Localized Laser Enclosure

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Abstract

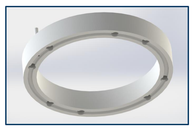
The group was tasked with creating a laser enclosure for laser marking on large objects that would otherwise not fit inside a typical laser enclosure. All aspects of the laser marking process had to be considered to ensure there were adequate safety measures in place. Many simulations were performed using finite element analysis and computational fluid dynamics software to validate the structural integrity and operation of the enclosure and all its components. As the prototype was constructed, various tests were conducted by the group to determine each of the safety measures worked as designed and would be able to operate correctly in a real-world application.

Customer Needs and Requirements

Customer needs:
The group must create an enclosure that safely contains a class 4 laser, evacuates harmful fumes and particulate, and is effectively modular in design.

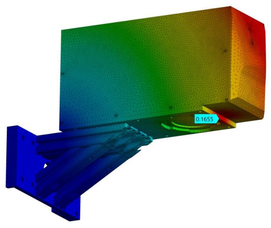
Customer requirements:
- 178 mm diameter minimum enclosure size
- Must contain at least two redundant safety interlocks
- Air within enclosure should be refreshed 30 timer per minute
- Must be able to filter particles 0.3 micron and larger
- Pressure seal must be capable of holding at least 1 psi

Concept Selection

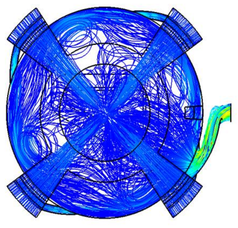




- Selected pneumatic actuator as method of vertical movement
- Selected a rigid, modular end effector 3-D printed for desired marking region
- Selected a Fumex system to remove and filter marking particulate and fumes
- Photodiode as a pre-firing check to ensure no light leakage from enclosure

Design Solution



Ansys Fluent and Workbench simulations were conducted to verify flow and structural integrity of components

1) Main enclosure with Quick Disconnect
2) Modular end effector
3) Rubber pressure seal with skirt for light protection

Manufacturing / Assembly

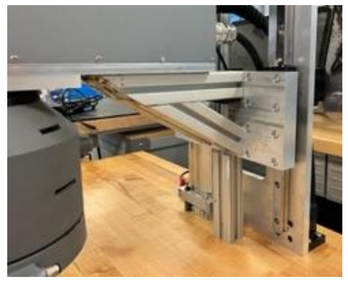
Controls

A Beckhoff embedded PC using a windows OS to give commands to and receives feedback from the system

Pneumatics


A valve bank was used to move the rod-less actuator as well as direct air into the pressure seal. A vacuum and filter removed particulate from the enclosure.

Z-actuation



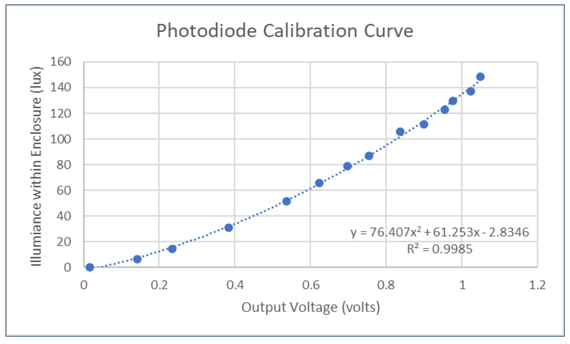
This subassembly is used to raise and lower the laser and the enclosure using a rod-less pneumatic actuator.

Laser Enclosure

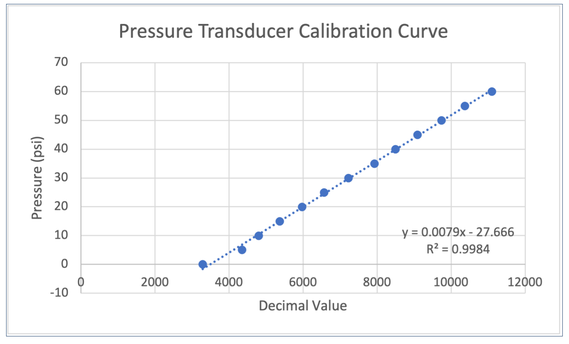

The enclosure and end effector was 3-D printed by Photon Automation with a Formlabs 3L printer and Tough 2000 Resin.

Testing and Validation

Photodiode Test
- Calibrated photodiode to measure change in light levels
- A difference of 50 Lux is read between enclosure up and down positions



Pressure Seal Test
- Generated calibration curves for transducers to convert decimal values output by the pc to psi values
- 1 psi = 3628.61 (decimal)



Software States
- Generated multiple states in which the program will walk through
- Start State: Raises head off table
- Sensor Check State: Checks for safe condition
- Marking State: Lowers head onto part, creates a seal, and waits for laser
- Shutdown State: Lowers head
- Error State: If sensors fail, stop everything

Due to an error with the embedded pc, no further testing was able to be conducted

Acknowledgments

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