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Sandia National Laboratories

A Sunshade Design Process

11/12/2021
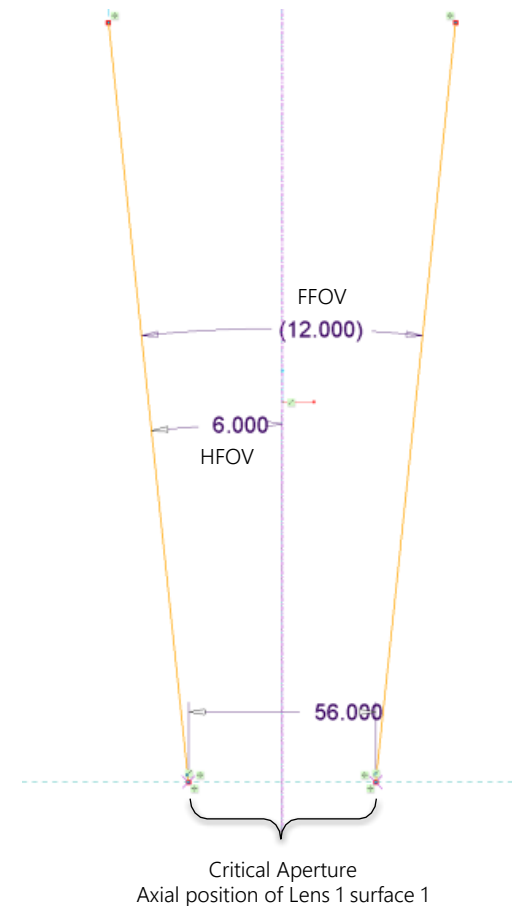
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U.S. DEPARTMENT OF ENERGY

NNSA
National Nuclear Security Administration
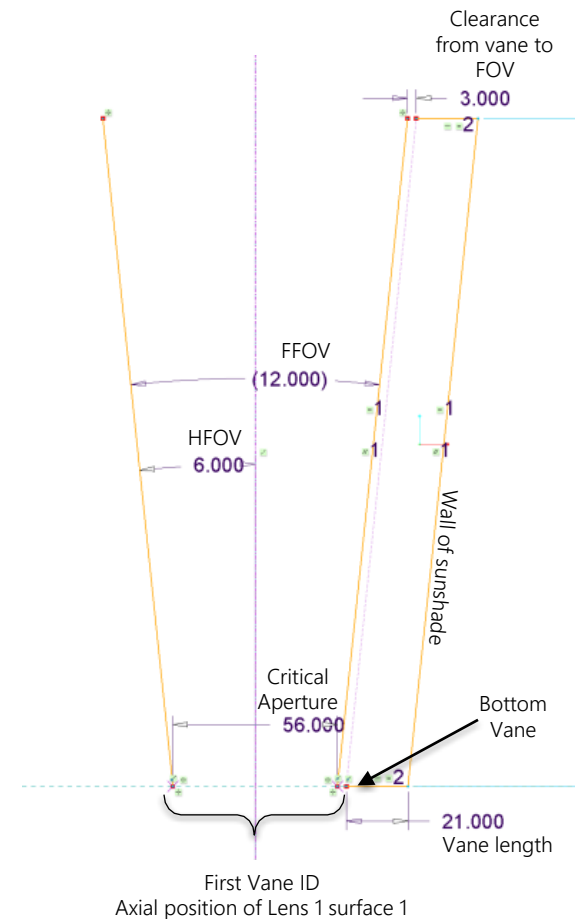
Sunshade Vane Placement Process

- Sketch in CREO parametric design software
  - Parametric nature allows for easy alterations based on driving dimensions.
- Start with "critical aperture" centered on optical axis
  - Aperture where light can enter the system and cause performance issues. A diameter where light outside that diameter is acceptable and light hitting inside that aperture at Its axial location will enter the optical system.
  - 56mm critical aperture in this case.
    - Front optic OD.
- Draw line at Field of view half angle from edge of critical aperture
  - 6 deg half angle

FFOV

(12.000)

6.000

HFOV

56.000

Critical Aperture
Axial position of Lens 1 surface 1

Survival Temp Stress
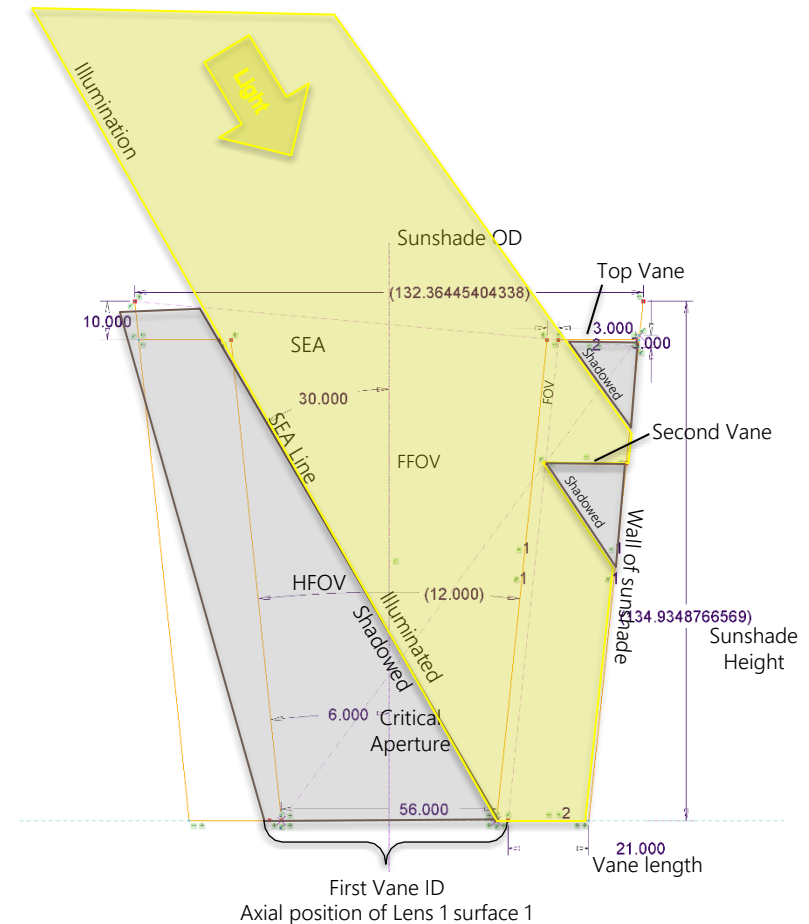
Sunshade Vane Placement Process

- Decide on clearance from ID of vanes to FOV to prevent vignetting
  - Using 3mm in this example
  - Provides margin for assembly alignment
- Bottom vane is at critical aperture at clearance distance from FOV (3mm)
- Pick vane length (throat depth)
  - Parametric driving dimension
  - Using 21 mm in this example

Clearance from vane to FOV
3.000

FFOV (12.000)

HFOV 6.000

Wall of sunshade

Critical Aperture 56.000

Bottom Vane

21.000 Vane length

First Vane ID
Axial position of Lens 1 surface 1

Survival Temp Stress

Sunshade Vane Placement Process

- General Purpose of Vanes
  - Create shadow regions on sunshade inner wall
  - Vane underside provides shadowed surface to block view of illuminated sections of sunshade inner wall from areas inside critical aperture.
    - Points within Critical Aperture required to only have a view factor to shadowed surfaces (so no single-bounce light paths to CA)
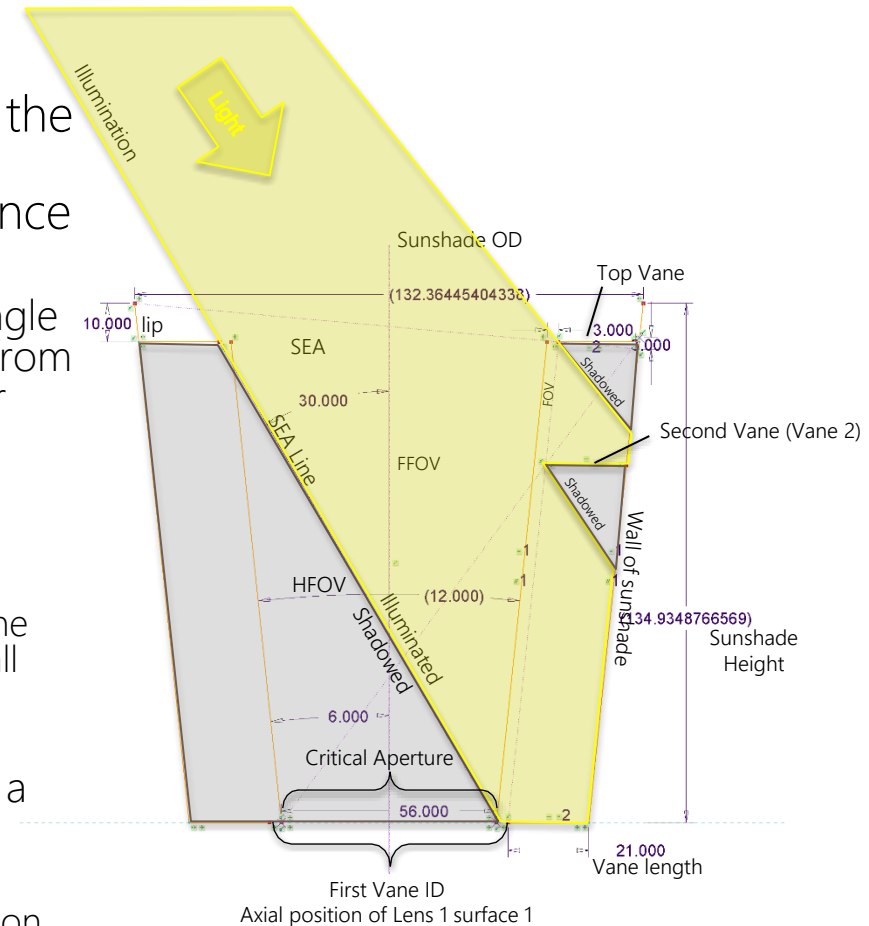

Survival Temp Stress

Sunshade Vane Placement Process

- SEA defines angle where sun can enter the system (if source at angle <SEA it is acceptable to have direct or single bounce light enter the critical aperture (CA).
  - CA to remain shadowed from direct or single bounce rays with light sources anywhere from SEA angle to mirrored SEA angle on other side of optical axis. (+30deg to -30deg)
  - Note: Special case where sun or source is perpendicular to the optical axis
    - Shown in more detail on next slide
    - Light rays hit top vane are ~ parallel to vane and cast no shadow on sunshade inner wall (causes issues in placing Vane 2)
    - No shadowed wall region under Top vane
  - Remedy: (create a shadowed region) with a lip above top vane on OD of sunshade
    - Adds to Sunshade height and OD
    - 10mm lip here creates a shadowed region on wall under top vane
      - This is the target area for the sight line from the critical aperture used to set the next vane (see next slide)
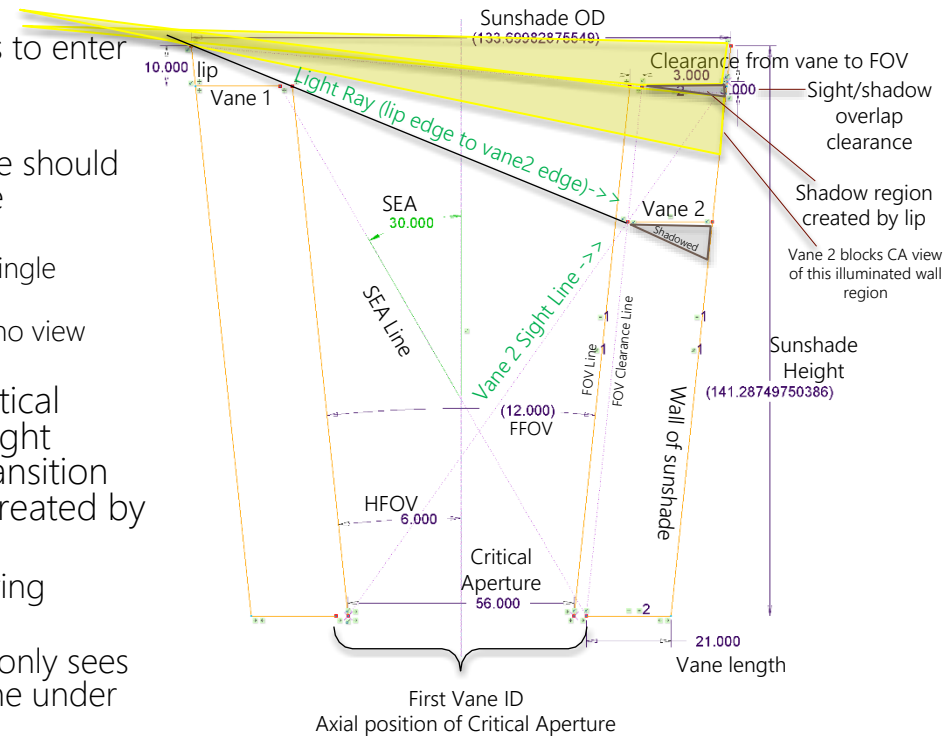

Survival Temp Stress
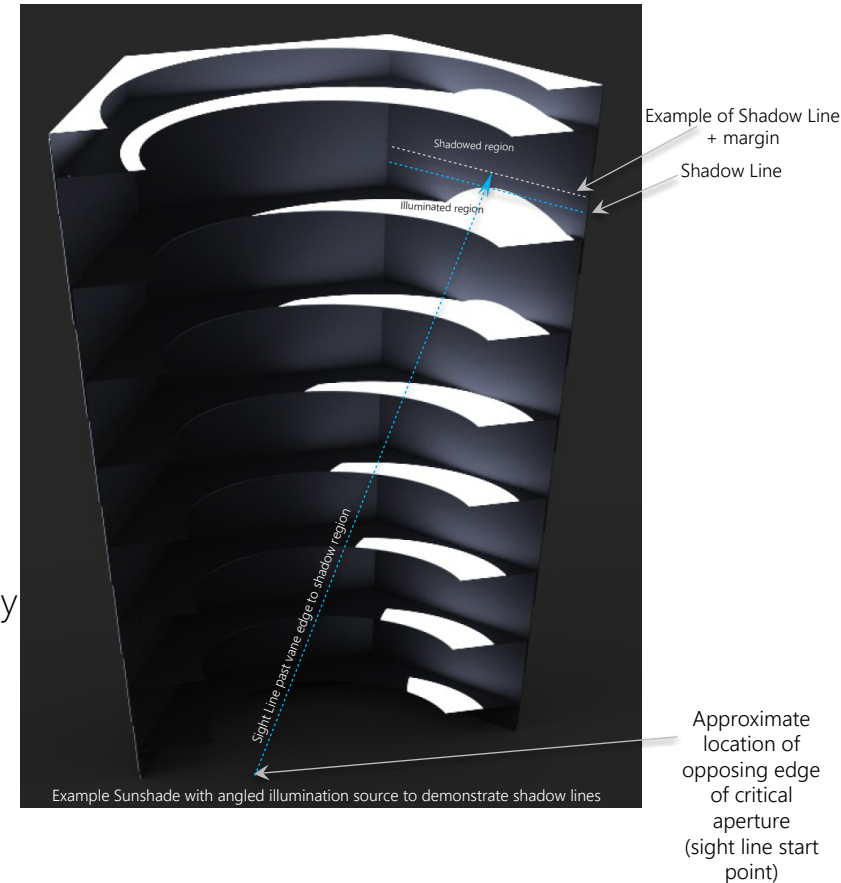
Sunshade Vane Placement Process

- **Second Vane Placement**
  - Logic for placing vanes
    - Sunshade requires no single-bounce rays to enter critical aperture.
    - Assume this is equivalent to:
    - Looking out from edge of critical aperture should see no directly illuminated surfaces of the sunshade.
      - ("seeing an illuminated surface" implies single bounce path to the "eye")
      - Always want to see shadowed surfaces (no view factor to illuminated surfaces)
  - Draw sight line from bottom left edge of critical aperture to the inner wall at a clearance height above the shadow line (line representing transition from shadow to illumination on a surface) created by the lip under the first vane.
    - Clearance accounts for some manufacturing variability. Using 3mm in this example
    - View from edge of CA past vane 2 edge only sees region of wall 3mm above the shadow line under vane 1 (top vane)
  - Vane 2 ID is at the intersection of the sight line and the FOV clearance line (FOV + 3mm radial clearance for vignetting)
    - Height determined by geometry
    - Creates new shadowed region on interior wall used to set Vane 3
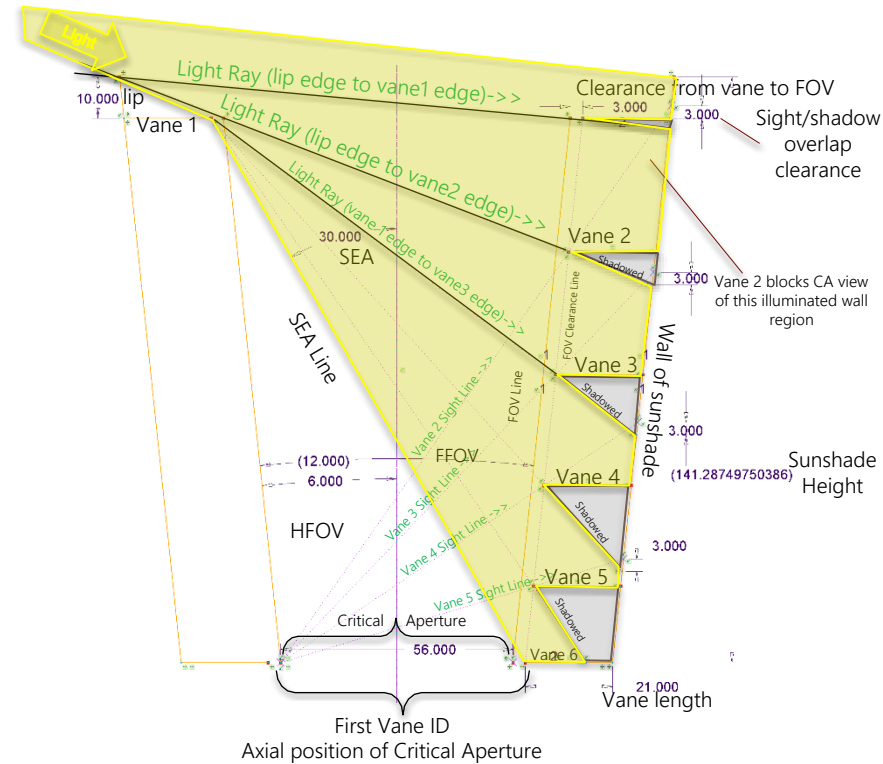
Sunshade Vane Placement Process

- Vane Placement
  - Logic for placing vanes
    - Sunshade requires no single-bounce rays to enter critical aperture.
    - Assume this is equivalent to:
    - Looking out from edge of critical aperture should see no directly illuminated surfaces of the sunshade.
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  - Draw sight line from bottom left edge of critical aperture to the inner wall at a clearance height above the shadow line (line representing transition from shadow to illumination on a surface) created by the lip under the first vane.
    - Clearance accounts for some manufacturing variability. Using 3mm in this example
    - View from edge of CA past vane 2 edge only sees region of wall 3mm above the shadow line under vane 1 (top vane)
  - Vane 2 ID is at the intersection of the sight line and the FOV clearance line (FOV + 3mm radial clearance for vignetting)
    - Height determined by geometry
    - Creates new shadowed region on interior wall used to set Vane 3

Example of Shadow Line + margin

Shadow Line

Shadowed region

Illuminated region

Sight Line past vane edge to shadow region

Example Sunshade with angled illumination source to demonstrate shadow lines

Approximate location of opposing edge of critical aperture (sight line start point)

Sunshade Vane Placement Process

- Third Vane Placement
  - Replicated process from Vane 2 used for all remaining vanes (until you reach the axial position of the critical aperture)
  - Draw sight line from bottom left edge of critical aperture to the inner wall at a clearance height above the shadow line below vane 2 (line representing transition from shadow to illumination on a surface) created by the ray from lip edge to vane 2 edge
    - Clearance accounts for some manufacturing variability. Using 3mm in this example
    - View from edge of CA past vane 3 edge only sees underside of Vane 2 (shadowed) and region of wall 3mm above the shadow line under vane 2
    - Vane 3 ID is at the intersection of the sight line and the FOV clearance line (FOV + 3mm radial clearance for vignetting)
    - Height determined by geometry
    - Creates new shadowed region on interior wall used to set Vane 4
    - Continue to set all vane positions

Comparison to Solidworks baffle model

Comparison to Solidworks Baffle Model

- By tracing lines from top vane, past vane tips to wall, then back down past next lower vane tip to edge of CA (green lines in previous slide) shows effective CA edge location at edge of lens surface.

- Overall height difference likely due to SNL proscribed clearance between FOV and vane edges.

- Opinion: Possibly better SWAP if sunshade were designed around the rectangular FOV projected from detector.