Minimizing Cost and Environmental Impact of Product Manufacture

Introduction

- There are many options for manufacturing a part. Process planners must choose among numerous manufacturing processes, machine tools, cutting tools and process parameters.
- How do you optimize for lowest cost and environmental impact?

Manufacturing Cost

<table>
<thead>
<tr>
<th>Process Planning Decisions</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.) Manufacturing Process</td>
<td>Workpiece Shape, Feature Tolerance, Surface Roughness</td>
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<tr>
<td>2.) Machine Tool</td>
<td>Workpiece Size, Feature Tolerance, Surface Roughness</td>
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<tr>
<td>3.) Cutting Tools &amp;</td>
<td>Feature Size, Feature Tolerance, Surface Roughness</td>
</tr>
<tr>
<td>Process Parameters</td>
<td></td>
</tr>
</tbody>
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Part’s Precedence Diagram

1. 2. 3. 4. 5.

Background and Project Objective

- Previous work has focused on process planning strategies for reduction of environmental impact.
- Process planning system [1]
- Environmental burden calculator of machining [2]
- Parts typically require a range of manufacturing processes, so available facility resources should be accounted for
- Project objective: minimize cost and environmental impact at the facility level

Facility Impacts

- Facility layout dictates the part’s transfer time between machine tools.
- Facility HVAC and lighting are non-negligible and can account for 40-65% of total use phase energy consumption for part production [3].

Minimizing Cost and Environmental Impact

- Objective = \( \text{min} [C_{\text{Total}}, E_{\text{Process}}, G_{\text{Process}}] \)
- Facility HVAC and lighting impacts will therefore be amortized by machine tool and workspace footprint, \( f \).

Advantages and Limitations of Method

- Advantages:
  - Simulation is less expensive than running test pieces.
  - Cost and environmental impact do not necessarily have to have the same weight; weighting factor is user-defined.
  - Specific energy model of a particular machine tool is used instead of aggregate machining data, so accuracy is increased.
  - Comprehensive with the inclusion of facility HVAC and lighting impacts, components that are significant yet often ignored.

- Limitations:
  - This project focuses on the macro-planning level, but cost and environmental impact improvements can also be made at the process level.