TRACEABILITY INTRODUCTION

Monday, 10 – Tuesday, 11, March at Sandviken, Sweden

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- Traceability.
  - What is Traceability?
  - For what is it implemented?
  - How is it performed (activities)?
  - Why Traceability in AP-238?

- Current status of the Traceability proposal for AP-238.
  - Traceability nc_Functions as SC4 Dallas meeting.
  - Some discussions & progress since SC4 Dallas meeting.
1. Traceability.

- **What is Traceability?**
  - The objective of Manufacturing Traceability is to provide all the relevant information about a manufacturing process.

- **Which Data?**
  - **With what and where has been manufactured a piece?** raw material, coolant, tools, machine, software.
  - **How/how well?** Tool paths, tool paths deviations, actual velocities, control events.
  - **Who?** Operator
  - **When?** manufacturing timings.

![Diagram showing the flow of AP-238 File to CNC System with Traceability to parts with traced data.](image-url)
1. Traceability.

• **For What?**
  
  • For Quality analysis (and long term data analysis)
  
  • To be able to investigate the origin of a manufacturing default (**TRACE**). To answer questions like: **Why this feature is not ok?**
  
  • To be able to identify other pieces with the same fault (**TRACK**). To answer questions like: **Which other pieces may have also the same default and should be review?**
1. Traceability.

- **For What?**
  - For knowledge capture and optimization (for re-design and re-planning)
    - To answer questions like: *How long does it take to machine this feature?*

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- To provide data for advanced “manufacturing” services.
  - Programmed Monitoring.
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```

```
1. Traceability.
```

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  - Programmed Monitoring.
```
1. Traceability.

- How is it performed (activities)?
  - Before manufacturing (Design phase).
    - Definition/Configuration of what to trace, where, how.
  - During Manufacturing (Shop floor phase).
    - Data recording process (shop floor).
    - Establishment of the link between the traced data and the piece.
  - After Manufacturing (Quality and re-design phase)
    - Data communication.
    - Data storage.
    - Data analysis, etc.
1. Traceability.

- Activity Model, 3 main activities:

Before Manufacturing
  (design phase)

While Manufacturing
  (shop floor phase)

After Manufacturing
  (inspection, re-design, re-planning)
1. Traceability.

- Why Traceability in AP-238?

  A- Many relevant data is just know by the process controller, so it has to provide this data.

  The CNC controller knows much of this data. The HMI+CNC controller knows all the data.

  B- In Client-supplier relationships, traceability data has to be understandable, trustable...

    • **Understandable.** In terms of format and meaning.
      • The contractor has to understand the requirements without doubts.
      • The client has to understand the data by its own.
    
    • **Trustable.**
      • There shouldn’t be doubts about the recording process.

  Traceability DATA (requirements & results) should be standard & automatically understood:
  - Automatically understood by controller.
  - Understood by the analysis system (linked to an understandable specification of the machining process).

Current status of the Traceability proposal for AP-238.

- 2. Traceability NC-Functions as SC4 Dallas meeting (October 2007).
  - The AP-238 executable Unit of Functionality and nc-functions.
  - Proposal: Traceability nc-functions.
  - How the Traceability nc-functions work: an example.

- 3. Progress since SC4 Dallas meeting.
  - New data types for recorded data.
  - Redefinition of Block I functions.
  - Other comments.
  - Open issues.

- Executable model (AP-238).

- (ABS) Program structure: Control flow for the machining program.

- (ABS) workingsteps: Program Steps that move the machine axes

- (ABS) nc_functions: Program steps that do not move the machine axes.

- AP 238: Adding Traceability NC-Functions

![Diagram showing control flow for the machining program with program steps that move the machine axes and those that do not move the machine axes.](image-url)

NEW Traceability nc_functions

- **Three Groups of Functions for data traceability:**
  - **Group I:**
    - **Blocking Functions,** take control of the program, collect a punctual or single value of data to be used in CNC calculations and return control to machining flow.
  - **Group II:**
    - **Switching Functions,** activate data collection or event information for a period of time. A **switching on** functions activates the data monitoring until the corresponding **switching off** functions id found in the program.
  - **Group III:**
    - **Synchronous Functions,** continuously monitor data to trigger if a condition is fulfilled a series of actions grouped as a workplan.

- Group I Functions.

  (ABS) nc_function

  - get_time
  - get_operator_id
  - get_x_position
  - get_y_position
  - get_z_position

  One Value Is Returned!

  nc_variable

Program Sample with Group I Functions.

- **Group II & III Functions.**

  - **(ABS) nc_function**

    - `start_measuring_maximum_deviation_position_along_toolpath`
      - maximum deviation values $L[0:?]$
      - Results_data
        - Its_threshold_value
        - length_measure
        - Its_actions
        - workplan
        - Bounded_amount_of_values Returned following the same Toolpath Parametrization!
      - measured_for
        - Bounded_curve
      - toolpath

    - `stop_measuring_maximum_deviation_position_along_toolpath`

- maximum_deviation_values $L[0:?]$ is used to store in AP-238 a bounded curve, series of collected values (per toolpath and following the same parametrization as the corresponding workingstep toolpath).
- its_threshold_value is used only if nc_function acts as a group III function to specify a threshold value for the comparing/triggering condition.
- its_actions is an alternative workplan (a series of actions) to be done in case the specified condition is fulfilled (just for group III).

Program Sample with Group II.

Program Sample with Group III Functions.

- Complete Ap-238 nc-Functions Model.
• How nc_functions Work?

1. Configuration: requirements are translated into nc_functions in the AP238 executable.
2. nc_functions are automatically executed when they are found in the executable sequence.
   2.1 Data can support run-time.
   2.2 Data can be logged when machining finish
3. Logged data is used.


- How the Traceability nc_functions work: An example.
  - 1. Traceability requirements are specified by inserting nc_functions in the executable sequence.

- How the Traceability nc_functions work: An example.
- 2. Accessing the Data while machining:

  - 2.1 With Current Technology:
    - nc_functions have to be translated to G&M codes. Limitations: current CNC resources (Memory, file access mechanism, etc).

    ```
    N100  $AC_TIMER[1] = 0 ... 
    ;RESET R[] variables 
    ;R[1] WILL Hold the threshold value 
    .......... 
    ;START Synchronized ACTION threshold set for each segment 
    G1....
    WRITE("ERROR","LOGFILE","SEGMENT 1 TIME: " << $AC_TIMER[1]); 
    $AC_TIMER[1]= 0 ;
    G1...
    WRITE("ERROR","LOGFILE","SEGMENT 1 TIME: " << $AC_TIMER[1]); 
    $AC_TIMER[1]= 0 ;
    G1...
    .......... 
    CANCEL(1)
    ```

- Through the HMI interface (Accessing to the PLC internal variables with, for instance OPC communication) (Experiments at NIST)

- 2.2 With a AP-238 controller (TODAY, Simulation): The controller access its internal variables, computes the values, stores them in memory. When mechanization ends (or when cycles ends), it writes the values into a file.

- **How the Traceability nc_functions work: An example.**
2. Proposal: Progress since SC4 Dallas meeting.

- Logged Data format (model)?

- Is it ok the Bounded Curve approach for data from Block II/III?...should it be improve?
  - More points than the programmed ones are needed to save traceability records.
  - Problem of the amount of data.

- Should be improve the nc_variable approach for data from Block I?
  - Need to define data types to hold the data values...Administrative data? Machine software version? Etc...
2. Proposal: Progress since SC4 Dallas meeting.

- **Block I nc_functions issues:**
  - **Block I nc_functions more like Block II:** Most Block I nc_function will become as block II to store data in the same way.
  
  - Nc_function to start/stop getting execution times of toolpaths.
  - Nc_function to start/stop getting (along toolpath): operators involved.
  - Nc_function to start/stop getting (along toolpath): manual override intervention.
  - Nc_function to start/stop getting (along toolpath):
    - Used tools Identification.
    - Used machines identification?.

- Still, may be some Block I nc_functions returning single values???
3. End.

- Conclusions.
  - Traceability nc-Functions seems to be a good mechanism??
  - To log data as standard format ....more data types definitions?

Thank you for your attention