Adaptable Thermal Shroud for Thermography NDI Equipment

Problem Statement:

Develop a specialized thermal shield to prevent unwanted thermal drafts that can obscure results, minimize escaped flash intensity, and adapt to geometries that come in various sizes and shapes.

Design Parameters:

1. Design an adjustable thermal shroud that:
   - A. Fits the pre-exiting hood.
   - B. Is lightweight and easy to install/maintain.
   - C. Can withstand high intensity thermal flashes
   - D. Minimizes air flow across the testing surface.
   - E. Contains high intensity light flash.
   - F. May be utilized manually or in automated fashion.
   - G. Has no sharp corners.
2. Once designed:
   1. Conduct testing to quantifiably confirm design.
   2. Generate manufacturing and cost analysis.

Background Information:

Spirit AeroSystems is a first-tier aerostructures manufacturing company that is known around the world. Spirit AeroSystems manufactures many pieces of Boeing's aircrafts, like fuselages for the 737, portions of the 787, and the Airbus A350, just to name a few. Thermography testing is a type of Non-Destructive Inspection (NDI) testing used in many industries including engineering. The process consists of a high intensity flash produced by a series of bulbs that heat the testing specimen. During and for a time period after the part is heated, an infrared camera records the heat change as a function of time as the part cools. Thermography detects changes in heat flow, and these can be from air but can also be from changes in material or thickness. If there are voids in the material, the camera will pick up on very poor heat transfer as the void will cool and not heat up very well due to having an increased resistance due to air. Airflow over the surface obfuscates the reading by introducing non-relevant heat flow changes. Our project consists of minimizing the outside effects on the testing equipment. By doing so, this will allow for much better testing results in the acquisition area and the thermography machine will operate as it was intended to.

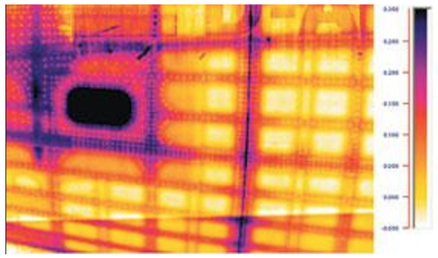

Figure 1-Example Thermal Image

Acknowledgements:

We would like to special thank you to our sponsor Zach Benedict for his help through this journey as well as Caleb Saathoff and his team at NIAR.

Team Members:

Dylan Funk
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Emily Zuelke

Project Duration:

16 Weeks

Design Development :

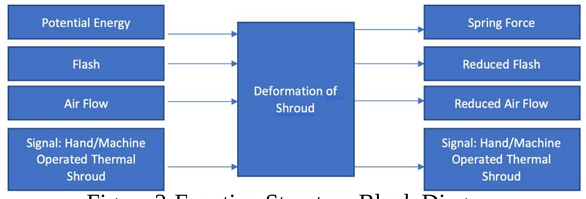

Figure 2-Function Structure Block Diagram

Working Principle					
Function	Elements	Task of Elements			
Finger	Material	ABS	Nylon	Ceramic	PVC
	Shape				
	Signal	Human Operated	Machine Operated		
	Position	Spring Concentric to Dowel	Spring Attached to side of dowel		

Table 1-Working Principle Matrix

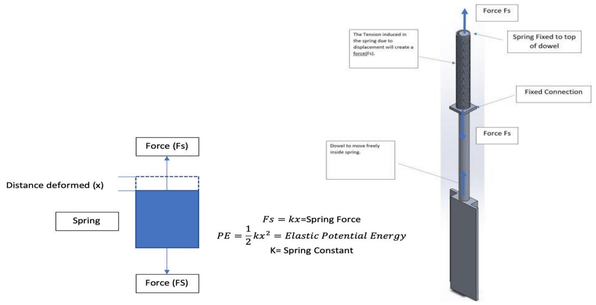

Figure 3- Physical Principles and Effect on Finger

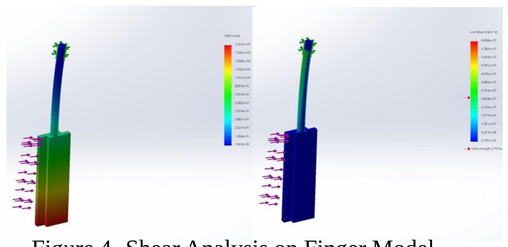

Figure 4- Shear Analysis on Finger Model

Design Validation:

Preliminary Air-Flow Testing

Testing was conducted for:
- Base w/ no geometry
- Base w/ rectangular geometry
- Base w/ triangular geometry
- Hood w/ no geometry
- Hood w/ rectangular geometry
- Hood w/ triangular geometry
- Shroud w/ no geometry
- Shroud w/ rectangular geometry
- Shroud w/ triangular geometry

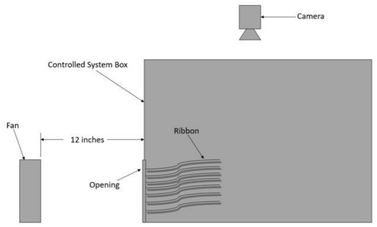

Figure 5- Air-Flow Testing Block Diagram

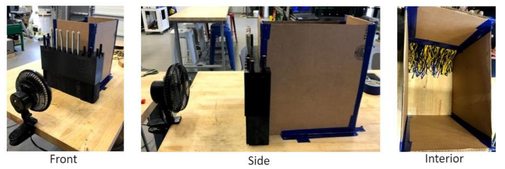

Figure 6- Images of Air-Flow Testing Setup

Preliminary Flash Testing

Testing was conducted for:
- Base w/ no geometry
- Base w/ rectangular geometry
- Base w/ triangular geometry
- Hood w/ no geometry
- Hood w/ rectangular geometry
- Hood w/ triangular geometry
- Shroud w/ no geometry
- Shroud w/ rectangular geometry
- Shroud w/ triangular geometry

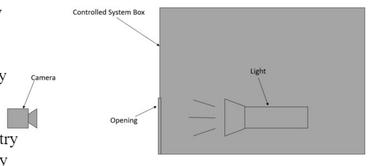

Figure 7-Flach Flow Testing Block Diagram

Figure 8- Images of Preliminary Flash Testing Results

Cost Analysis:

Item #	Description	Cost Per Piece	Quantity	Total Cost
1	Tension Spring the Spring Store PE030-500-110334-MW-4000-MH-N-IN	$ 0.10	$ 44.00	$ 4.40
2	3D Printed Fingers on Drawings	$ 22.00	44	$ 968.00
3	3D Printed Housing On Drawings	$ 1,500.00	1	$1,500.00
4	16GA Aluminum Sheet Metal	$ 50.00	1	$ 50.00
5	1/2"x1-1/16" O.D., Flat Washer, Stainless Steel, 18-8, Plain	$ 0.17	4	$ 0.68
6	1/2"-20, Stainless Steel Hex Head Cap Screw, 18-8, 3/4"L, Plain Finish	$ 1.59	4	$ 6.36
7	3/8" Hardened Steel Self Drilling Tapping Screw with Hex Washer Head Type and Zinc Plated Finish	$ 0.03	52	$ 1.76
8	1/2"-13 Nylon Insert Lock Nut, Zinc Plated Finish, Grade 2 Steel	$ 0.22	4	$ 0.88
			Sum	$2,532.08

Table 2-Individual Component Cost Breakdown

Occupation	Description	Hours	Cost/Hr	Total Cost	
Engineer	Research, Calculation, Modeling, Detailed Drawings, FEA	60	$ 35.00	$2,100.00	
Manufacturing	Bending Sheet Metal	1	$ 22.00	$ 22.00	
			Sum	$2,122.00	
		Total Cost For Material/Labor			$4,654.08

Table 3-Manufacturing Cost and Total

Models:

ITEM NO.	PART NUMBER	DESCRIPTION	QTY
1	P000 Rev2	Shroud Housing	1
2	CP000	Existing Housing	1
3	Spring		44
4	SA00 REV2	Small Finger Sub Assembly	40
5	SA02	Corner Finger 1 Sub Assemb	2
6	SA03	Corner Finger 2 Sub Assemb	2
7	BRSA	Support Bracket Assemb	4

Table 4- Assembly Part List

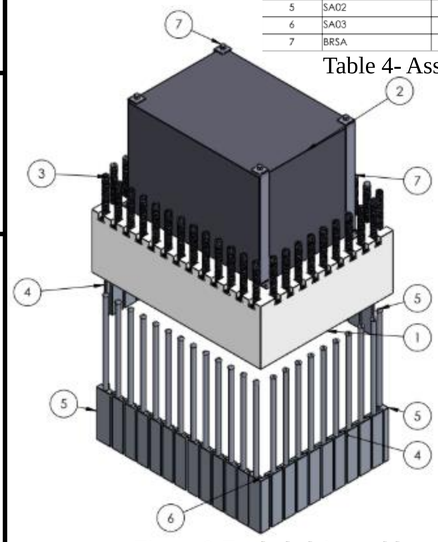

Figure 9-Exploded Assembly

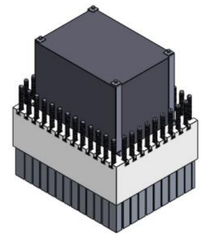

Figure 10-Assembly

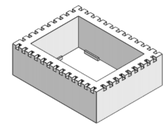

Figure 11-Shroud Main Housing

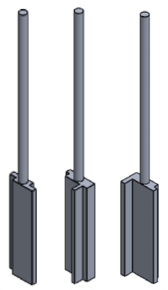

Figure 12-Small Finger, and Corner Fingers

Figure 13-Spring Assembly

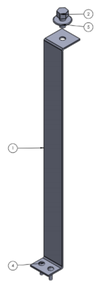

Figure 14- Bracket Assembly

Deliverables:

Changes	D/W	Requirements	Responsibilities
		Geometry: Desired sizing considerations	
None	D	Shroud to adapt to stinger geometry.	Further Testing
None	D	Shroud to be capable of 5-inch travel.	Met
None	W	Shroud to adapt to crossing and corner structures	Further Testing
		Forces:	
None	D	Structure must withstand forces of springs.	Met
None	D	Attaching clamp forces are nondestructive to hood.	Met
		Materials:	
None	D	Nonconductive	Met
None	D	Thermally stable	Met
None	D	High rigidity	Met
None	W	Minimal weight	Met
		Safety:	
None	D	Must meet OSHA, ASTM, ASME and Spirit Safety Standards	Met
None	D	Low conductivity- no flash over	Further Testing
		Production:	
COVID-19	D	Only one will have to be produced. Along with a working prototype.	Cancelled
None	D	Create virtual model, perform design analysis	Met
		Assembly:	
None	D	Must fit up with existing sheet metal box	Met
		Operation:	
None	D	May be manually operated	Met
None	D	May be operated by an automated machine.	Met
		Maintenance:	
None	D	Minimal modification required for changing samples.	Met
None	D	Quick repair time	Met
		Costs:	
None	D	Total cost should be kept to a minimum- under $5000.00	Met

W – wish requirement, D – demand requirement