Laser Machining Assist Gas Flow Characterization and Optimization

Sponsor: LASERDYNE SYSTEMS Division, PRIMA North America, Inc.
Sponsor's General Business Statement: "LASERDYNE SYSTEMS designs, manufactures, and markets multi-axis laser machines that incorporate C02 and Nd:YAG lasers on a worldwide basis for precision drilling, cutting, and welding of 3D parts. The company is the world's leading supplier of multi-axis laser systems for turbine engine (jet engine) applications."
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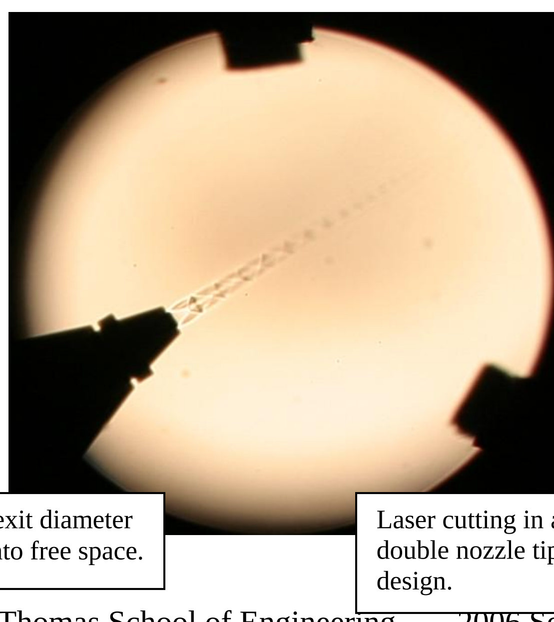
Senior Design Clinic I-II (ENGR 480-481) 2005-2006 Project Mission Statement: Characterize the flow through the existing laser machining gas assist system and investigate means to reduce gas consumption, through changes to the 7.5" focal length nozzle assembly, while maintaining or improving cut quality.

Major Design Requirements:

1. Characterize the flow through the existing laser machining gas assist system. This includes determining the pressure losses throughout the system and determining the mass flow rates through the system for various operating pressures and nozzle types and diameters.
2. Investigate means to reduce the gas consumption through changes to the 7.5" focal length nozzle assembly, while maintaining or improving cut quality.
3. Locate, select, and purchase various commercially available nozzle designs that may be used to reduce gas consumption, while maintaining or improving cut quality.
4. Analyze the performance of the new nozzle designs as well as LASERDYNE's existing designs through cutting trials, Schlieren visualization, and CFD simulation.

Senior Design Project Summary: The project was begun by performing experiments to characterize the flow through LASERDYNE's existing gas assist system. We successfully determined the mass flow rates through the system at various operating pressures, nozzle designs, and nozzle diameters. Additionally, we were able to compute an efficiency through comparing the mass flow rates of the actual system to that of an ideal system. Also, we performed pressure testing which indicated a total pressure drop of 22.5%, with only 1.5% over our area of influence, the nozzle assembly.

Given that we did not have to redesign the nozzle assembly to reduce pressure losses, our focus for improving the system was placed on determining nozzle designs that may deliver the gas to the cut more efficiently. Cold drawn and double nozzles were selected and purchased to compare their performance to LASERDYNE's existing standard nozzle designs. Nozzle flows were compared using Schlieren visualization techniques, which allow one to see the structure of the supersonic flow out of the nozzles. Additionally, we performed cutting trials, utilizing a full design of experiments, to analyze the performance of the different nozzle designs.



Schlieren image of a 3mm exit diameter cold form nozzle flowing into free space.

Laser cutting in action, using commercial double nozzle tip and nozzle adapter of our design.