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Quality Assurance & Data Capture

David Forsyth (discussion facilitator)

ENGINEERED RESIDUAL STRESS IMPLEMENTATION WORKSHOP 2016

Date: September 15, 2016

Location: Weber State University Downtown Campus,
2314 Washington Blvd, Ogden, UT 84401

Outline

- The Role of Capturing Quality Assurance Data for Deep Residual Stress Inducing Processes and How to Manage that Data for Future Use.

- Outline
  1. What is the current state-of-the-art for capturing the proper application of the Cx process at fastener holes?
  2. What are the technological gaps that still need to be overcome?
  3. What type of governing document do you see the requirements for this type of quality assurance tool being placed for USAF usage?
     a. TO, Workspec, Planning documents????
  4. How can the data produced via this method be stored?
  5. Why is the capture and storage of this information so important for the implementation of residual stresses into the sustainment paradigm?

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1. Current State of the Art

- Measurement of hole diameter during the process.
  - Post-ream?
- Performed by the technician using manual gauge.
- If within spec, no record is required and process moves to the next step.

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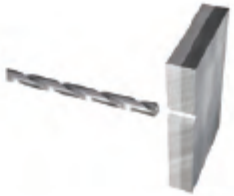
Typical of -6, -36 processes in the depot. If everything is "good", no record exists.

FTI process overview

STEPS FOR PROPER COLD EXPANSION:

1) If necessary, drill the starting hole to size it for the starting reamer



2) Ream to correct starting hole size

3) Verify the starting hole dimensions with the stepped blade on the combination gauge

4) Check the expansion portion of mandrel is within tolerance

5) Slide a split sleeve onto the mandrel

6) Insert the mandrel and sleeve into the hole

instructions may require specific orientation of sleeve split

7) Activate the puller unit to retract the mandrel and expand the hole

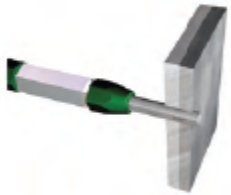
8) Retract the mandrel fully through the sleeve and into the nosecap

release trigger to return mandrel

FTI process overview

9) Remove the split sleeve from the cold expanded hole and discard

10) Verify the expanded hole size with the pin end on the combination gauge



11) If necessary, size hole for required fastener

2. Always observe these process quality steps:

- Use the combination gauge to verify hole size before and after cold working.
  - Use the stepped blade end of the gauge to check starting holes
  - Use the pin "go/no-go" end of the guage to verify that the hole has been properly cold expanded
- Use the mandrel check fixture to ensure that the major diameter of the mandrel is not worn beyond acceptable limits. A worn mandrel will result in insufficient cold expansion and life enhancement.

- Multiple QA steps built into this process.

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2. Technology Gaps

- Depends on your requirements.

- IF you need auditable, quantitative measurement to show:
  a. CX process was performed to spec
  b. residual stress amount was at least per spec.
  c. residual stress is X

2, 5

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2, 5

- What is the variability and uncertainty (not the same thing) that you can accept
  - in your processes of prediction
  - in your manufacture/depot process
- This drives the answer.
- Typical CX hole expansions are in 3% to 5% range. How precise do you need to know for your particular application?
  - Validate your measurement capability w.r.t. your requirements.

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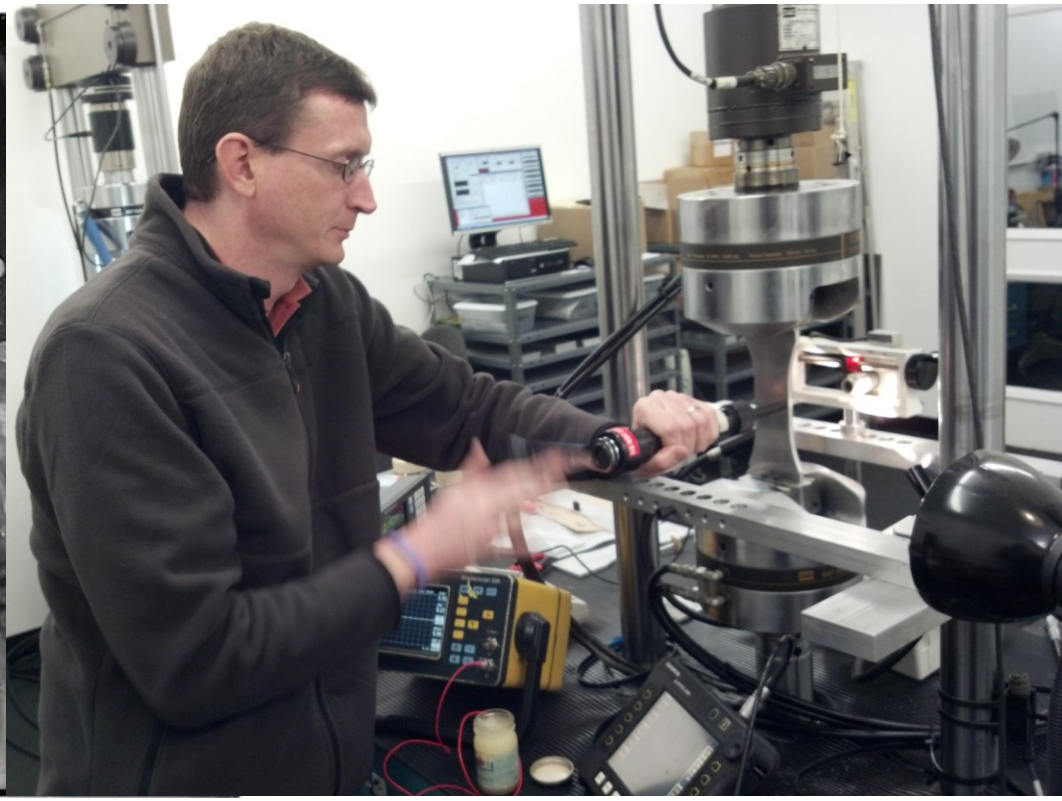
2. a. Process performed to spec

- Could take a photo!



2 b. residual stress amount was at least per spec.

- Basically a threshold. Easier than a precise measurement.
- Measure hole diameter before and after?
  - What is required precision, tooling to do this?
- Measure CX
  - Deformation due to process
  - Surface residual stresses due to process

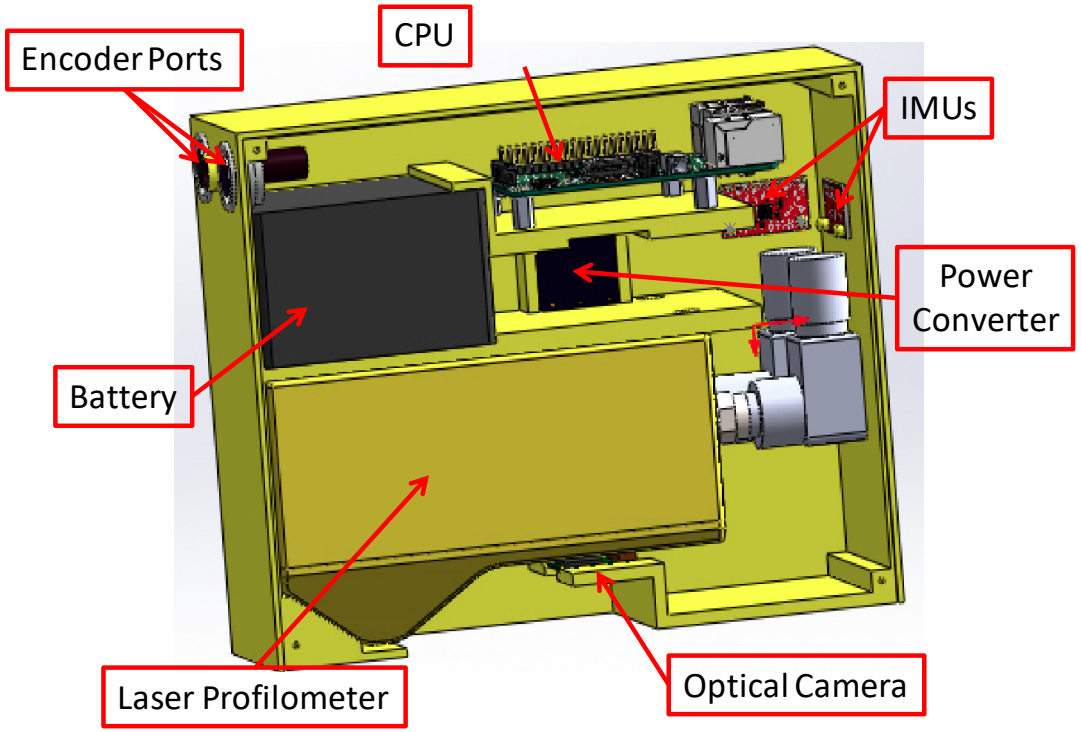
2 b. residual stress amount was at least per spec.

- Some examples of hole diameters and changes due to CX.

	MAX	MID	MIN	OUT
Hole Diameter	Hole 1 CX %	Hole 2 CX %	Hole 3 CX %	Hole 4 CX %
0.168”	4.75	3.98	2.80	1.40
0.246”	4.41	3.27	2.63	1.17
0.374”	3.99	3.42	3.00	1.20
0.494”	4.00	3.44	2.99	1.24
0.574”	3.63	3.20	2.93	1.07

Measuring plastic deformation caused by CX process

- TRI/Austin's FastenerCam™ mark I and mark II design

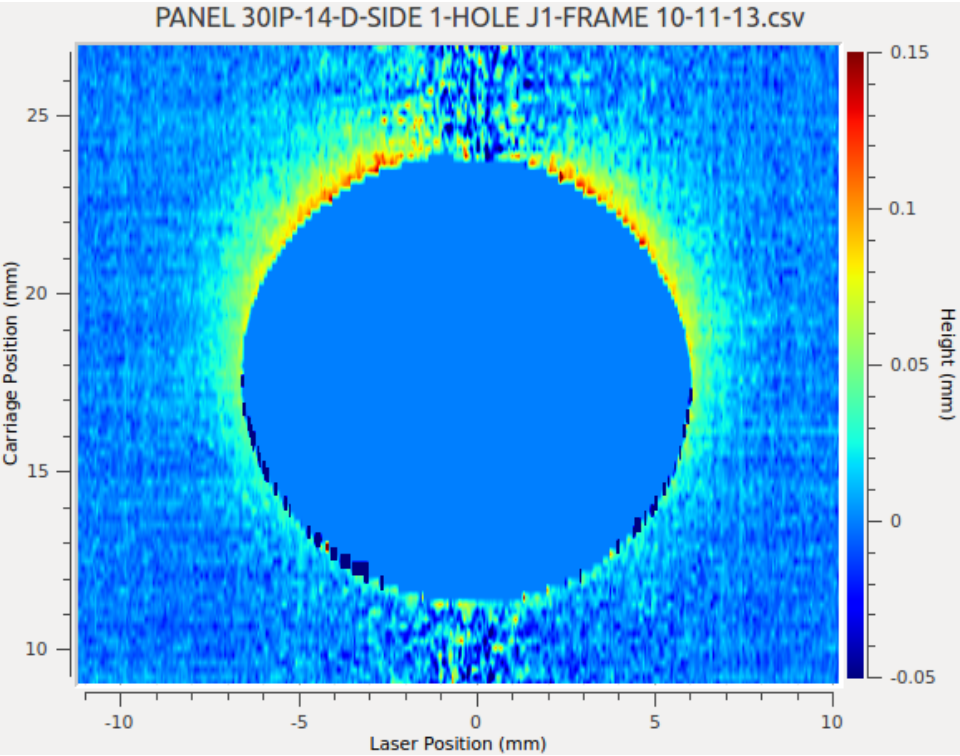


Measuring plastic deformation caused by CX process

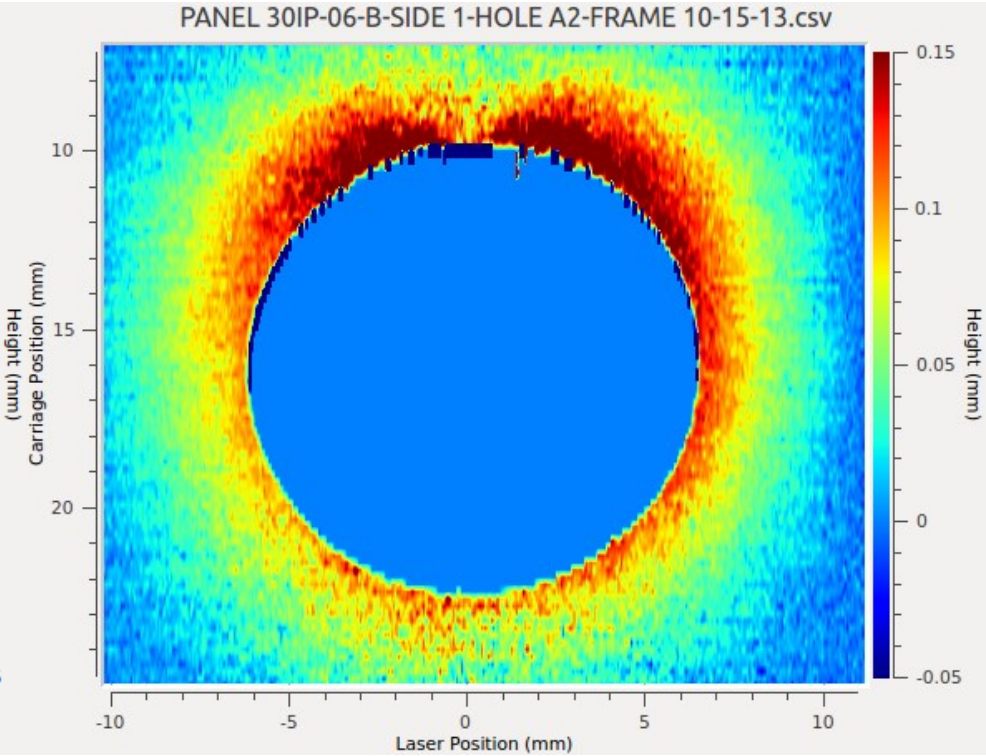
- TRI/Austin's FastenerCam™

0.494" Diameter Straight Shank Holes

1.24% CX



4.00% CX



Measuring residual stresses caused by CX process*

- A system by Proto

Measuring Residual Stress
Inside a Bolthole

Measuring residual stresses caused by CX process*

Residual Stress Analysis Near a Cold Expanded Hole in a Textured Alclad Sheet Using X-ray Diffraction

by J.C.P. Pina, A.M. Dias, P.F.P. de Matos, P.M.G.P. Moreira and P.M.S.T. de Castro

Vol. 45, No. 1, February 2005

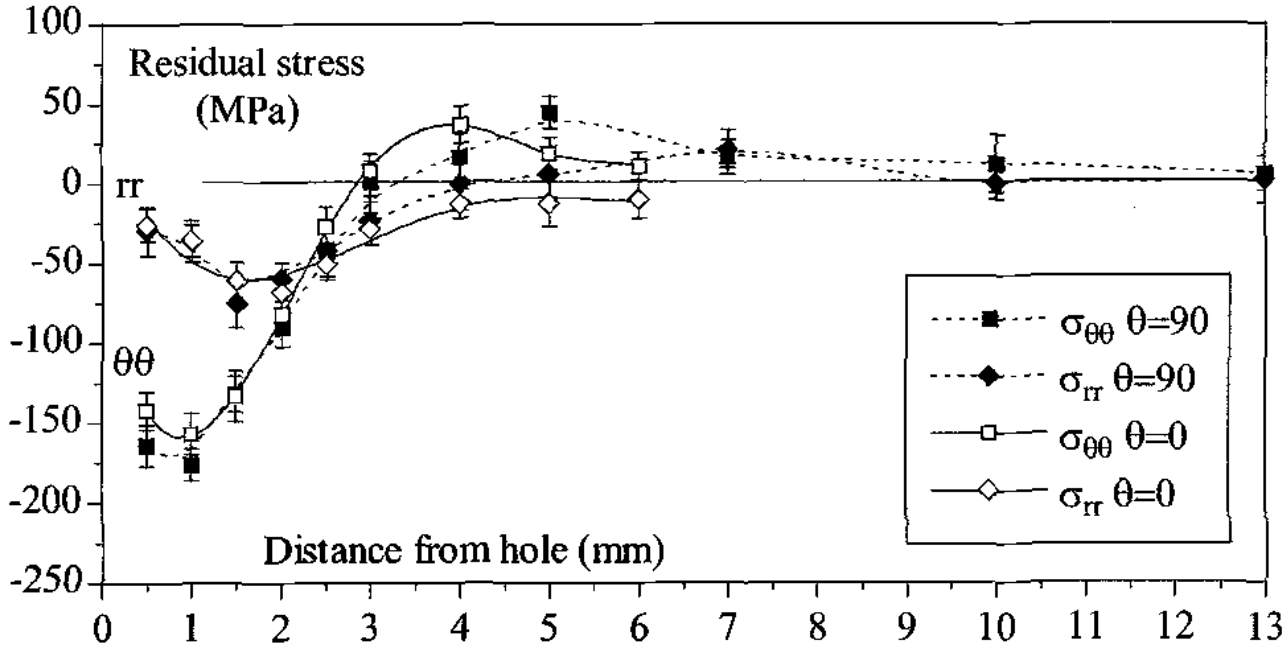


Fig. 6—Residual stresses determined on the entrance face of the aluminum sheet for $\theta = 90°$ and $\theta = 0°$

2. c. residual stress is X

- You have some model to convert the measured parameter to your residual stress.
  - Hole diameter, plastic deformation, surface residual stresses
- You really want to know stress tensor at all locations.
  - Modeling, experimental work described by previous speakers provides a means to infer this from simpler measurements

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So are we there yet?

- That's up to you to decide.
  - Does the system of measurement provide sufficient performance and variability to enable prediction of structural performance?
  - Is it affordable, practical for use?

- I don't think we have solid answers for either the
  - structural performance prediction requirements
  - measurement system capabilities

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3. Governing Docs

What type of governing document do you see the requirements for this type of quality assurance tool being placed for USAF usage?

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- This belongs to the owner. Discuss to your hearts' content, but you don't get to decide unless you are the owner.

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4. Data Storage

- This is a problem of the owner. Argue amongst yourselves. Manufacturing, depot, field all have their issues.

- Any of the processes described for QA provide digital data. You need to provide a receptacle for said data.

4. Data Storage

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5. Why?

- CX doesn't get credit it deserves sometimes.
- CX sometimes gets extra/wrong credit.
- If you are going to make lifing/risk decisions, you need to ensure CX has been done to your specifications.

FINAL DISCUSSIONS

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That's all Folks
A WARNER BROS. CARTOON