N93-26931

NP-TIM-92

Nuclear Propulsion
Technical Interchange Meeting - 1992
NASA Lewis Research Center, Plum Brook Station
Sandusky, Ohio, October 20-23, 1992

Probabilistic Structural Analysis for Nuclear Thermal Propulsion

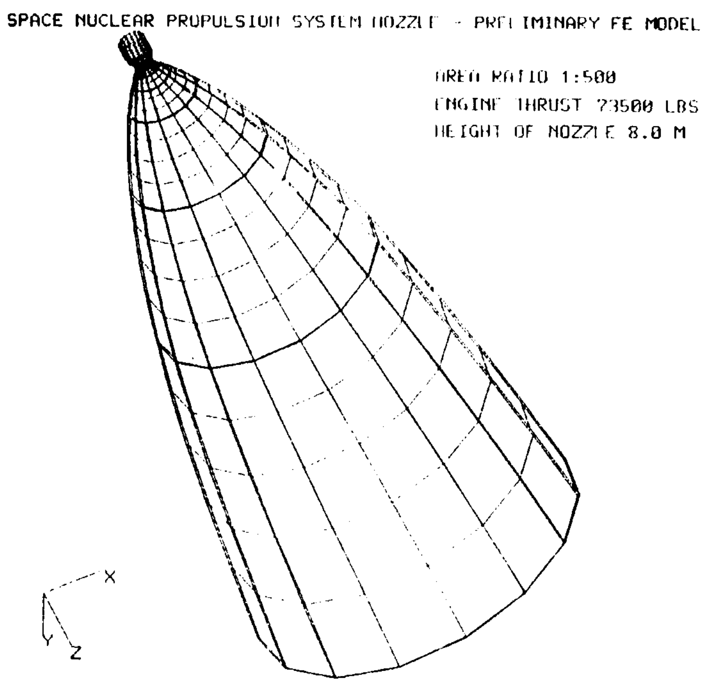
Dr. Ashwin Shah

Sverdrup Technology

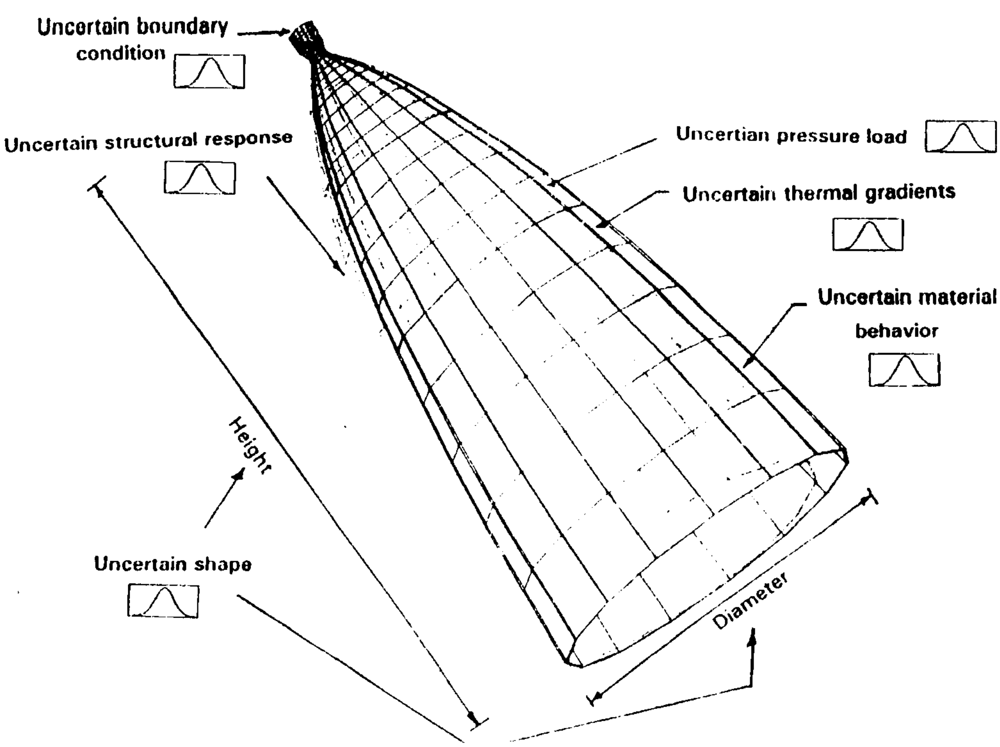
(presented by J.R. Stone, LeRC/NPO)

CERTIFICATION OF SPACE NUCLEAR PROPULSION SYSTEM NOZZLE WITH ASSURED RELIABILITY

OBJECTIVE: To develop a methodology to certify Space Nuclear Propulsion System Nozzle with assured reliability

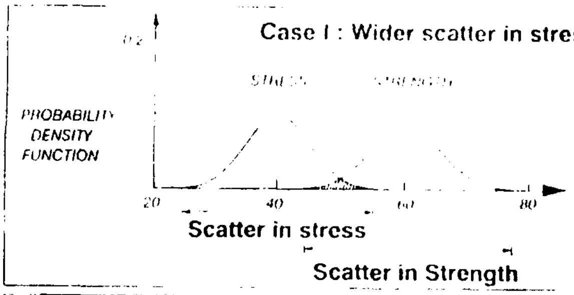


Certification of Space Nuclear Propulsion System Nozzle with Assured Reliability



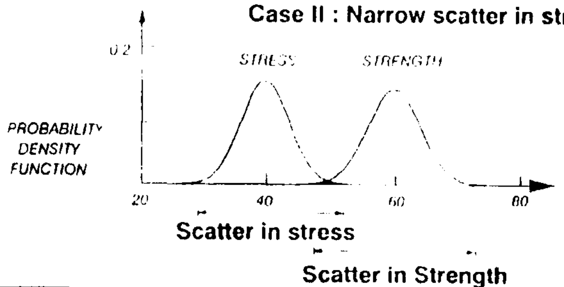
ADVANTAGE OF PROBABILISTIC STRUCTURAL ANALYSIS

Case I : Wider scatter in stress and strength



Safety factor = 60/40 = 1.5
Reliability = 0.99
Reliability is small because shaded overlapping area is large due to wider scatter

Case II : Narrow scatter in stress and strength



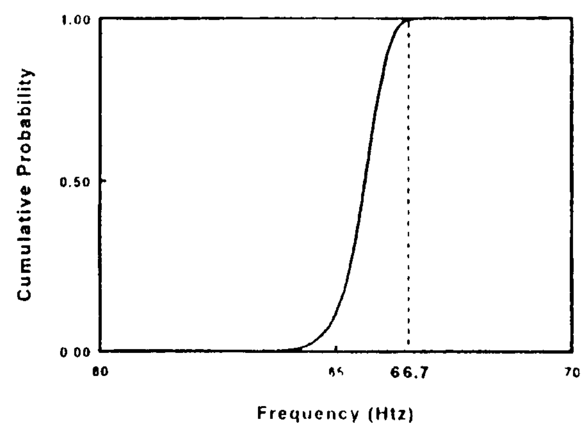
Safety factor = 60/40 = 1.5
Reliability = 0.999
Reliability is large because shaded overlapping area is small due to narrow scatter

Reliability of structure depends on scatter in stress and strength
Probabilistic approach accounts for scatter in stress and/or strength rationally

Space Nuclear Propulsion System Nozzle
Uncertainties in the Random Variables

Random Variable		Coefficient of Variation /Standard Deviation	Distribution
Pressure		5 %	Normal
Geometry: X- Coordinate		0.25 In	Normal
Geometry: Y-Coordinate		0.25 In	Normal
Geometry: Z-Coord. (Height)		0.25 In	Lognormal
Thickness		2.5 %	Normal
Temperature Gradient	Inside surface	5 %	Normal
	Layer 2	5 %	Normal
	Layer 3	5 %	Normal
	Layer 4	5 %	Normal
	Outside surface	5 %	Normal
Modulus of Elasticity		5 %	Weibull
Coefficient of thermal Expansion		2.5 %	Normal
Strength		4 %	Weibull

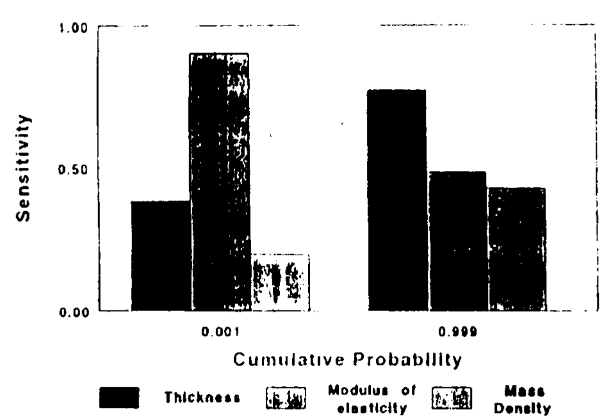
SNPS nozzle natural frequency



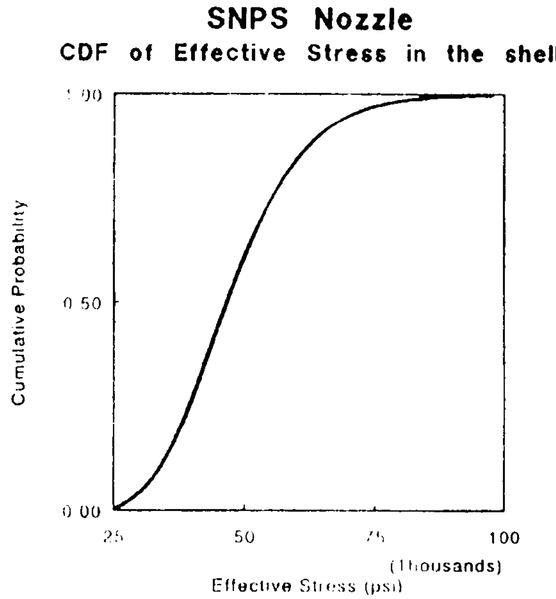
Probability of the natural frequency being less than 66.7 Hz = 0.999

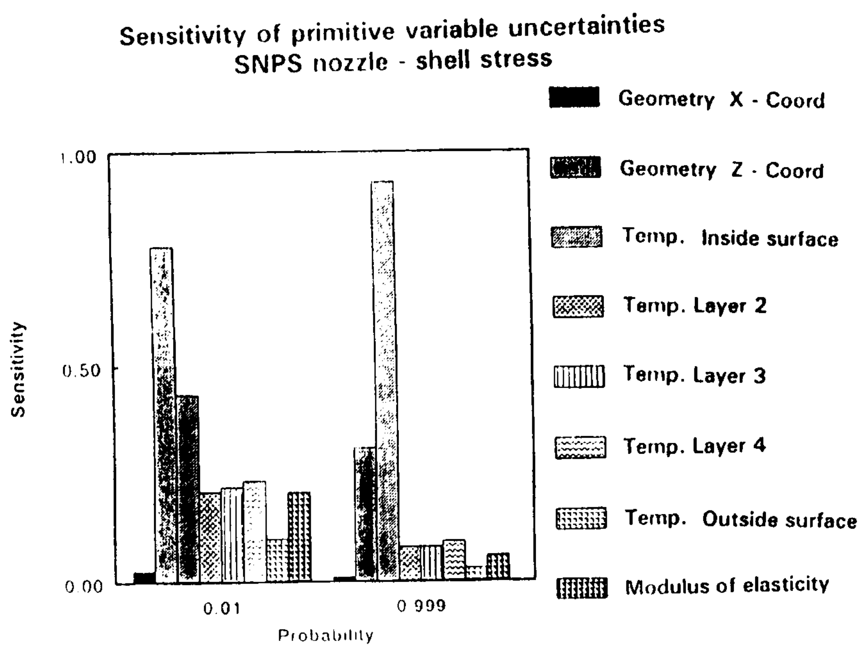
Therefore, to achieve a reliability of 0.999, the frequency of exciting force should be larger than 66.7 Hz to avoid resonance.

Sensitivity of primitive variable uncertainties
SNPS nozzle natural frequency



Variabes controlling the scatter of natural frequency within 66.7 Hz are thickness, modulus of elasticity and mass density. Therefore a tighter tolerance for the thickness and material properties are essential.





To control the stresses in the shell and achieve higher reliability, the uncertainties in the inside surface temperature should be reduced.

Work in progress:

- Modelling of NERVA base model with coolant tubes
- Development of pseudo-super element to reduce the size of the gloabal model to achieve computational speed and accuracy