Here's a method for using the power of SolidWorks to develop complex thermal spray paths on the lower platform of a vane assembly. This method can be applied to all areas of this part. It is much easier to create spray paths on blades, and this will be covered in another Blue Technik Tutorial. Let's concentrate on the most difficult area only, the space between the blades. Call these blades Blade1 and Blade2.

The goal is to create SolidWorks Compound Curves on the surface of the platform for robot spray paths. The Compound Curves will follow the contours of the Blade1 and Blade2 and have a curve-to-curve spacing of ~3mm.

SUMMARY
A 5-Step process will be used for part preparation:

- Copy and Offset existing part contours to Sketch Entities in a SolidWorks Sketch. These Sketch Entities will be used as "guides" for drawing robot paths.
- Create a second SolidWorks Sketch and use the "guide contours" from the first Sketch to draw a group of individual robot spray paths.
- Then for each individual path element, create a new SolidWorks Sketch and copy the the path to it.
- Project the individual path in each Sketch to the surface.
- Convert the resulting projected curve to a Compound Curve entity. These Compound Curves can then be used by RobotWorks to create robot path points for the Thermal Spraying Process.

DISADVANTAGES:
- This is an intricate process that requires a lot of concentration and attention to detail.
- Some learning of the "best approach" will be achieved through trial-and-error until the sequence and process is fully understood.
- A complete spray path development for a component like this vane assembly (all areas of upper and lower platforms, and blades) could take several hours of CAD work depending upon the path precision required.
ADVANTAGES:

- *Extreme precision of spray path spacing is possible with this method.*
- User has complete control of the shape of the path contours to fit any "special" geometry.
- Symmetry of part features may allow copying of paths from one area to another, saving significant time.
- Creating new offset contours may be a function that is semi-automated with SolidWorks Macro programming, thus saving significant time.

ACTUAL PROCESS CONCERNS

- While the path contours can be developed with high precision, actual manufacturing processes may not require such precision. This is an issue for the Process Engineer to determine. If process parameters do not require such a high level of precision, then it stands to reason that significant time can be saved developing the path contours.
METHOD

1. Apply a plane across the blades for a section cut.
   a. For the purposes of this tutorial, assume the Section Plane is identified as Plane200.
   b. A section cut will allow us to see the internal space between the blades.
   c. The position of the plane should be such that the remaining stumps of the blades are minimized without sectioning the platform itself.
   d. The orientation of Plane200 should give a good "balance" between the different blade axis orientations.
      i. The meaning of this is that any spray path curves developed by this method are to be projected onto the platform surface.
      ii. An oddly-oriented Section Plane will cause a skewed projection.
      iii. It may not be possible to have a single plane that sections through all blades, depending upon the geometry of the part.
      iv. We want to be able to project elements from a sketch plane back down to the surface of the platform.

Figure 1: Start with a Stator Vane Assembly.
   a. For purposes of this tutorial, assume the sketch is identified as Sketch100.
3. Use the edge of the root as a starting point of the 3mm contours.
   a. **OPTION:** on Sketch100, draw "Spray Path Zones" to define boundaries for spray paths directed from one side or the other. **See Figure 5.**
Figure 4: Use Plane200 to create a new Sketch.
Figure 5: Terminology used in this Tutorial.

Arbitrary line put on sketch for purposes of cutting the closed Blade Root Edge contour.

Blade root edge contour

Selected & Highlighted Blade Root Edge contour

Platform surface

Blade1

Blade2
b. Select and highlight the Blade Root Edge Contour on Blade1.
   i. If the CAD model does not have suitable existing contours, then a new contour on Sketch100 must be created with existing SolidWorks Sketch tools.
Figure 7: Select the Blade Root Contour as a starting point for path development.

c. While highlighted, select the Convert Entities icon. This will convert the blade root edge contour of Blade1 to a sketch element on Sketch100.
d. OPTION: It may be desired to use only a portion of the starting contour. In this case it is necessary to trim the contour to something suitable. On Sketch100, cut the blade root edge contour at suitable points to have a portion of the contour. Two possible methods:
   i. Apply Split Entities to two points on contour and delete remainder.
   ii. Apply lines at desired points and use the Trim tool to cut the contour. Delete the cutting lines.

e. Do the same procedure for Blade2.
Figure 9: The complete Blade Root Edge Contour must be trimmed. An arbitrary line is used as a cutting boundary.
Figure 10: OPTION: Insert simple lines to be used for trimming the starting contour.
4. Create multiple contour segments on Sketch100 using the Offset Entities tool.
   a. Select the original contour on Sketch100.
   b. Select the Offset Entities tool.
   c. Create an offset contour at 3mm from the original.
   d. Repeat these steps for a sufficient quantity of offset contours.
      i. HINT: only the original contour can be offset. This is a limitation of SolidWorks.
   e. Do the same procedure for Blade2.
   f. Close Sketch100.
Figure 12: After Blade Root Edge Contour is trimmed, then start building the Offset Entities.

Offset Entities
Adds sketch entities by offsetting faces, edges, curves, or sketch entities a specified distance.
Figure 13: The yellow line shows the 3mm Offset Entity of the Blade Root Edge Contour. (Partial contour shown)

Figure 14: Add more Offset Contours by repeating the Offset Entities process. (Partial contour shown)
Figure 15: View of multiple Blade Root Edge contours offset by 3mm, created on Sketch100.
Figure 16: Perspective View of multiple Blade Root Edge contours offset by 3mm on Sketch100.
Figure 17: The complete set of Blade Root Edge contours offset by 3mm on Sketch100.
Figure 18: Perspective view of the complete set of Blade Root Edge contours offset by 3mm on Sketch100.
Figure 19: Here is another example. Notice the contours are trimmed more than the previous example.
Figure 20: This example shows developing path contour guides using trimmed contours.
Figure 21: Perspective view of the Trimmed Contours example.
Figure 22: The contours can be modified as desired. Here additional lines are added. REMEMBER: this Sketch is ONLY used as a visual guide to build the actual spray paths on another Sketch.
5. Build the spray paths that will be projected onto the platform surface.
   a. Create another sketch from the section plane Plane200, assume it is called Sketch101.

   Figure 23: Create another Sketch from the Section Plane.

   b. The sketch entities from Sketch100 will be visible. Use the sketch elements from Sketch100 as guides to create robot spray paths on Sketch101.
Figure 24: Use the Spline Tool to start building a series of spray path on Sketch101. Use the contours lines visible on Sketch100 as a visual guide to achieve 3mm spacing.

i. Verify that new robot spray paths DO NOT extend over the edge of the platform. Projecting the paths onto the surface of the platform will fail in this case.

c. Use a variety of SolidWorks Sketch Entities to build the robot spray paths:
   i. Lines
   ii. Curves
   iii. Arcs
   iv. Splines (PRIMARY)
PLAN AHEAD HINT:
RobotWorks requires Compound Curves for paths on surfaces. The Compound Curves are derived from Curve Entities projected onto the surface. To determine the direction of robot motion on the Curve Entity, RobotWorks requires that the Curve Entity be segmented into at least TWO SEGMENTS. Use the **Split Entities** tool to split the Sketch Entity into at least two segments.

![Image of completed spray paths](image.png)

*Figure 25: The completed series of spray paths (blue color) created on Sketch101. The contours on Sketch100 (gray color) were used as visual guides to construct the spray paths.*
Figure 26: Perspective view of the spray paths on Sketch101 (blue color) with contour guides visible on Sketch100 (gray color).
6. **OPTION:** copy the spray paths on Sketch101.
   a. Depending upon the symmetry of the part, it may be possible to copy the path Sketch Entities onto the same Sketch. *This will save a lot of design time.*
   b. These copied paths can be used to project curves onto another area of platform surface.
Figure 28: In order to copy the Sketch Entities, you must be editing the Sketch.

**PLAN AHEAD HINT:**
SolidWorks and RobotWorks cannot tolerate crossed or overlapping spray path Sketch Entities. If it is required to have crossed or overlapping (visualize a "Figure-8" pattern), then it will be necessary to split the Sketch Entities and put each segment on a separate Sketch for projecting onto a surface.
Figure 29: Click and Drag to select all path Sketch Entities, then enter CTRL-C to Copy. Enter CTRL-V to Paste. Placement of the Pasted path Sketch Entities is a Trial and Error process.
Figure 30: Copied Path Sketch Entities. Notice the original selection of the Section Plane has caused a problem on the platform area for the 2nd set of paths (slanted face).

7. Convert each individual spray path to a new Sketch.
   a. For each individual spray path, create another Sketch from the Section Plane Plane200.
   b. Use Convert Entities to convert the individual spray path to the new Sketch.
Figure 31: Select each individual spray path Sketch Entity and use the Project Curve tool to project the Sketch onto the platform surface.
**PLAN AHEAD HINT:**

Do not allow the spray path Sketch Entities to extend over the edge of the part. Projecting the Sketch Entity onto the surface of the part will not be possible. Use the RobotWorks function **Landing+Takeoff** to easily extend the spray path over the edge of the part for overspray.

8. Project each individual spray path onto the surface of the platform.
   a. Select the spray path Sketch in the SolidWorks Feature Manager.
   b. Select the Project Curve tool.
   c. Select the platform surface
      i. SHORTCUT: select BOTH the spray path curve AND the platform surface with CTRL+Click, THEN select the Project Curve tool.
Figure 33: The Project Curve tool requires BOTH the selection of the Sketch Entity AND the surface to which the Sketch is projected. Notice the yellow projected curve on the platform surface.
Figure 34: Perspective view of all spray path Sketch Entities projected onto the platform surface.

9. Convert the projected Curve Entity to a Compound Curve Entity.
   a. Select the Curve Entity in the SolidWorks Feature Manager.
   b. Select the Compound Curve tool to convert the projected Curve Entity to a Compound Curve Entity.
Figure 35: Convert the projected Curve Entity to a Composite Curve Entity.
Figure 36: Perspective view of all projected Curve Entities converted to Composite Curve Entities.
Figure 37: Finished spray paths ready for selection by RobotWorks.

Now the complex spray path on the complex part is fully prepared. RobotWorks can now be used to create a complete series of spray path locations utilizing the required tool orientation to get between the blades.

END OF DOCUMENT