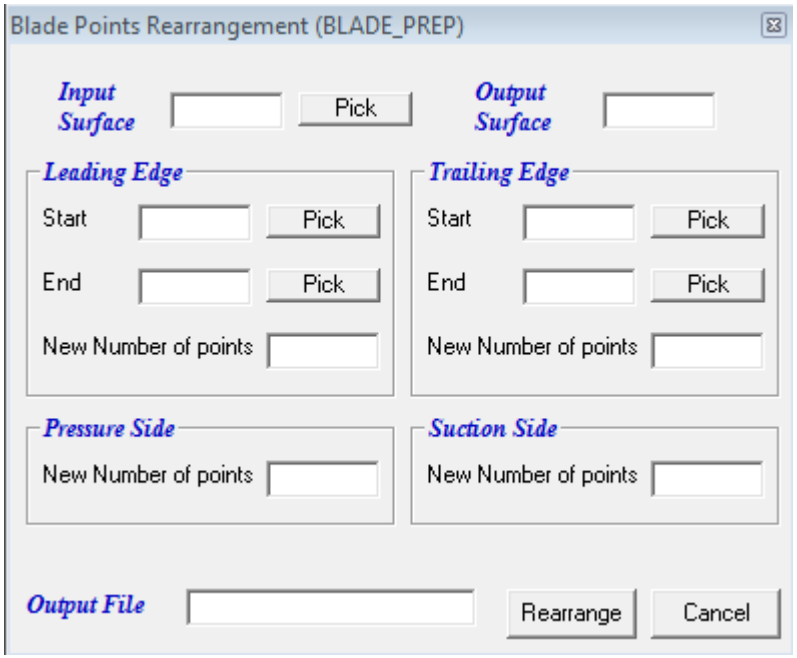
NUFORM System

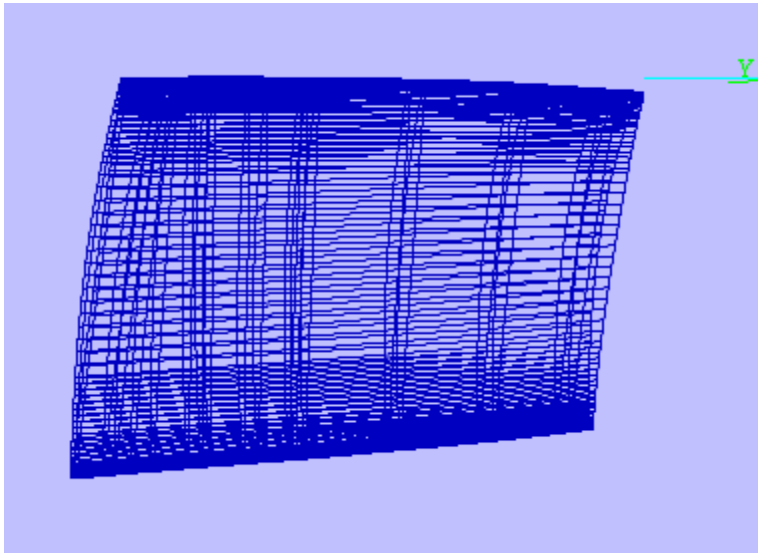
Blade Machining Capability

Blade Prep

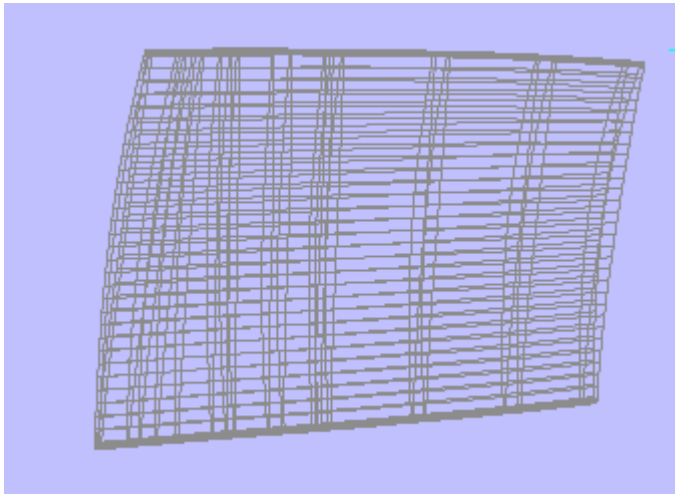
- Allows interactive application of L2PREP type 8 point distribution to surfaces imported via IGES or UG.



Blade before and after



Before



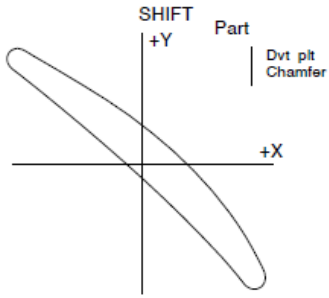
After

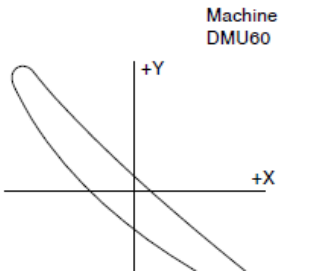
CMM/Inspection Reports

- Interactive Level-II Support for point selection
- Level-I modules for analysis
- PDF reports
- Integration with SPC

A. S. THOMAS, INC. CMM INSP Date: 07/02/2009 Time: 12:21:49
JOB 2488-06 PCTP337P02 Rev: 01 P337-2488-06-32.CMM

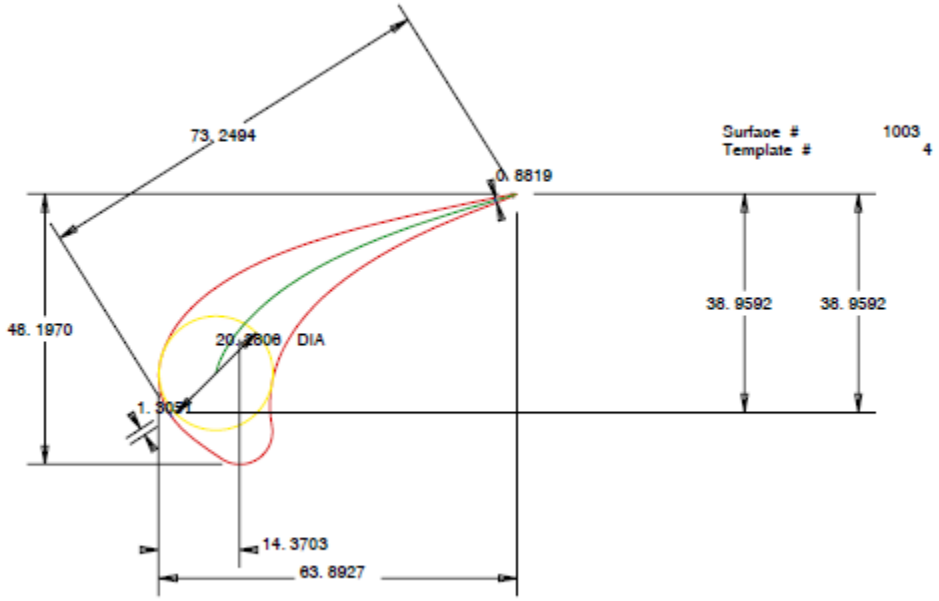
FEATURE	ACTUAL	NOMINAL	MIN TOL	MAX TOL	DEV	OUT
SECTION A		HEIGHT 0.3030				
CHORD	0.7981	0.7955	-0.0050	0.0050	0.0026	
MAX.THICK	0.0691	0.0680	-0.0030	0.0030	0.0011	
TEM-0.100	0.0302	0.0290	-0.0030	0.0030	0.0012	
LEM-0.100	0.0444	0.0420	-0.0030	0.0030	0.0024	
X SHIFT	0.0013	0.0000	-0.0050	0.0050	0.0013	
Y SHIFT	-0.0005	0.0000	-0.0050	0.0050	-0.0005	
CIRCULAR						
DSPLCMT	0.0014	0.0000	-0.0050	0.0050	0.0014	
TWIST	-0.2668	0.0000	-0.3000	0.3000	-0.2668	
SECTION B		HEIGHT 0.4270				
CHORD	0.7951	0.7929	-0.0050	0.0050	0.0022	
MAX.THICK	0.0644	0.0630	-0.0030	0.0030	0.0014	
TEM-0.100	0.0237	0.0240	-0.0030	0.0030	-0.0003	
LEM-0.100	0.0410	0.0410	-0.0030	0.0030	0.0000	
X SHIFT	0.0012	0.0000	-0.0050	0.0050	0.0012	
Y SHIFT	0.0003	0.0000	-0.0050	0.0050	0.0003	
CIRCULAR						
DSPLCMT	0.0012	0.0000	-0.0050	0.0050	0.0012	
TWIST	-0.2357	0.0000	-0.3000	0.3000	-0.2357	
SECTION C		HEIGHT 0.5760				
CHORD	0.7947	0.7924	-0.0050	0.0050	0.0023	
MAX.THICK	0.0569	0.0580	-0.0030	0.0030	-0.0011	
TEM-0.100	0.0207	0.0230	-0.0030	0.0030	-0.0023	
LEM-0.100	0.0372	0.0380	-0.0030	0.0030	-0.0008	
X SHIFT	0.0013	0.0000	-0.0050	0.0050	0.0013	
Y SHIFT	0.0010	0.0000	-0.0050	0.0050	0.0010	
CIRCULAR						
DSPLCMT	0.0016	0.0000	-0.0050	0.0050	0.0016	
TWIST	-0.2758	0.0000	-0.3000	0.3000	-0.2758	
SECTION D		HEIGHT 0.7260				
CHORD	0.7924	0.7902	-0.0050	0.0050	0.0021	
MAX.THICK	0.0483	0.0510	-0.0030	0.0030	-0.0027	
TEM-0.100	0.0184	0.0200	-0.0030	0.0030	-0.0016	
LEM-0.100	0.0308	0.0320	-0.0030	0.0030	-0.0012	
X SHIFT	0.0017	0.0000	-0.0050	0.0050	0.0017	
Y SHIFT	0.0022	0.0000	-0.0050	0.0050	0.0022	
CIRCULAR						
DSPLCMT	0.0028	0.0000	-0.0050	0.0050	0.0028	
TWIST	-0.2510	0.0000	-0.3000	0.3000	-0.2510	
SECTION E		HEIGHT 0.8760				
CHORD	0.7897	0.7879	-0.0050	0.0050	0.0018	
MAX.THICK	0.0400	0.0430	-0.0030	0.0030	-0.0030	
TEM-0.100	0.0180	0.0180	-0.0030	0.0030	0.0000	





Max Chord

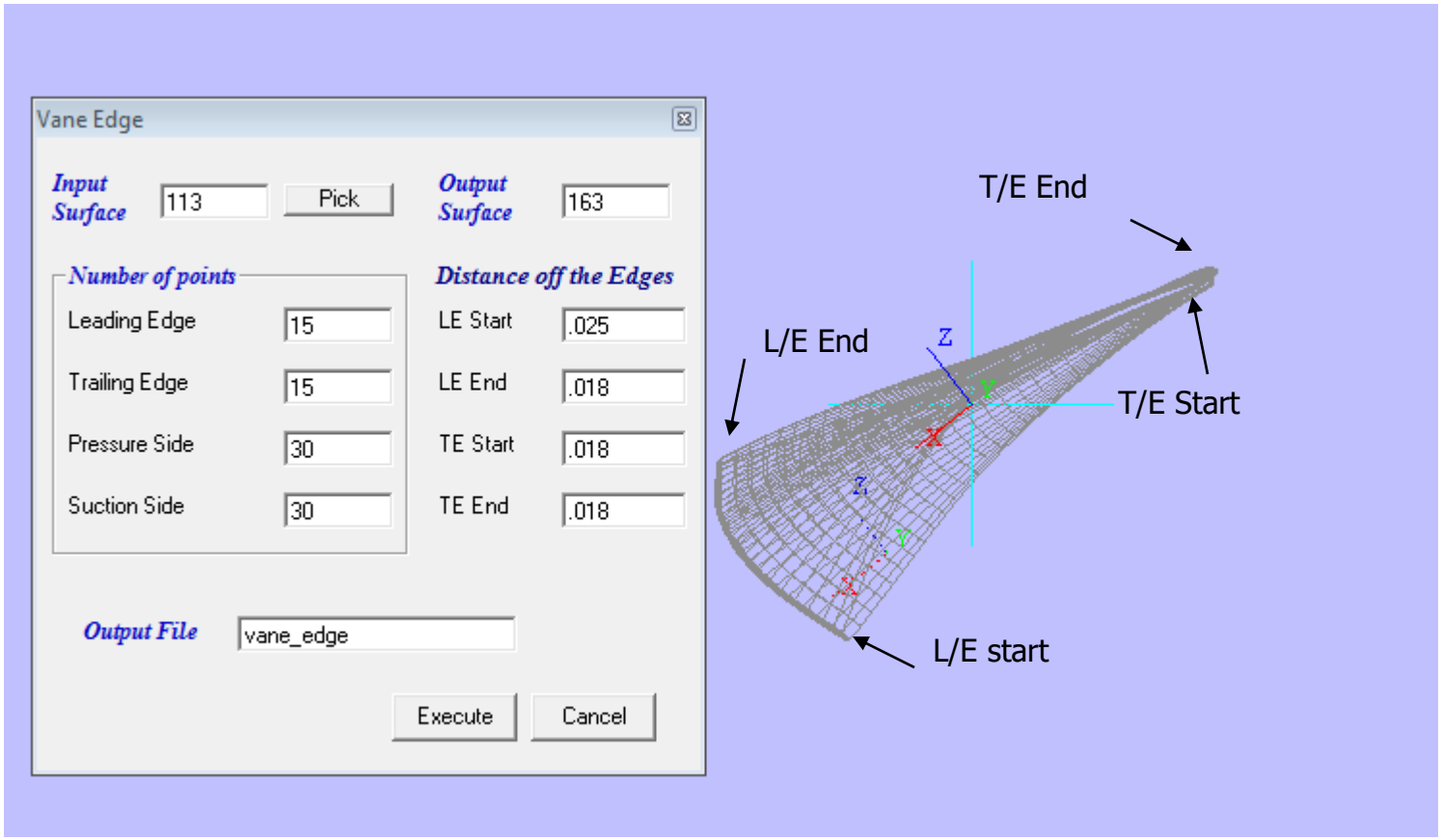
- Camber line
- Chord length
- Maximum thickness
- Edge thickness at specified distance from edge
- PDF file optional
- Available through FOP, Level-I and Interactive Level-II



Vane Edge

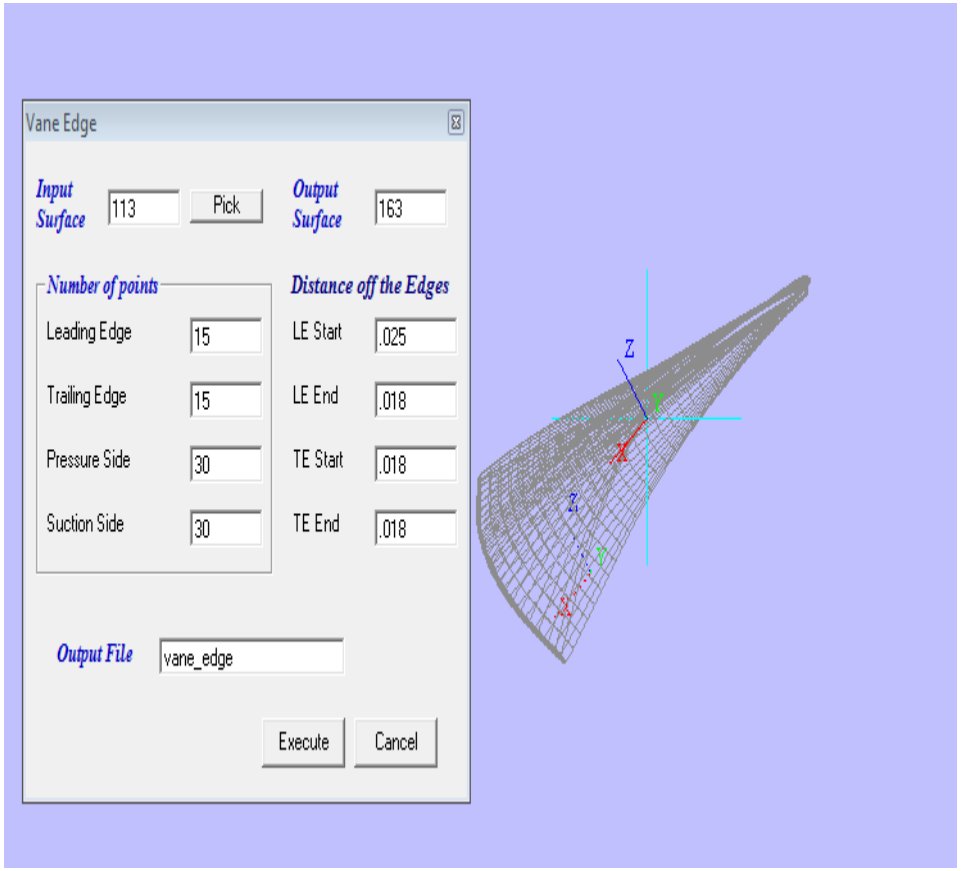
- Distributes stations based on distance from edges
- Different edge distances may be specified to allow for smooth change from first to last template

Vane_Edge


Vane Edge
Input Surface
113
Pick
Output Surface
163
Number of points
Leading Edge
15
Trailing Edge
15
Pressure Side
30
Suction Side
30
Distance off the Edges
LE Start
.025
LE End
.018
TE Start
.018
TE End
.018
Output File
vane_edge
Execute
Cancel
T/E End
L/E End
T/E Start
L/E start
Z
Y
X

Input Explanation

- Distance back from edges is generally the radius of the edge.
- L/E and T/E start is distance back at first template.
- L/E and T/E end is distance back on last template.
- Distance back is linearly scaled from first to last template.



Further Explanation

- Quick Measure can be used to get approximate values.
- Max Chord will calculate various blade parameters including radii for possible use in Vane Edge Input.
- Points are distributed evenly, so specifying an odd number of points for an edge will yield a station at the mid point of the edge.
- Care should be taken to not use too large a distances since there might not be enough points around the edge.

Surface Offsets

Airfoils/blades generally need modification of surface geometry around the leading and
trailing edges of the foils. Such modification is performed to allow for:

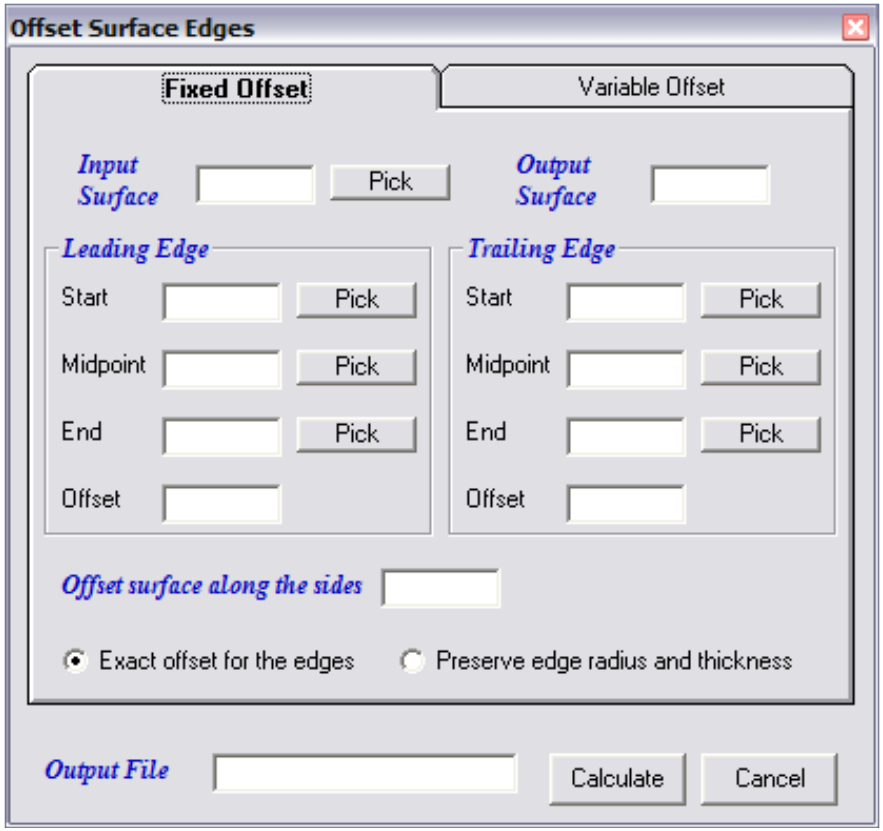
- Lengthening of Chord Lengths to allow for long life in operation.
- Extra stock to accommodate processing in subsequent operations, e.g. peening, polishing, etc.
- Compensate for machine dynamics.

The Offset Surface Edges module in Interactive Level-II provides an automatic way to modify the blade shape.

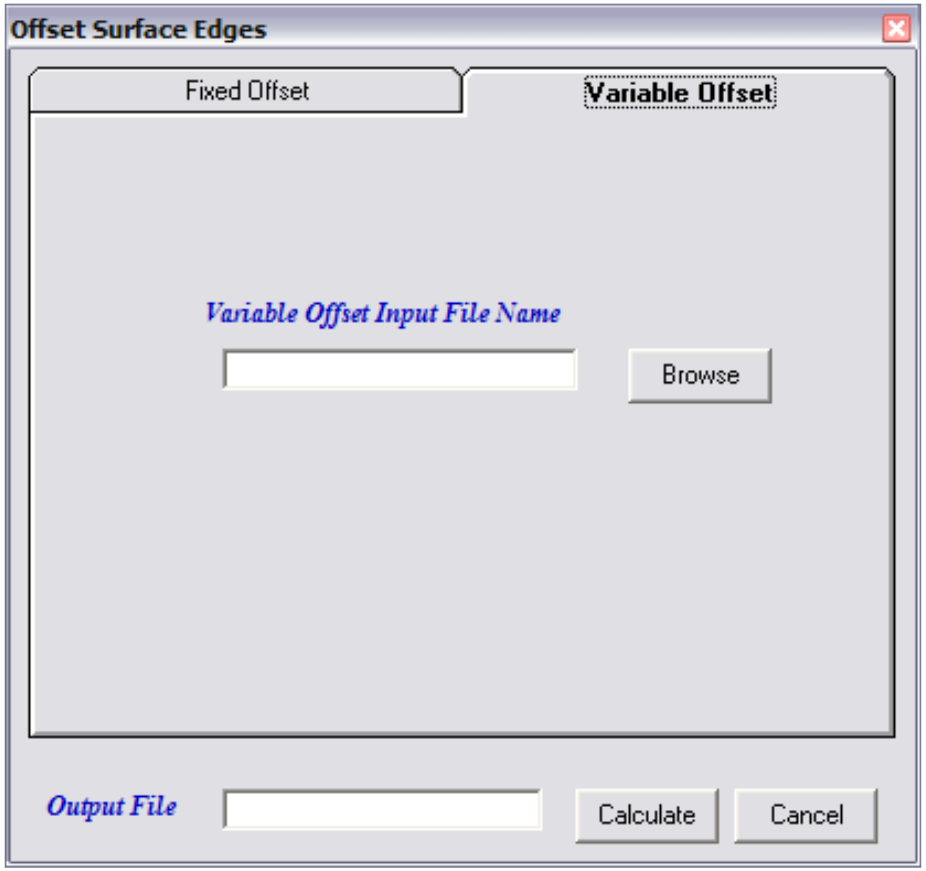
Lengthen Edges

- Two cases are provided:
  - Identical offsets for all templates
  - Per template offset values. The per template offset values allow for tapering offsets, e.g. the thinner sharper sections ness the blade tips are generally lengthened to accommodate down stream operations.

Fixed (Constant) Offsets



Variable Offsets



Edge Offset Types

- Exact Offset, where the edge is lengthened in a smooth and continuous fashion along the camber of the blade. The edge radii will typically be reduced.
- Preserve Edge Radii and Thickness.

Distance Between Surfaces

- Calculates difference between two surfaces
- Plot is produced
- Report is created

Alignment and Orientation

- Add two transformations
- Align corresponding edges of surfaces

Great Circle

- Approach and retract take into account new CNC capabilities and Machine tool geometries
- Great Circle motion is calculated rather than simple direct motion.

Offset Surface

- Change section properties:
  - Maximum thickness
  - Lengthen edges
  - Change twist
  - Change shifts
  - Adjust edge thickness

Blade/Airfoil Definitions

- Surfaces in NUFORM Level-II consist of templates (cross-sections) and stations.
- There are several different types of surfaces:
  - Rectangular – where templates reside in planes usually perpendicular to X, Y or Z
  - Cylindrical – templates reside on cylindrical sections (Marine propellers)
  - Spherical – templates reside on spherical sections
  - 3D – templates are curves in space (usually from NURBS)

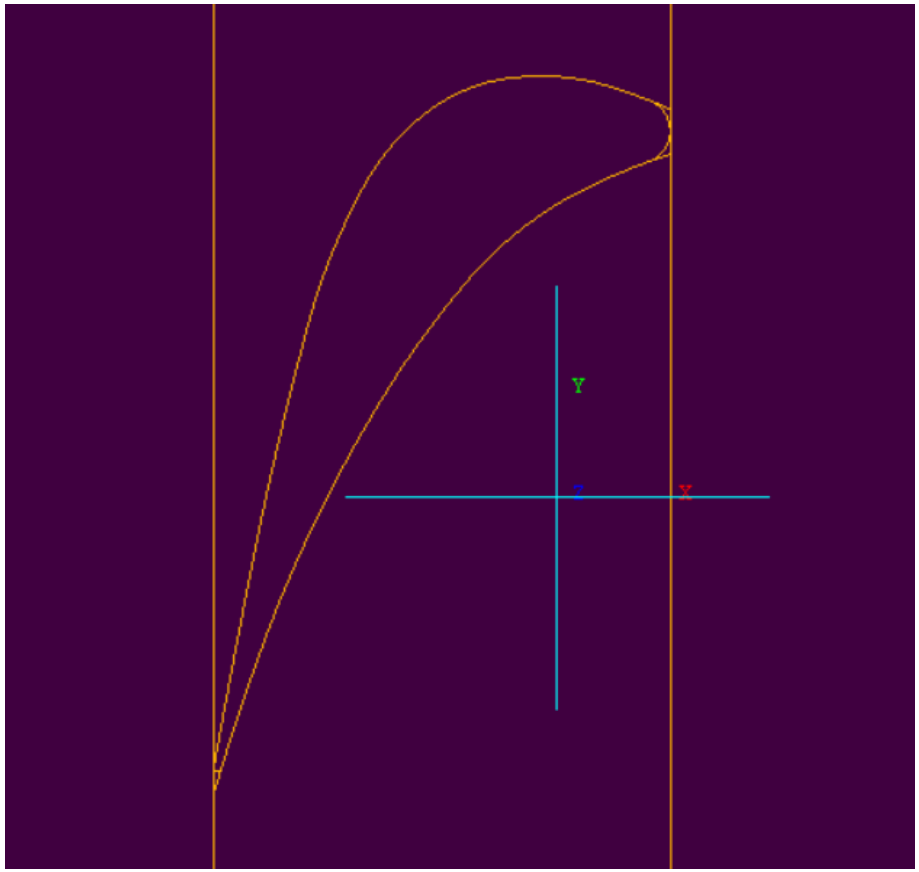
XYT or XYR Blade Definition

- XYT or XYR – templates are defined in planes by arc tangency points and radii. Such are commonly used in power generation and turbine blade definitions, especially in older designs.
- NUFORM provides the XYTPRF utility to generate the NUFORM Level-I input to solve the geometry problem.
- L2PREP is then utilized to create a NUFORM Level-II Surface.

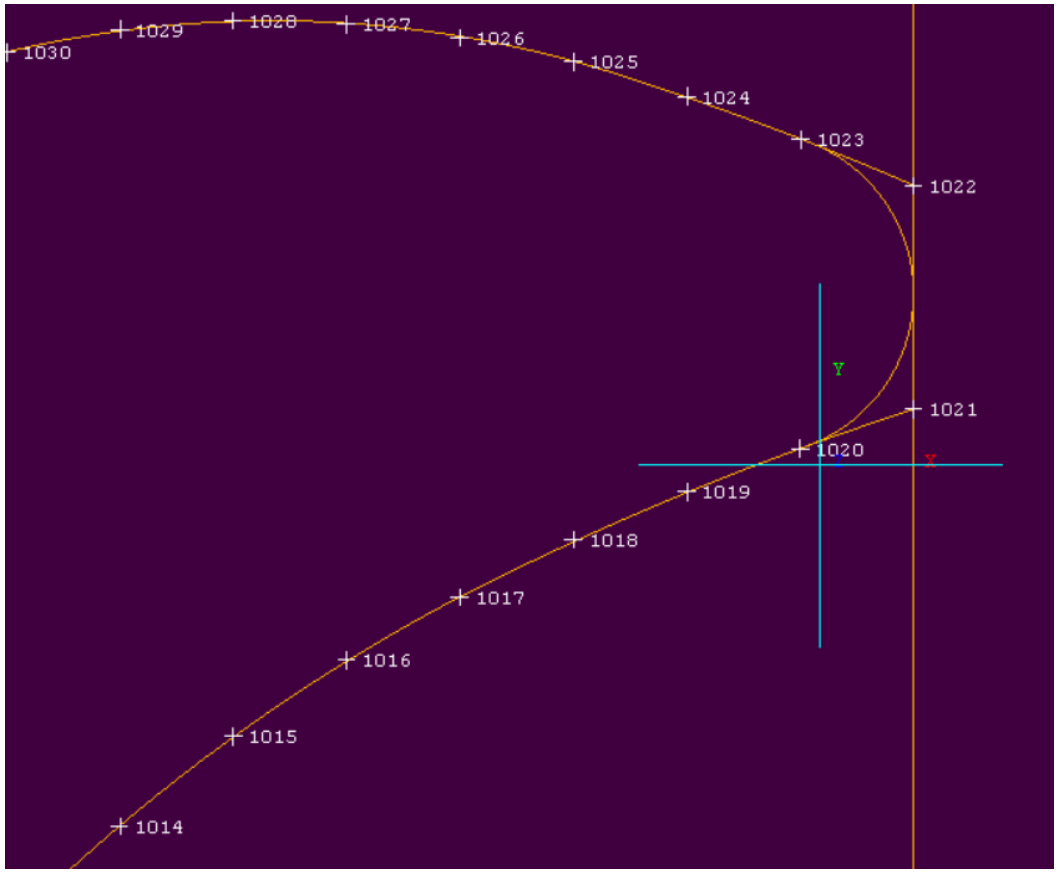
Leading and Trailing edges

- Another common blade definition involves pressure and suction surface curves with leading and trailing edge radii tangent to specified curves. The position and radii are unknown.
- NUFORM Level-I provides modules to solve this geometry problem.

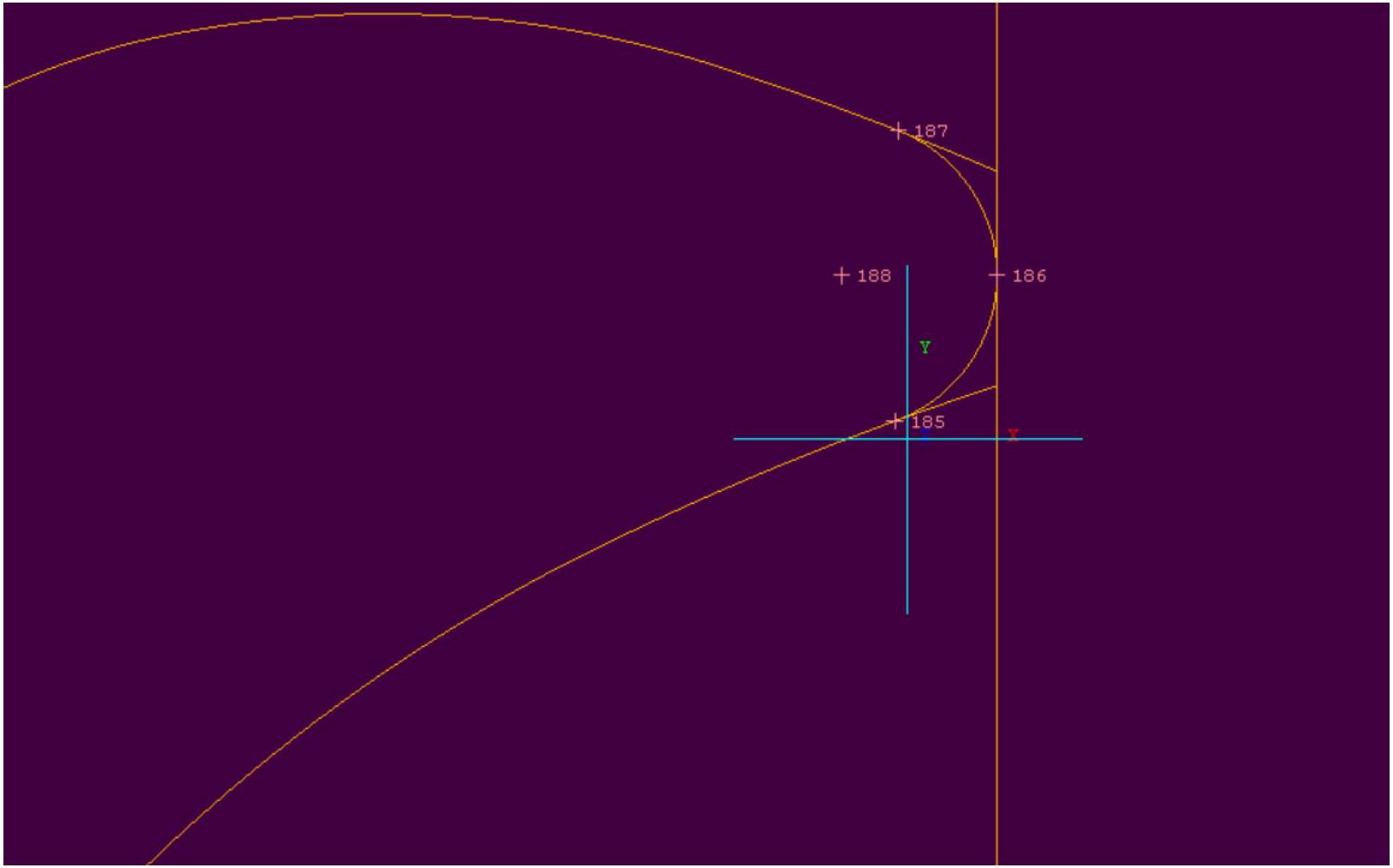
Single Section (solution)



Curve Data Points



L/E Solution



Minimum Radius of curvature

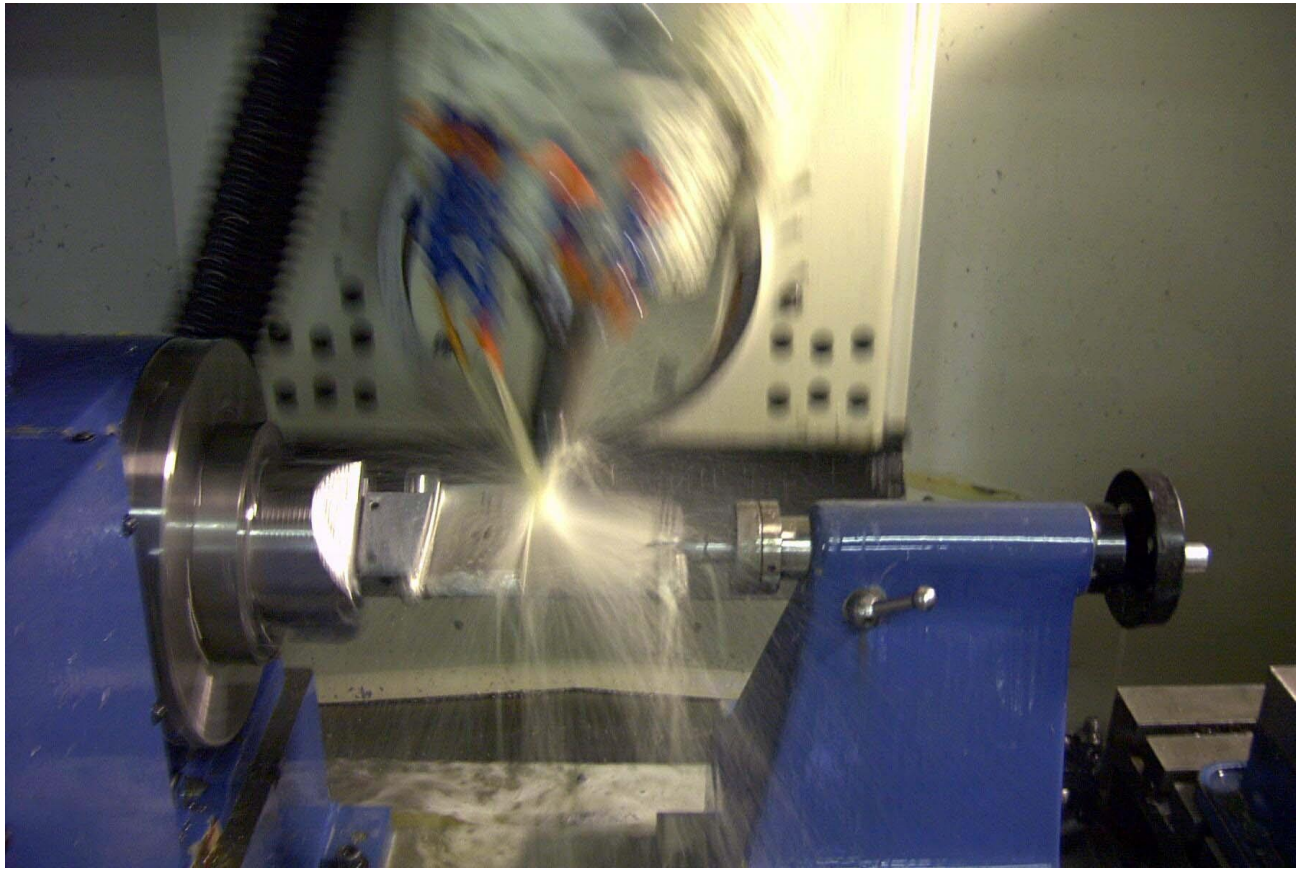
- Tools are provided to calculate minimum concave and convex radii on surface.
- Calculation is made along templates and along stations.
- Report is available providing detailed information for each defined point on surface.

Blisc

Impellers & Blisc

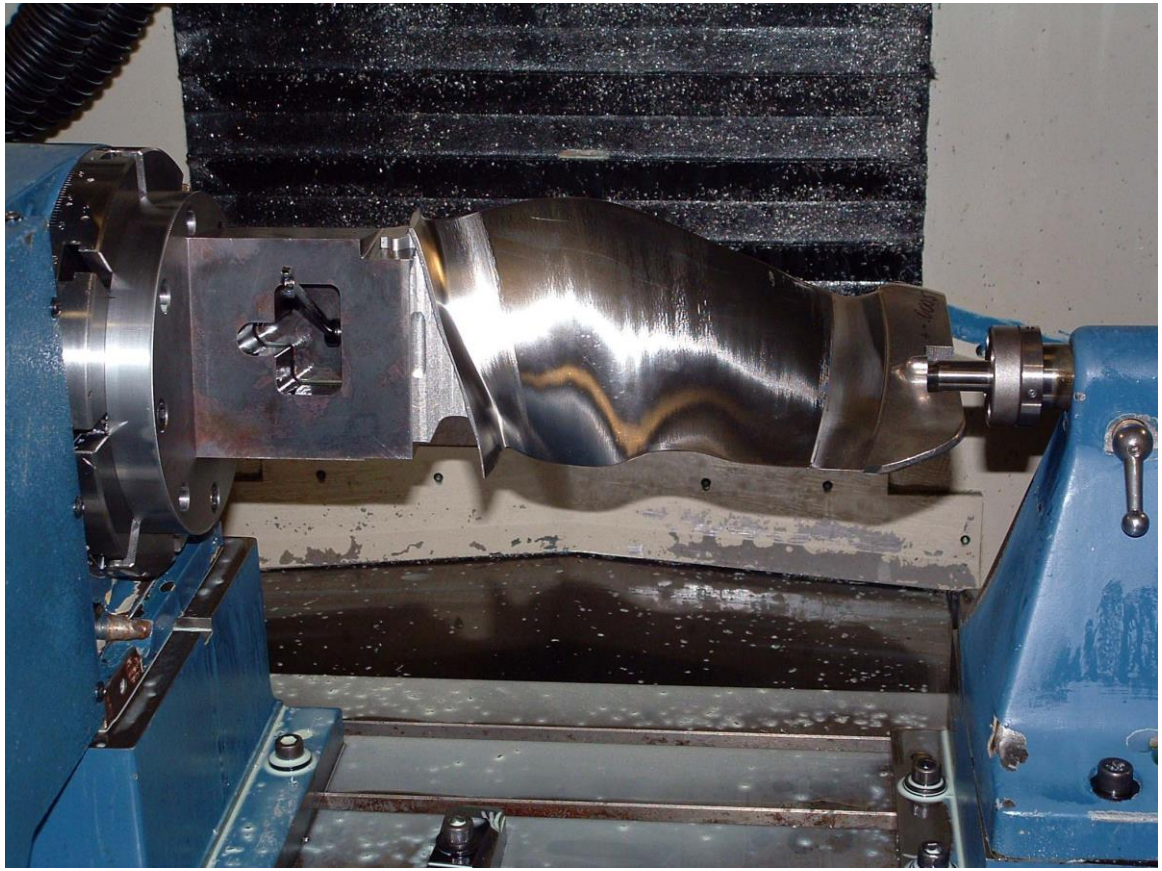
Bucket

Airfoils



Airfoils

Airfoils



Airfoils