Title: IN-PROCESS QUALITY ASSURANCE FOR PRECISION JOINING: PRINCIPLES AND GUIDELINES

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In-Process Quality Assurance for Precision Joining: Principles and Guidelines


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Introduction

Lean manufacturing and its associated principles of continuous improvement and quality inherent to processes have had a significant impact on manufacturing operations over the past two decades (Ref.s 1, 2, 3). However, thoughts on quality in joining have not progressed as far as in other manufacturing disciplines. The present work outlines principles that can be used to largely obviate post-process inspection and achieve in-process quality assurance. Methods are outlined for brazing, diffusion bonding, inertia welding, and fusion welding.

The current method has four principal steps. First, all the directly controllable and uncontrollable inputs are enumerated. Then, the key in-process physical behaviors directly influencing part quality are identified, and their associated in-process variables are selected. Next, cross-correlations are made between the inputs and available in-process measurements or other methods of control. The tangible output from this process is termed a ‘process control roadmap,’ a sample of which is schematically shown below:

<table>
<thead>
<tr>
<th>Inputs related to particular in-process behaviors</th>
<th>Measurements or methods of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Input 1</td>
<td>Meas. 1 Meas. 2 Meas. 3 Meas. 4</td>
</tr>
<tr>
<td>• Input 2</td>
<td></td>
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<tr>
<td>• Input 3</td>
<td></td>
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<tr>
<td>• Input 4</td>
<td></td>
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<td>• Input 5</td>
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</tbody>
</table>

The dark squares suggest a strong correlation between an input and an in-process measurement, the light squares indicate a lesser correlation, whereas the clear squares indicate little or no correlation at all. A process window may be designed around the appropriate in-process measurements, leading to the last step, which is control system implementation. Note that this final step, which is most often associated with process control, occurs at the end of the process after the key in-process physical behaviors and...
measurement methods have been determined. A combination of statistical methods and neural nets are used to analyze in-process measurements and generate quality metrics using multi-tier, web-based manufacturing process knowledge management software written in Java and C++.

This work defines process control roadmaps such as the one shown above for brazing, diffusion bonding, inertia welding, and GTAW. The objective in each case is the same: define the characteristics of a process control scheme that will allow the operator to immediately know the part quality as it is being made, or immediately after it has been made. Inspection in such cases is relegated to inspection for cause. In the aerospace manufacturing sector for example this can be a significant cost savings, since inspection for flight hardware can often add as much as a 200% time overhead to the manufacturing process.

Conclusion

A systematic method for creating in-process quality assurance systems for welding has been presented, and specific applications to brazing, diffusion bonding, inertia welding, and GTAW have been discussed. This approach will lead to substantial cost savings by reducing or eliminating inspection operations or relegating them to inspection for cause. This information allows the manufacturing or product engineer to make fundamental quality improvements in welding, and is most applicable to small, precision lots that are characterized by high quality requirements, discontinuous operations, and high product diversity. Such manufacturing operations are commonplace in the aerospace and defense manufacturing sectors, among others.

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References