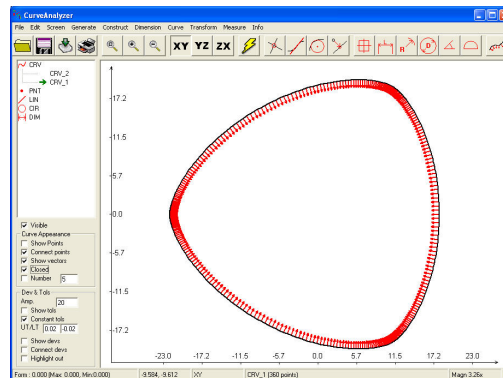


Fig. 2. Example of nominal normal vector calculation

Another implemented algorithm gives the possibility to re-calculate or re-order points according to some expressions. This allows to perform any type of parametric calculations of the points. Some of the typical cases are already included – as for example the calculations of the “law” or the transfer of point sequence measured in any plane to XY plane. In similar manner it is possible to generate point sequences according to some expressions. Already included expressions support all basic 2D geometric figures as for example the cycloid, hypocycloid, involute, spiral of Archimede etc.

2.3. Geometrical elements

The geometric element calculation is performed according to the minimum square sum algorithm. The selection of points is executed by simple clicking, but then it is still possible to include other points in the selection or to eliminate points from the selection. The construction of geometric element creates also “Curve” object that can be used in order to represent graphically the deviations. It is possible to create theoretical elements, indicating their dimension and position.

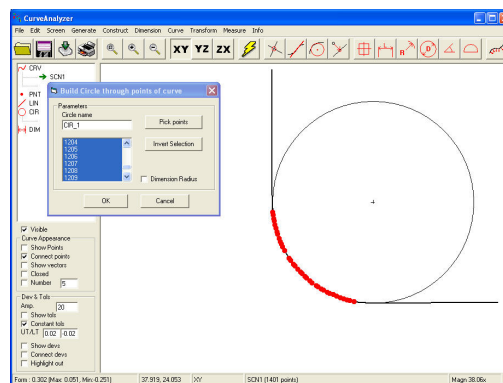


Fig. 3. Example of a circle starting from a curve

Algorithms for projections and intersections between geometrical elements are included as well.

2.4. Dimensioning

General dimensioning includes “diameter/radius”, ”linear dimensions” along the main and secondary axis and as direct distance, “angular dimensions” to main or secondary axis or between 2 axes, general position (collecting the possible evaluations for certain kind of element in one box), form error.

Dimensioning algorithms support dynamic update, i.e. if some element is recalculated then the dimension will be automatically updated. This allows for example to examine very fast the eventual changes of dimensions due to changes in the alignment (it will be enough to align and all the dimensions will be updated).

3. INTERACTING WITH THE MEASURING SOFTWARE AND WITH OTHER POINT DATA – IN THE FOLLOWING LIST THERE ARE THE CURRENTLY SUPPORTED IMPORT / EXPORT FUNCTIONS

Following formats are available for importing data:

- Generic ASCII files – there is a generic parser function for import of ASCII files
- Data from PC-DMIS – direct acquisition of already measured single points or scans from PC-DMIS. The program can also drive PC-DMIS, those driving the CMM in order to measure single points or execute scans.
- Data from QUINDOS - import of point data exported by the standard instructions of QUINDOS
- DXF data – there is a DXF parser function for importing DXF files. This functions allows to set up the point density for the lines and the max/min point density for the arcs.
- Milling data - Circular path definitions
Exporting can be performed in one of the following formats:
 - Generic ASCII file as CSV file
 - Transfer data as point elements or scans in PC-DMIS
 - Creates files for QUINDOS with point data
 - Export as DXF file

4. OTHER FUNCTIONS AND REPORTING

It is possible to save and load the set of objects you have created (that is all the curves, circles, point dimensions etc.). Additional customisation is possible setting the background colour of the graphical area, the font type and size, and the logo that will be printed out on the report. Currently 3 formats of reporting are supported – single curve, multi-curve, screen. In all this reports it is possible to compile a table with the part data, that will be printed at the bottom.

5. EXAMPLES OF USE – SOME TYPICAL EXAMPLES, DEMONSTRATING THE PROGRAM CAPABILITIES.

5.1. Dimensioning of a generic 2D profile using geometrical elements:

In this case a single scan has been performed, then the points has been loaded in the program and the required elements constructed. In the critical segments it is possible to request graphical representation of the form errors.

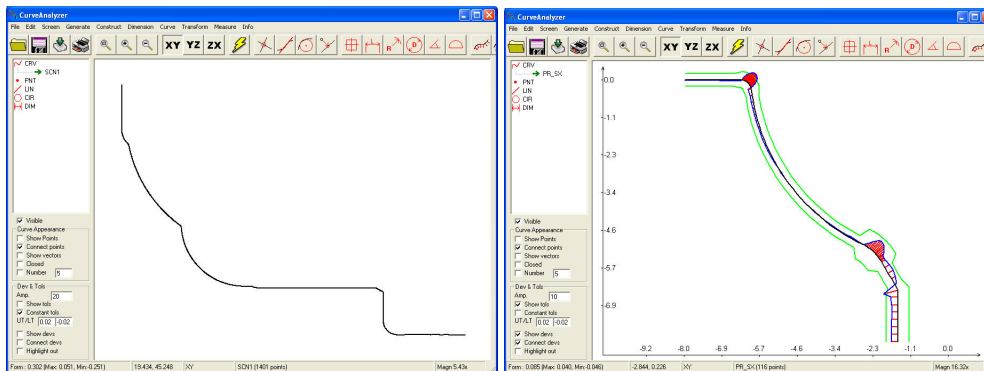


Fig. 4. Source curve (left) and dimensioned curve (right)

5.2. Measuring of the stamp seat comparing the result to the imported nominal curve.

Note that in this case a variable tolerance band has been requested. The nominal has been imported from DXF, then the normal vectors has been calculated and a tolerance band has been defined (different for each segment). Using PC-DMIS the measurement was directly executed by “CurveAnalyzer”, those providing an inspection report.

5.3. Example of single cam analysis.

The actual to nominal comparison can be made both on the profile as measured, or after the transformation of the measured points to “law” curve. In this example the tolerance band has been applied to the “law” curve. The “law” can be calculated as “direct” low (just transforming the Cartesian coordinate of the point to polar coordinate) or simulating a flat pusher applied on the cam.

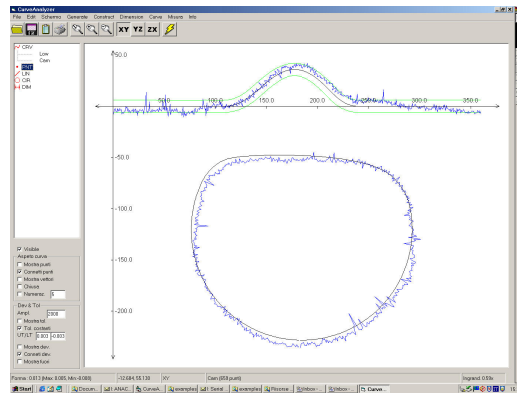


Fig. 5. Example of single cam analysis

5.4. Example of multi-cam analysis

In this examples 6 curves are measured and the report represents them in one graph. The nominal data for these cams were obtained importing the file used by the milling machine. For this type of cams (there are 3 gaps, that form the cams) it is also possible to perform analysis of the “clearance”, using the offset function followed by a comparison between the curves.

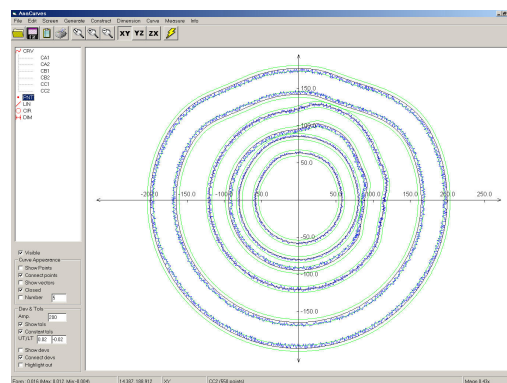


Fig. 6. Example of multi-cam analysis

6. ACKNOWLEDGEMENTS

The Spline library used in “CurveAnalyser” has been developed by Ivan Peev.

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