DEVELOPMENT OF COVARIANCE BETWEEN PREFORM VARIATION AND FLOW PATTERN EMERGENCE IN VARTM

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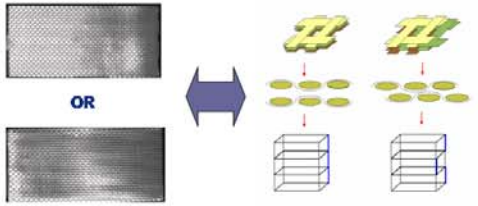
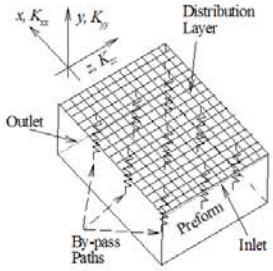
INTRODUCTION

- Model effect of preform heterogeneities on flow variations
- Calculate the dry spot content due to these variations
- Explore avenues to reduce dry spot content
- To reproduce composite processing conditions in VARTM
- To formulate concept of averaged preform properties

Possible Causes?



MODEL SYSTEM



- **Bulk Medium**

$$S_d = \{\mathbf{K}_{bulk}, K_{dl}, d_{dl}\}$$

- **By-pass Paths**

$$K_{bp} \sim \boldsymbol{LN}\left(\overline{\ln(K)}, \sigma_K\right)$$

$$S_s = \{\sigma_K, N\}$$

- **Calculate**

$$\bar{c}_{DR}, \sigma_{DR}$$

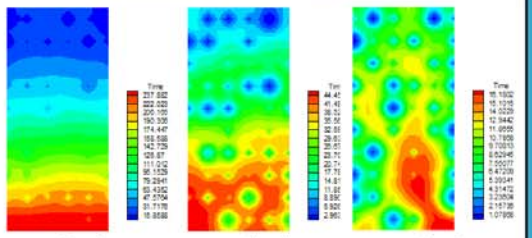
Average Dry Spot Content

$$\bar{c}_{DR} = \frac{1}{n}\sum_{i=1}^{n} c_{DR}^{i}$$

Standard Deviation

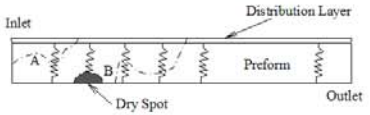
$$\sigma_{DR} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(c_{DR}^{i} - \bar{c}_{DR}\right)^2}$$

RESIN ARRIVAL TIMES AT THE SIDE IN CONTACT WITH THE TOOL



$\sigma_K = 2$

Define Dry Spots as Fluid Front Delay



AVERAGING

For a Random Permeability Array

- **Arithmetic Average, High Values**

$$K_A = (1/n)\sum_{i=1}^{n} K_{bp}^{i}$$

- **Geometrical Average**

$$K_G = \left(\prod_{i=1}^{n} K_{bp}^{i}\right)^{1/n}$$

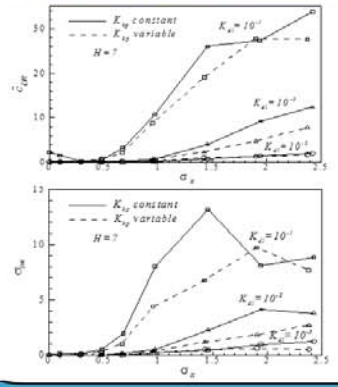
- **Harmonic Average, Low Values**

$$K_H = n \Big/ \sum_{i=1}^{n} 1/K_{bp}^{i}$$

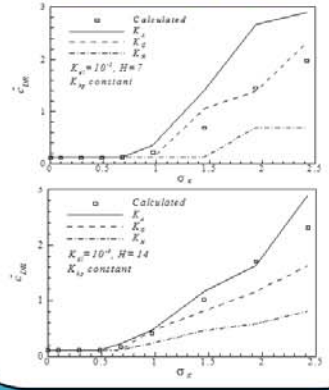
It always holds,

$$K_A \geq K_G \geq K_H$$

NUMERICAL PREDICTIONS



USING AVERAGES



CONCLUSIONS

- Experimental results suggest that there are variations in preform permeabilities due to nesting and preform architecture
- A model was developed to quantify their influence on dry spot formation
- It was found that dry spot content can be altered by proper choice of distribution media and by controlling the variability in preform structure
- Usage of averaged permeability is limited to providing rules of thumb to predict the level of dry spot formation

ACKNOWLEDGEMENTS

This work is supported by the Army Research Laboratory through the Composite Materials Research program.