Digital twin for improved control of the fabrication process

Aerospace Technology Congress 2019
Hugo Hultman
2019-10-08

Presentation outline

- About me
- My industrial PhD project
- Fabricated components
- Geometry assurance
- The digital twin
- Smart production concept
- Case study 1: Welding simulation of formed sheet metal
- Case study 2: Case study at PTC
- Future work

About me

- Started out as a design engineer within solid mechanics at GKN Aerospace in Trollhättan, doing simulations on aircraft and rocket engine components to predict life
- Moved over to production, doing root cause analysis to improve the reliability of different processes and operations
- Both within design and production, the problem was a lack of real data: the analysis was based on predictions and estimations
- Last year, applied for an industrial PhD project in order to dig deeper into the possibilities of data collection in production systems

My industrial PhD project

- “Data-based automated production control for fabricated components”
  - Main research question: how can increased data collection be used to achieve better control of the fabrication process?
  - Goal is to feed data from all process steps to a database that also includes digital twins of the production system and produced parts
  - Having access to process and geometry data from all manufacturing steps will enable handling and analysis of variation in which downstream operations can be adapted to process outcome from upstream operations

Fabricated components – opportunities and challenges

- Fabrication is a manufacturing method where several small parts are joined together, commonly through welding
  - Large, complex castings can be avoided by splitting the part into a fabricated assembly
  - Possible to mix different materials in single assembly to decrease weight
  - Having several smaller parts creates more variation in the final assembly, since the unique variation of each part will propagate in the assembly
  - Inspection and testing requires a lot of man-hours
  - Inspection data is not used to its full potential!

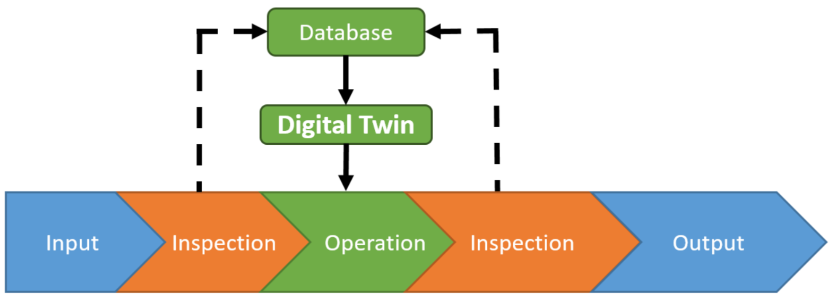
- How can concepts and strategies from industry 4.0 be applied to handle this variation in order to reduce inspection, re-work and cost?

Increased robustness with geometry assurance

- Geometry assurance is a common approach to managing variation and mitigating its effect on the final product
  - Analysis is often done through simulation, using models to explore different solutions and find a robust approach
  - Geometry assurance is normally applied to nominal products and production systems to evaluate robustness
  - RD&T is a software tool developed specifically for geometry assurance, and is currently being used as a part of the design process
  - Digitalization of the production process has led to increasing data collection using scanners to measure parts and assemblies
- What if we could move RD&T from the design process into the production process, by using actual scanned geometries of incoming parts instead of nominal geometries?

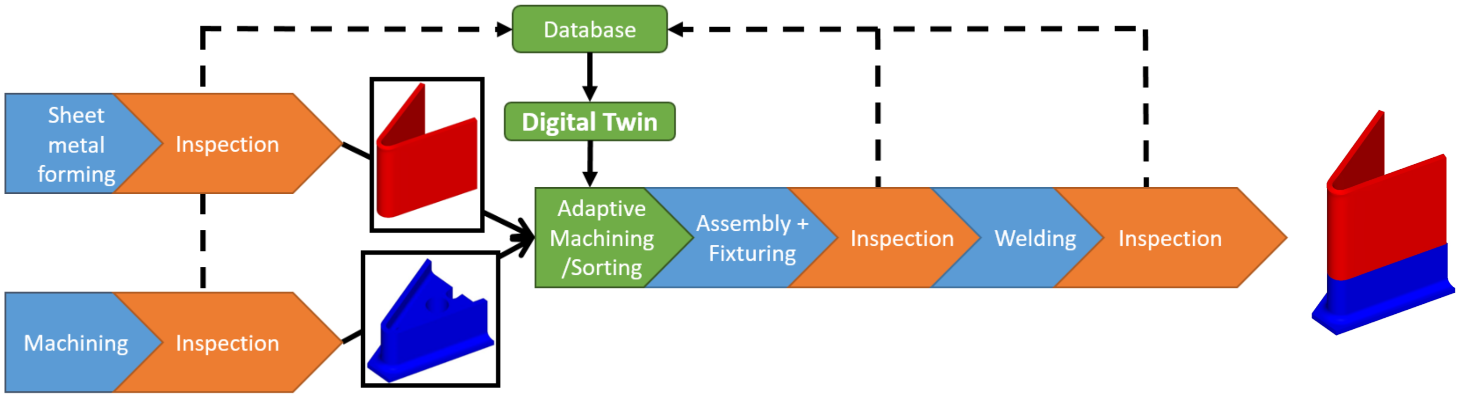
The digital twin

- First proposed by NASA as a way of tracking remaining life in flying parts, a digital twin is a comprehensive physical and functional description of an active system
  - Increased computing power and data collection has made it possible to run process simulation with real data in order to accurately track the status of the system
  - If a simulation is done ahead of each operation, the incoming parts can be measured in order to take individual variation into account
- What could a digital twin for a production system look like?



Smart production concept

- The smart production concept is a proposed solution for conducting in-line geometry assurance activities
  - Goal is to use RD&T to realize the digital twin by running in-line simulations of the production process steps
  - In order to supply the digital twin with enough data, measurement systems need to be in place within each operation in the production line
- Many gaps and missing links remain before the concept can be implemented!

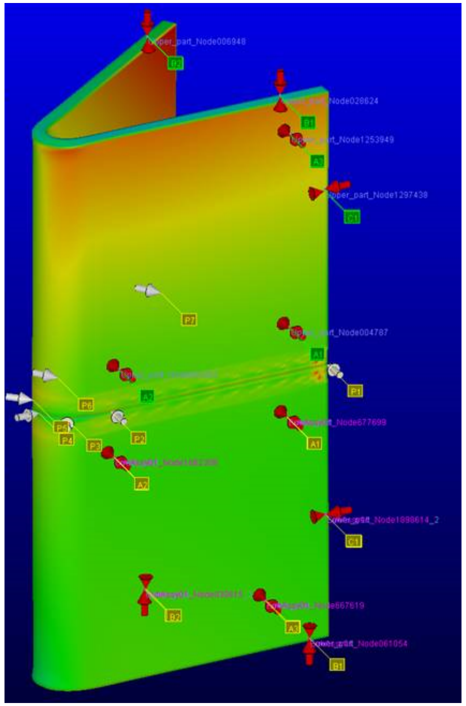


GKN AEROSPACE CHALMERS UNIVERSITY OF TECHNOLOGY

Case study 1: Welding simulation of formed sheet metal

- Residual stress can be an important factor when managing variation
  - First article will focus on welding simulation and residual stress
  - The study focuses on a sheet metal forming process that generates residual stresses in the formed part
  - The residual stress may have an impact when the part is welded onto another part

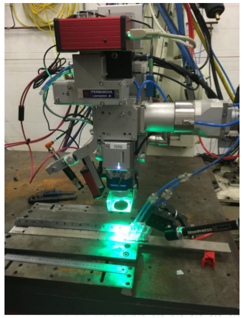
- A better understanding of the impact of residual stress will bring us one step closer to an accurate digital twin!



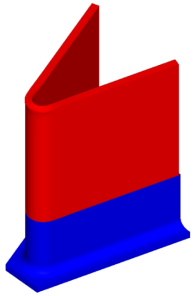
Case study 2: Test manufacturing

- A simplified T-sector will be manufactured at a research center belonging to GKN Aerospace in Trollhättan, utilizing data collection strategies linked to Industry 4.0
  - The assembly consists of a sheet metal vane and a machined base that are welded together
  - Machining will be done in a Grob G352 equipped with an extended data acquisition system
  - Welding will be done in a Laser welding cell equipped with scanning capability
- The case study will help to identify and fill out gaps in order to realize the digital twin and the goals of reduced cost and lead time

Machining



Laser welding



Result

GKN AEROSPACE CHALMERS UNIVERSITY OF TECHNOLOGY

Future work

- Many challenges remain before a digital twin can be implemented in a real production line
  - What parameters need to be measured?
  - What target variables should be adjusted using information from the digital twin?
  - How should the infrastructure look like in order to accommodate a digital twin?
- Digital twins have great potential to reduce cost by simulating with real data instead of estimations and predictions!

Thank you!