SCS Laser Cutting Optimization

Optimization Test Locations

Trumpf, Inc. North America
Farmington, CT Laser Center

Bystronic North America
Hauppage, NY Laser Laboratory

OBJECTIVES

- Validate faster laser cutting speeds for SCS.
- Establish procedure for optimizing laser speed with acceptable cut quality for SCS.
- Document 'Best Practices' and assist gas considerations.

BACKGROUND

Tests of laser cutting SCS-processed steel have demonstrated higher cutting speeds than hot rolled black or HRPO of comparable thickness and hardness. These tests, conducted at both fabrication production shops and at development laboratories of laser cutting machine manufacturers (OEMs), have shown that "tuning" laser machine parameters is the key to achieving increases in cutting speeds for SCS-processed steel with no sacrifice of quality.

The wide variety of industrial laser machine designs, resonators, power levels, assist gasses, etc. makes impractical the development of a single set of parameters for setting up the laser machine to achieve maximum speed at acceptable cut quality. However, tests conducted have established a general set of "best practices" and a procedure that experienced laser technicians can follow to "tune" their particular laser cutting machines to achieve optimum performance when cutting SCS-processed steel. Those best practices and instructions are described below, along with comparative benchmarks of cutting speed from tests conducted at laser equipment OEM labs.

Best Practices for Preparing Industrial Lasers for Speed Optimization

1. Maintain the laser resonator as per the manufacturer's specifications.
2. Mode is controlled by resonator and optics. Use a qualified laser technician who can perform 'Mode Shot' for maximum performance.
3. Pierce Methods:
   a. Continuous Wave.
   b. Pulse allows operator to select or modify parameters.
   c. Controlled Pulse monitors cut, completes pierce, starts travel.
4. Steel Chemistry Specification:
   a. Carbon - .08% or less is optimum.
   b. Silicon - less is better.
5. Lens sizes for cutting hot rolled steel products on newer 4kw lasers:**
   a. 5.0 mm lens for material 1/8" and thinner.
   b. 7.5 mm lens for material thicker than 1/8".
6. Assist Gas Considerations:

Nitrogen	Oxygen	Shop Air
a. Will not cut material thicker than 12 ga. (4kw laser) to 11 ga (6kw laser).	*a. Oxide on edges of cut has to be removed prior to painting.*	*a. Leaves very hard oxide layer on cut edge; however, this has good paint adhesion and does not need to be removed.*
b. Will cut faster than Oxygen.	*b. For material 0.125" thick or less, expect a light finger dross on the bottom side of cut.*	*b. Large volume and high pressure required make it impractical for material thicker than 14 ga.*
c. Cuts will have slightly rougher edge.	*c. Requires lower pressure to operate.*	*c. Requires very clean, very dry air.*
d. No oxidation of cut edge. Edges can be painted w/o additional preparation.		
e. More costly to operate because more gas is used.		

7. Nozzle size selection depends on assist gas. Nozzle sizes below are for newer 4kw lasers:**
   a. For Nitrogen, use 0.8 to 1.0 mm nozzle for material 16 ga. to 12 ga. thick.
   b. For Oxygen, nozzle size should increase from 0.8 mm for 16 ga., to 1.0 mm for 1/8", to 1.2 mm for 1/2" material.
   c. For Shop Air, use 2.3 mm nozzle up to 14 ga.

** Optimum lens and nozzle size depend on laser power and design. Use your laser manufacturer's recommended settings for hot rolled steel as a starting point if they are notably different from the values listed here.

SCS Laser Cutting Optimization (continued):

SCS Laser Cutting Speed Optimization Procedure

1. Start with laser settings that have given the best performance for cutting similar material. If unclear what these settings should be, use the laser OEM's recommended settings as follows:
   - *for material thickness 0.250" or less, use settings for cold rolled steel (CRS).*
   - *for material thickness greater than 0.250", use settings for HRPO.*
2. Increase speed until cut quality decreases. Experience shows increasing speed in increments of 250 mm/min (10 in./min.) is an efficient way to reach this peak speed.
3. Adjust focus (up or down) to improve cut quality.
4. Adjust assist gas pressure (up or down) to improve cut quality.
5. Adjust power (typically increase, but may decrease) to improve cut quality.
6. Decrease frequency to improve cut quality.
7. If cut quality is now acceptable, ***go to Step 2 and repeat,*** or . . .
8. If speed appears to be maximized with acceptable cut quality, ***switch to next larger nozzle, go to Step 2 and repeat.***

COMPARATIVE BENCHMARKS

Bystronics, a leading manufacturer of laser cutting systems, ran SCS Laser Speed Optimization Tests to compare against their benchmark top speeds for cutting P&O in their Hauppage, New York laser lab. The table below presents the Bystronics P&O benchmark top speeds and the optimized SCS laser cutting speeds. Note that the assist gas for all cases was oxygen.

Sheet Thickness	Focal Length	Assist Gas Pressure	Laser Power	Nozzle Type	Optimized Nozzle Size - P&O	Maximum Cutting Speed - P&O	Optimized Nozzle Size - SCS	Maximum Cutting Speed - SCS
0.071”	5.0	60 psi	1400 watts	standard	1.0 mm	5600 mm/min	1.0 mm	6800 mm/min
0.071”	5.0	60 psi	1400 watts	standard	1.0 mm	5600 mm/min	1.2 mm	7000 mm/min
0.071”	5.0	45 psi	1400 watts	standard	1.0 mm	5600 mm/min	1.5 mm	7000 mm/min
0.125”	5.0	60 psi	1450 watts	standard	1.0 mm	3800 mm/min	1.2 mm	5000 mm/min
0.250”	7.5	7 psi	3500 watts	standard	1.2 mm	3100 mm/min	1.5 mm	3100 mm/min
0.250”	7.5	7 psi	3500 watts	NK[1]	1.2 mm	3100 mm/min	1.2 mm	3300 mm/min
0.250”	7.5	7 psi	3500 watts	NK[1]	1.2 mm	3100 mm/min	1.0 mm	3400 mm/min
0.250”	7.5	7 psi	3500 watts	NK[1]	1.2 mm	3100 mm/min	1.0 mm	3300 mm/min

[1] *special Bystronics tip - it has slits around the OD of the nozzle which puts a gas shield around the cut to keep contaminants out.*

SCS Laser Cutting Optimization (continued):

COMPARATIVE BENCHMARKS (continued)

Trumpf, a leading manufacturer of laser cutting systems, ran SCS Laser Speed Optimization Tests to compare SCS with hot rolled black (HRB), cold rolled (CRS) and P&O (HRPO) sheets. The tests, run at Trumpf's Farmington, CT laser lab, also included additional trials run only on SCS to examine sensitivities to different assist gases. The tables below presents the various trial results.

Cutting Speed vs. Thickness for HRB, CRS and SCS

Sheet Thickness	Assist Gas	Laser Power	Maximum Cutting Speed - HRB	Maximum Cutting Speed - CRS	Maximum Cutting Speed - SCS
4 gauge	Oxygen	4000 watts	60 in/min	65 in/min	70 in/min
7 gauge	Oxygen	4000 watts	85 in/min	110 in/min	100 in/min
10 gauge	Oxygen	4000 watts	150 in/min	160 in/min	200 in/min
12 gauge	Oxygen	4000 watts	170 in/min	205 in/min	200 in/min
14 gauge	Oxygen	4000 watts	220 in/min	250 in/min	320 in/min
14 gauge	Oxygen	6000 watts	-	-	450 in/min
14 gauge	Nitrogen	6000 watts	-	-	600 in/min

Cutting Speed Response to Assist Gas for SCS (4000 watt laser)

Sheet Thickness	Assist Gas	Assist Gas Pressure	Nozzle Diameter	Maximum Cutting Speed - SCS
14 gauge	Oxygen	1.0 X	1.0 mm	190 in/min
14 gauge	Nitrogen	1.5 X	0.8 mm	240 in/min
14 gauge	Shop Air	3.5 X	2.3 mm	350 in/min

Cutting Speed Comparison: SCS and HRPO (4000 watt laser)

Sheet Thickness	Assist Gas	Maximum Cutting Speed - HRPO	Maximum Cutting Speed - SCS
0.125 in.	Oxygen	165 in/min	180 in/min
0.125 in.	Nitrogen	165 in/min	180 in/min
0.125 in.	Oxygen	110 in/min	125 in/min