Powder bed fusion (PBF) is an additive manufacturing process used to 3D print metal parts. Thin layers of metal powder are spread across a flat build plate, where a laser melts them together into a desired shape. This process is repeated until a part is produced. The Lawrence Livermore National Laboratory carries two different machines that employ PBF: SLM and Concept Laser (CL).

The 2nd Generation Powder Spreading Machine (PSM) accurately replicates adaptations of the powder spreading processes of these two machines.

### Overview

The 2nd Generation PSM:
- Replicates PBF in SLM and Concept Laser
- Has a controllable autonomous system with an easy-to-use interface controlling various powder spreading parameters
- Is easy to operate with minimal set-up and clean-up

### Powder Spreading Processes

#### Concept Laser
1) Hopper chamber raises to expose powder stock
2) Build platform lowers
3) Blade sweeps across hopper chamber and build platform to create a fresh powder layer

#### SLM
1) Build plate lowers
2) Powder is deposited from above
3) Blade sweeps across the build plate
4) Process is repeated but in reverse direction

### Design Overview

The Design Overview includes the following components:

- **Overhead Hopper**
  - Dispenses powder into SLM Blade System
  - 6 flutes, each with enough volume for a 10 µm layer of powder

- **SLM Blade System**
  - Deposits powder on either side of blade, depending on spread direction
  - Swappable SLM and Concept Laser blades

- **Belt Drive**
  - Sweeps blade across build plate
  - Speeds up to 1.5m/s

- **Elevator**
  - Raises and lowers build plates and powder chamber
  - 25mm of travel, 10 µm accuracy

### Project Specifications

<table>
<thead>
<tr>
<th>System</th>
<th>Requirement</th>
<th>Specification</th>
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<tbody>
<tr>
<td><strong>General</strong></td>
<td>The machine shall have 2 parameter sets which mimic the motions of the CL and SLM Machines</td>
<td>• Blade speed, dose rate, layer height</td>
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<td>• Should be able to define number of layers</td>
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<td>• Manual positioning of stages and blade</td>
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<td><strong>Easy to use and clean</strong></td>
<td>For a given test:</td>
<td>• Set up shall take no longer than 10 minutes</td>
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<td>• Disassembly shall take no longer than 10 minutes</td>
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<td>• Powder clean up shall take no longer than 5 minutes</td>
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<tr>
<td><strong>Spreading Performance</strong></td>
<td>Machine shall spread powder in a unilateral method (Concept Laser)</td>
<td>• Blade shall remain perpendicular to build plate within .25 mm</td>
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<td>Machine shall spread powder in a bilateral method (SLM)</td>
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<td><strong>Blade Drive</strong></td>
<td>Linear Belt Drive System</td>
<td>• Spreading blade shall achieve speeds up to 300 mm/s</td>
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<td>• Spreading blade speed shall have capabilities to change speeds during travel with a defined ramp rate</td>
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<td><strong>Vertical Stages</strong></td>
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<td>• Accuracy: 10 µm</td>
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<td>• Uni-directional Repeatability: 10 µm</td>
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<td>• Minimum Step Size: 5 µm</td>
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### Results:

- Inspection of lines of powder dispensed from the Overhead Hopper showed a uniform distribution of powder along the full length of a flute
- Quantitative comparison of the theoretical and actual volume of powder dispensed from the Overhead Hopper showed an average powder loss of 0.909g/flute
- Qualitative observation of powder layers after spreading revealed flat layers, free from distortions for both processes

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