List of Model-based POD Studies - MAPOD Working Group

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Computational Tools

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Model-Based POD Studies

- **Objective:**

  - **Develop a list of model-based POD studies that have been completed to date**

Model-Based POD Studies

- **Potential Criteria:**

    1. **Description of NDE Measurement Model**

    2. Model Validation with Experimental Data

    3. **Simulated Studies of Model Parameter Variability on Measures:**
        - **flaw characteristics**
        - material properties, part geometry, measurement noise

    4. **Estimated POD / POFC - Based on Detection Criteria**
        - operator interpretation of signals / images
        - automated classification (threshold, â vs. a, advanced classifier)

    5. Validation of estimated POD / POFC through experimental studies

- **Categories:**

    - *Limited* **study (with potential for POD calculation)**
    - **Model-based POD study**
    - *Validated* **model-based POD study**

Model-Based POD Studies

- **Resources:**
    - **NTIAC Technology Assessment of POD for NDE** (Matzkanin and Yolken, 2001)
    - **Review Papers and Texts**
    - **Conference Proceedings**
        - **Review of Progress in QNDE**
        - **World Conference of NDT**
        - **European-American Workshops on Reliability**

List of Model-Based POD Studies

- **Early Works:**

    - **Fertig and Richardson (1983) – ultrasonic POD modeling**

    - **Martinez and Bahr (1984) - eddy current POD modeling**

- **SWRI (Beissner et al) and ISU (Nakagawa) - ET Works:**

#	Problem [Publication Year(s)]	Modality	Lead / Sponsors	Model (Validation?)	Simulated Factor Studies	POD / POFC Estimate (Validation?)
1	Surface breaking flaws [1988]	ET	Beissner et al. (SWRI)	BEM	- notch (length, depth) - scan spacing (wrt flaw) - experimental data used to construct no flaw pdf	- ROC curves of POD and POFA with varying flaw size (4 levels)
2	Surface breaking flaws [1990]	ET	Nakagawa et al (CNDE – ISU, SWRI)	BEM	- tight crack (length, depth) - scan spacing (wrt flaw) - experimental data used to construct noise pdf - convolve noise pdf with model generated pdf	- ROC curves of POD and POFA with varying flaw size (4 levels)

List of Model-Based POD Studies

- **ISU UT Works:**

#	Problem [Publication Year(s)]	Modality	Lead / Sponsors	Model (Validation?)	Simulated Factor Studies	POD / POFC Estimate (Validation?)
1	General [1989]	UT	Gray et al. (CNDE - ISU)	Kirchhoff	- planar circular cracks (radius, depth) - part geometry (fillet radius)	
2	Aircraft Engine Materials	UT	(CNDE – ISU) [FAA: ETC, phase I]	MOOT, Kirchhoff (FBH), Born (SHA)		- laboratory data
3	Aircraft Engine Billets (SHA)	UT	(CNDE – ISU) [FAA: ETC, phase I/II]	Born		- production system data
4	Riser Girth UT Welds	UT	(CNDE – ISU) [ARDAMA - Oil Industry]	SOV (Pores), Kirchhoff (FBH)		
5	Heat Exchanger Tube Cracks [1998]	UT	Sarkar et al, (CNDE – ISU)	Kirchhoff (FBH)	- deterministic model for known parameters (crack depth, inspection) - statistical model of noise (variable parameters)	- POD estimate - compare with experimental data (high variability due to flaw morphology)
6	Aircraft Engine Forgings	UT	(CNDE – ISU, PWA)	Kirchhoff (FBH)		- field data

List of Model-Based POD Studies

- ## Lalita and Satish Udpa (ISU/MSU) ET Works:

#	Problem [Publication Year(s)]	Modality	Lead / Sponsors	Model (Validation?)	Simulated Factor Studies	POD / POFC Estimate (Validation?)
1	Surface breaking cracks [1993]	ET	Rajesh et al. (ISU)	FEM	- notch (width, depth) - noise parameters: liftoff, surface roughness, temperature, material conductivity, measurement noise	- Monte Carlo simulation procedure - simulated POD – function of flaw width
2	Magnetostatic NDE [1994]	ET	Subramanya et al. (ISU)	FEM		
3	General [1994]	ET	El-Shafiey et al. (ISU)	FEM (3D, parallel)		
4	Pipeline inspection [1997]	ET	Zhang et al. (ISU)	FEM		
5	Cracks around fastener - MOI [2000-2004]	ET	Udpa et al (ISU/MSU)	FEM	- cracks - fastener holes	- POD / POFC estimate - operator interpretation

List of Model-Based POD Studies

- **UK National NDT Centre NNDTC** (AEA Technologies, Harwell):

#	Problem [Publication Year(s)]	Modality	Lead / Sponsors	Model (Validation?)	Simulated Factor Studies	POD / POFC Estimate (Validation?)
1	Subsurface cracks (planar defect) [1993]	UT	Ogilvy (UK NNDTC)	Kirchhoff, noise theory model (PODUT)	- flaw aspect ratio, orientation, depth, roughness - noise	- estimated POD / POFC
2	Surface cracks	UT	Silk (UK NNDTC)	Semi-empirical model (PODSURF)		
3	Cracks	UT	Temple (UK NNDTC)	TOFD, (PODTOFD)		
4	Ultrasonic C-scan model [1997-2000, 2002]	UT	Wall and Birch (UK NNDTC)	TOFD, (PODTOFD) [geometry convolved with UT beam, add noise]		- present multiple detection criteria (single point, multipoint, integral) - performed operator interpretation studies of simulated image data
5	Surface and near surface defects [1995]	ET	Holt (UK NNDTC)	FEM, POD model (PODET, OPERA)		
6	Ultrasonic C-scan model [1997-2000]	RT	Windsor and Wall (UK NNDTC)	Geometrical model (XPOSE)		

List of Model-Based POD Studies

- **Active Organizations - NDE Measurement Models (Study Model Parameter Variability):**

  - **CEA (CIVA)**

  - **IZFP (Spies et al)**

  - **Northwestern (Achenbach)**

#	Problem [Publication Year(s)]	Modality	Lead / Sponsors	Model (Validation?)	Simulated Factor Studies	POD / POFC Estimate (Validation?)
	Aircraft structures [2001]	UT	Aldrin et al. - (Northwestern) [SAIC, USAF]	BEM	- crack (length, location) - hole geometry	- validated model with experimental data - experimental POD validation of procedure - no model-based POD for comparison to date

List of Model-Based POD Studies

- ## Additional Recent Works:

#	Problem [Publication Year(s)]	Modality	Lead / Sponsors	Model (Validation?)	Simulated Factor Studies	POD / POFC Estimate (Validation?)
1	General [1998]	RT	Nockemann et al. (BAM – Germany)	Ray theory	- notch (depth) - noise	- compare theoretical and experimental POD results
2	Aircraft structures -SQUID NDE [1998]	ET	Ewing et al. (Vanderbilt University)	BIE		
3	General [2001]	UT	McNab et al (Strathclyde)	Ray theory NDT Workbench	- CAD model - coverage	
4	Piping - corrosion [2004]	UT (RT)	Volker et al. (TNO, Netherlands)	Kirchhoff, FDM (Ray theory)	- corrosion (depth, width)	- decision algorithm using simulated data - experimental validation

Model-Based POD Studies

- **Reason for List: Identify Existing Knowledge Base for MAPOD (Model Assisted POD)**

    – **Prior Work**

    – **Existing Models**

    – **Active Organizations**

- **Related Topics:**

    1. **NDE Model Benchmark / Validation Studies**

    2. **Inverse Methods in NDE**

    3. **Modeling Research and Development in NDE**

Related Topics

- **NDE Model Benchmark / Validation Studies**
  - **WFNDEC Benchmarking - UT:**
    - **CNDE-ISU,**
    - **IZFP – Germany (Spies),**
    - **Sungkyunkwan – S. Korea (Song)**
    - **IIT Madras – India**
  - **WFNDEC Benchmarking - ET (MFL, EC):**
    - **CNDE-ISU,**
    - **MSU,**
    - **U. Szczecin – Poland (Sikora et al.),**
    - **CII – Argentina (Pignotti et al.)**
    - **TU – Russia (Lunin et al.)**

Related Topics

- **Inverse Methods in NDE (Reviews)**
  - **International Journal of Applied Electromagnetics and Mechanics (1997)**
    - **Bowler, J. R.**
    - **Kojima, F.**
    - **Banks, H. T., Smith, R. C., Zhang, Y.**
    - **Udpa, L., Udpa, S. S.**
  - **Auld, B. A., Moulder, J. C., Journal of NDE (1999)**

- **Modeling Research and Development in NDE**
  - **Reviews of NDE Modeling Research
    (Gray et al, Achenbach, Schmerr, Chimenti, Thompson, Lhemery, Spies)**
  - **Software (Measurement Model Examples):**
    - **EC: ECSIM (ISU), CIVA, OPERA 3D, VIC 3D**
    - **RT: XRSIM (ISU/NDET), CIVA**
    - **UT: UTSIM (ISU), CIVA, Imagine3D**

Request for Feedback

Please feel free to contact me concerning additions / modifications / suggestions concerning the review

Email: aldrin@comptutationaltools.com

Thanks!