AM Machine Gas Flow Characterization & Improvement – Phase 3

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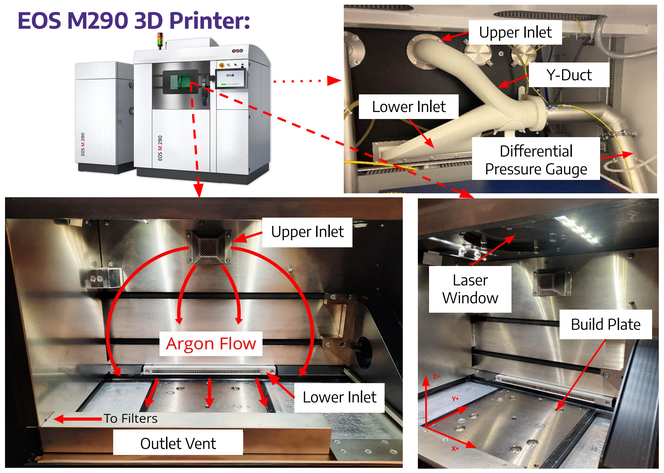
INTRODUCTION/MOTIVATION

PROBLEM STATEMENT: Boeing Additive Manufacturing needs a way to improve flow characteristics of the cyclic gas flow system within their EOS M290 Laser Powder Bed Fusion printers. Our team has been tasked with designing nozzles & other flow devices to improve the uniformity of flow within the build chamber and reduce dead zones and recirculation points.

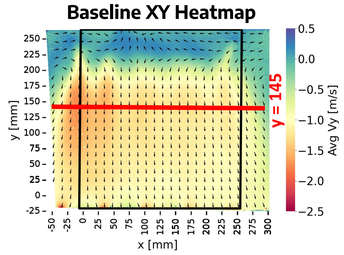
EOS M290 3D Printer:

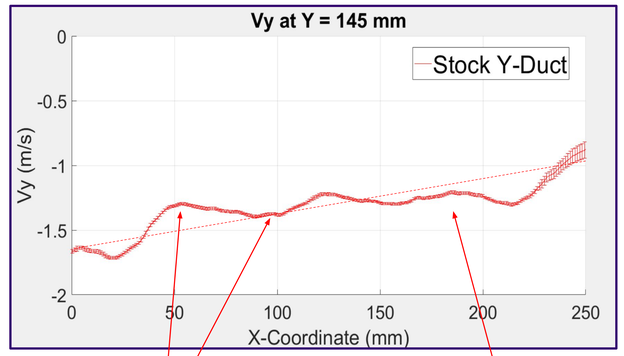


XY Plane Baseline Flow

XY Flow Context

Baseline XY Heatmap





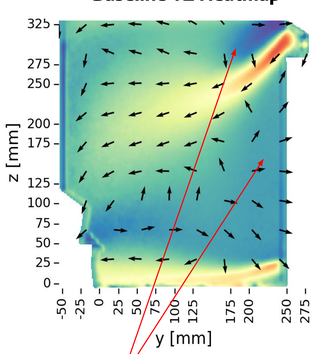
Flow Profile at Y = 145mm

Sinusoidal Behavior

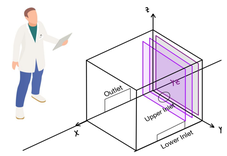
Velocity Gradient

YZ Plane Baseline Flow

Baseline YZ Heatmap



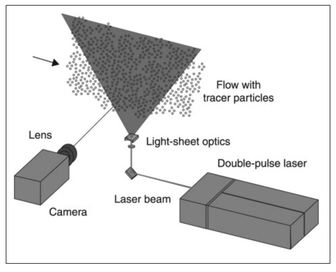
Dead Zones



TEST SETUP & PROTOTYPE EVALUATION

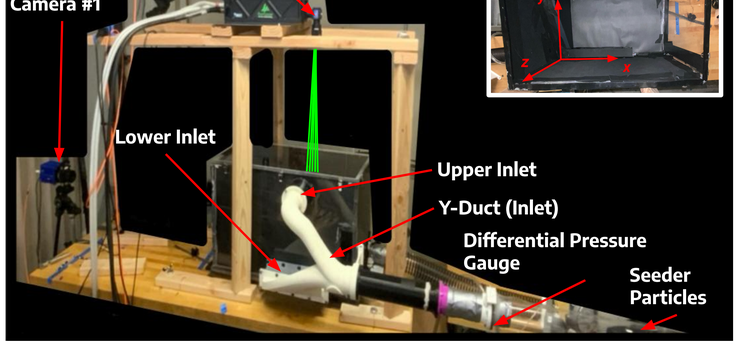
PIV Data Collection:

- The method we used to analyze the gas flow was particle image velocimetry (PIV).
- Using low-response time cameras in conjunction with laser-illuminated particles, PIV allowed us to map and evaluate the velocity distribution of the gas flow.
- Key parameters recorded were the velocity in x/y directions and vorticity.



Mock Build Chamber:

- To emulate the EOS M290 machine, we used two test set-ups to analyze gas flow in the XY and YZ planes within the build chamber.
- Analyzing each plane provided unique insight pertinent to different components of the system (lower/upper inlet, outlet), that was used to iterate on the existing stock designs.

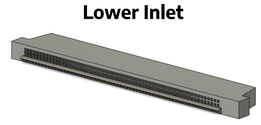


Prototypes:

- Created prototype nozzles and flow devices to "tune out" existing issues
- Focused on 4 primary areas: Upper/Lower inlets, outlets, and Y-duct
- Ran trials on multiple early phase prototypes in various PIV configurations to observe flow
- Iterated upon the most promising concepts

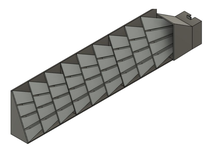
Prototype Examples:

Lower Inlet



Upper Inlet

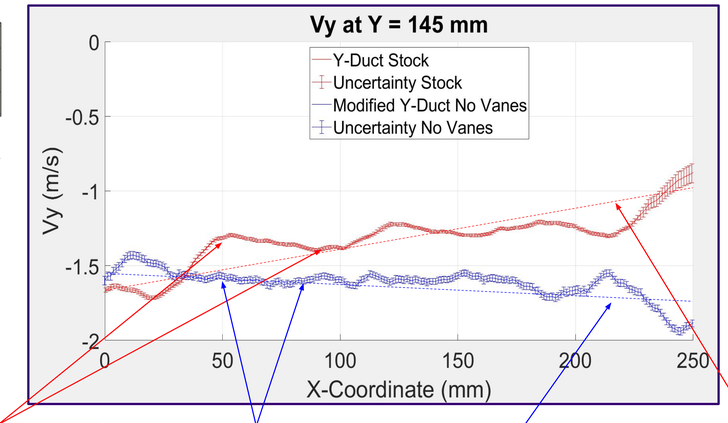
Outlet



Y-Duct

RESULTS & FUTURE WORK

XY Plane Improvements - Modified Y-Duct



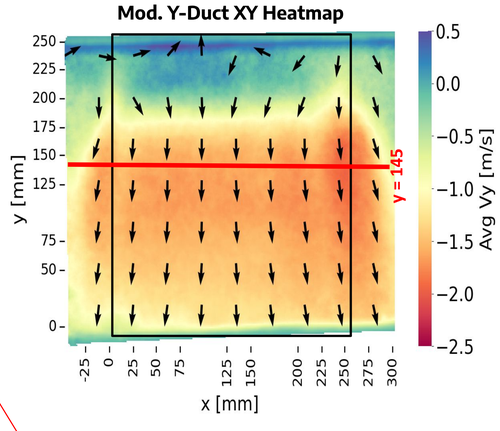
Sinusoidal Behavior

Sinusoidal Behavior Reduced

Velocity Gradient Reduced

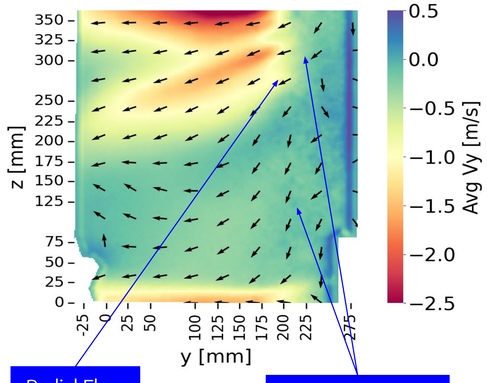
Velocity Gradient

Mod. Y-Duct XY Heatmap



YZ Plane Improvements - Mad Max Upper Inlet

Mad Max YZ Heatmap



Radial Flow

Deadzone Reduction

Future Work:

- Y-duct design expansion
  - Further exploration into Y-duct geometry changes
- Upper inlet / Outlet design iterations
  - Continuation of promising results seen this year
- Full scale machine implementation
  - Design modification to fit onto EOS M290
  - Material property testing of builds using baseline and modified flow systems

Mechanical Engineering Capstone Exposition
May 29th 2024, Husky Union Building, University of Washington, Seattle