

# **FIBER LASERSTARTER OPERATION KIT**

IN THIS MANUAL, YOU WILL FIND THE BASIC OPERATION PARAMETERS FOR CUTTING AND TROUBLE SHOOTING WHICH WILL HELP IN YOUR DAY TO DAY MACHINE OPERATION. This will also assist in increasing your cut quality and efficiency during operation from 500W power source to the 8000W laser power source. Enjoy!

## **THE AUXILIARY GAS:**

Uses:

- Blowing away slag from cutting.
- Cool the metal and reduces the heated zone
- Cooling protective lenses to avoid damage and keep consumables for longer.
- To protect the metal, eg nitrogen protects stainless steel against oxidation

## **MOST COMMONLY USED GASES ARE OXYGEN, NITROGEN AND HIGH PRESSURE AIR:**

- **Oxygen:**
  - Mainly for cutting carbon steel as it also oxidises the material being cut when it reacts with the carbon.
  - It supports combustion and also blows away slag
  - Purity requirements are normally 99.5% or higher.
  - Pressure is required at 0.3-1MPa according to material thickness
- **Nitrogen:**
  - Mainly for stainless steel, Aluminium and Brass
  - It acts as a suppression gas, not easy to burn and generate slag because it aids in corrosion resistance.
  - It's needed in high pressure amounts, therefore can cut at high speeds.
  - It's the most expensive of the above mentioned gases and it's also needed in higher purity and quantity.
  - E.g. cutting stainless steel above 8mm will need 99.999% pure nitrogen with pressure requirements at about 1.5MPa- 2MPa for 12mm-25mm thicknesses
- **Compressed Air:**
  - More suitable for thin metal less than 6mm at 8000W.
  - Cheaper than all the above mentioned

## **1: MORE ABOUT COMPRESSED AIR CUTTING**

- More preferred for thin metals (3mm or less for 1000W and ~8mm for 8000W)
  - Brass
  - Steel
  - Galvanised metal
  - Aluminium

- The compressed air needs to dry so that it doesn't have water and oil which will damage the protective lens and laser head.
- The quality and quantity of the compressed air has a direct effect on the cutting results.

#### **Advantages:**

- Much cheaper than pure oxygen/ nitrogen.
  - Initial purchase cost may be higher, but in the long term operation, it will be much cheaper.
- Has a combination of ~20% oxygen and ~70% nitrogen, which makes it have a bit of the benefits of both gases in cutting.
- More readily available
- 

#### **Dis-advantages:**

- Cutting speeds much lower than with pure oxygen
- A lot more after-work to smoothen the material is needed after cutting
- Mainly for cutting thin metal pieces

#### **Air-Compressor Requirements:**

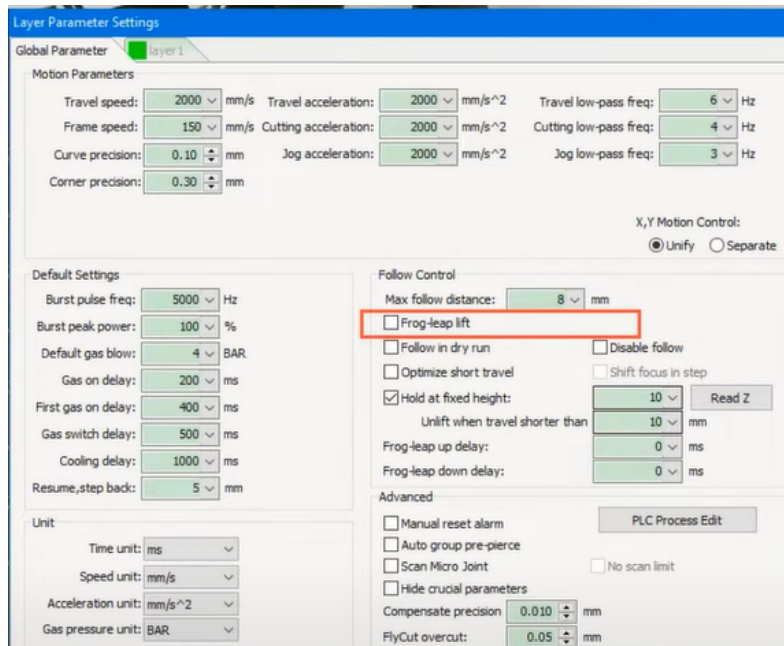
- Must have a good drying unit to reduce moisture.
- Dew point of the post treated air must be ~2-5 Degrees Celsius/ oil content  $\leq 0.001$ ppm/ Particulate content  $\leq 0.01$ micrometers
- Compressor should be returned to room temperature after drying.
- Piston air compressors are easier to obtain high pressure, but however too noisy, have more consumables and exhaust oil isn't well handled, so they aren't normally recommended for anything less than 1.6MPa
- For anything beyond 1.6MPa, use Screw compressors with select refrigeration dryers and precision filters.

#### **Compressor maintenance tips:**

- Drain the air filters daily and check if the auto-draining is properly functioning.
- Check voltage, current and oil levels for normalcy.
- Check for oil leaks inside the piping
- Radiators and air filters must be cleaned weekly to avoid high temperature and air filter blockages
- Clean the strainer and valve core monthly to avoid clogging

# FUNCTIONS TO ENHANCE LASER CUTTING EFFICIENCY/ SPEED

## 1: Frog leap function:

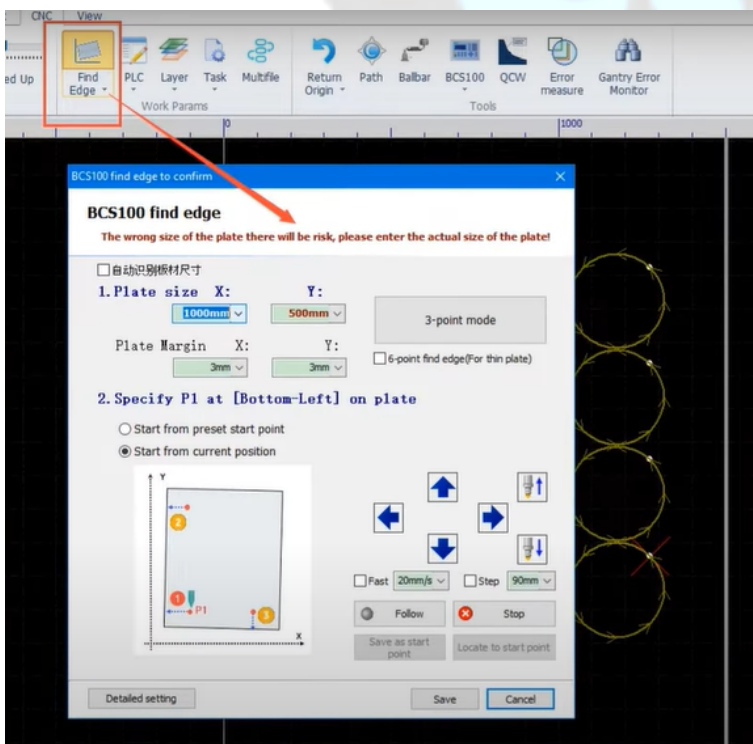


-to enable the cutting head to lift between cuts and move at the same time, allowing for multi-axis movement during cutting.

-this will reduce the total job time as well, since it won't to first lift the head, then move it to the next position, but will now be simultaneously doing the operations.

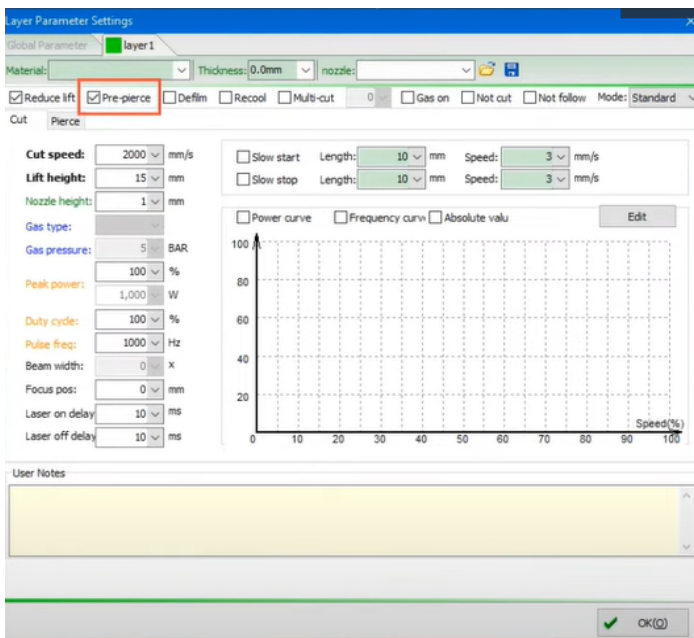
**2: Auto-Focus Function:** to reduce the time taken if having to refocus the laser every time the material thickness changes and it's no longer cutting well as before.

## 3: Edge Finding Function:



- Will allow for the laser head (using capacitance) to detect the material edges, hence find out if the material is skew or not and cut accordingly without us having to adjust the material and have to move heavy sheets.

#### 4: Concentrated perforation/ Pre-pierce

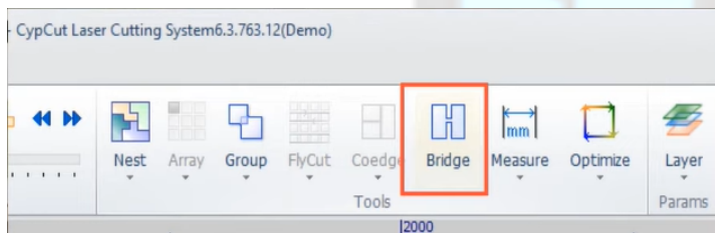


- Allows for the cutting process to first do all the perforation processes in advance and then go back to do the cutting process after.

- Remember that the focus distance for the perforation is normally a different speed in comparison to the cutting focal distance. So the nozzle will now first use one focal length to do all the perforations and finally change it to do the final cutting instead of constantly switching back and forth between the two during cutting.

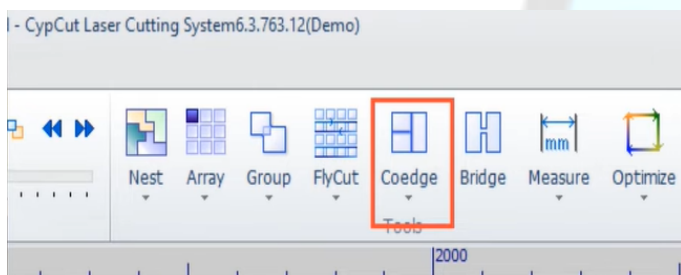
- This will almost half the total perforation and cutting time.

- Compressed air can be used for piercing and oxygen for cutting.



#### 5: Bridge Function

- to avoid the small cut out parts falling into the tray or tilting to damage the or collide with head



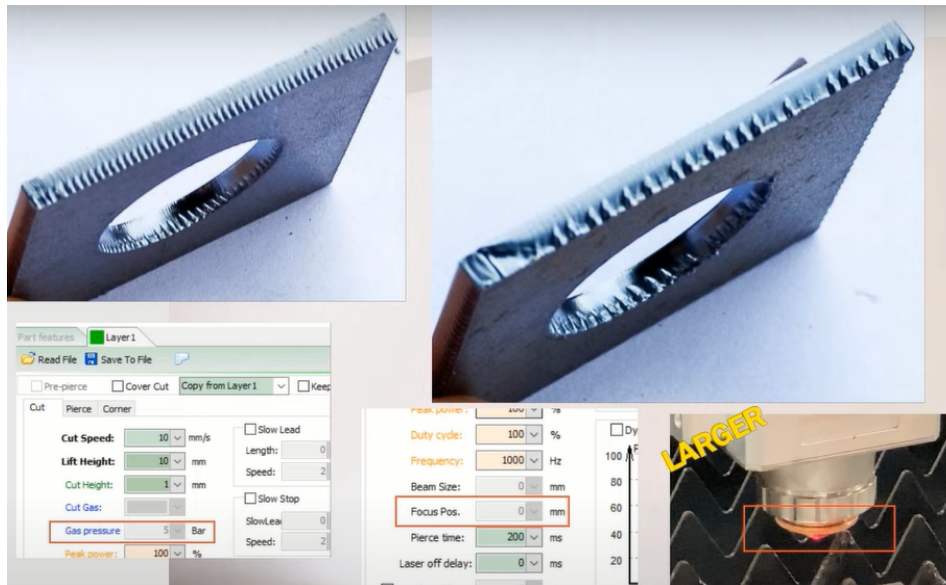
#### 6: CoEdge function:

- for combining the contours of adjacent parts if they are straight lines and have the same angle into one straight line.

- Only applicable if the distance between two edges is less than 0.1mm

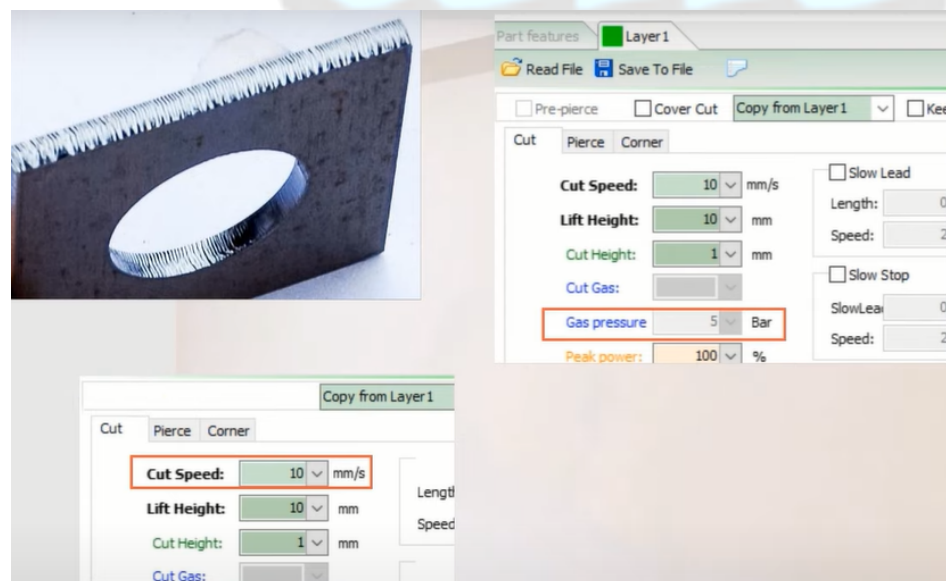
# POOR CUTTING AND REASONS:

## 1: CARBON STEEL:



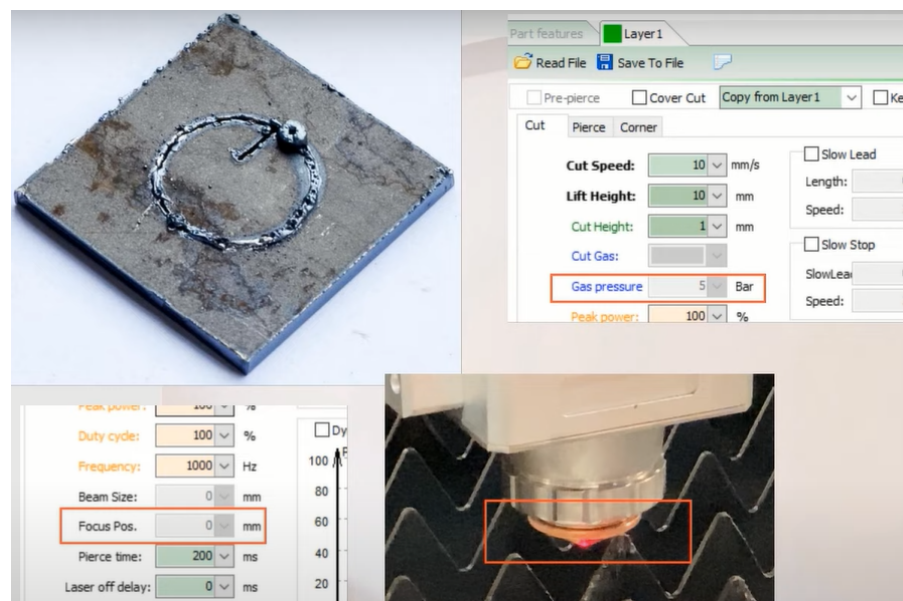
### **1: Jagged on the bottom.**

- The auxiliary gas pressure may be too much, so you can try reduce it.
- the nozzle may too large, you can use a smaller one
- increasing the focal length may also help



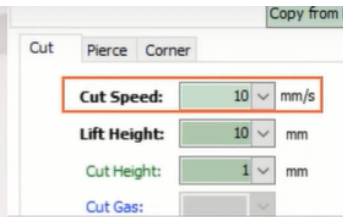
### **2: lines on the cutting surface:**

- Reduce the gas pressure
- increase the cutting speed



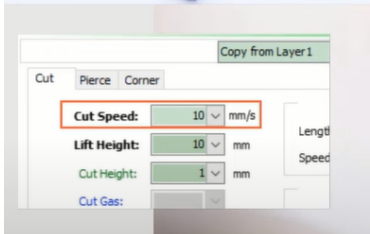
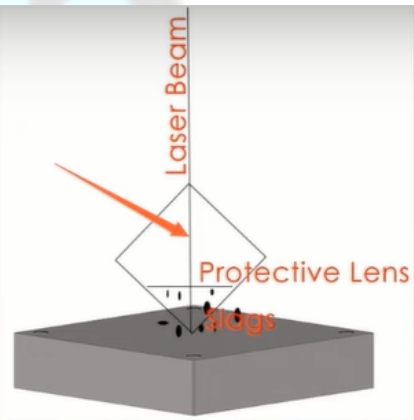
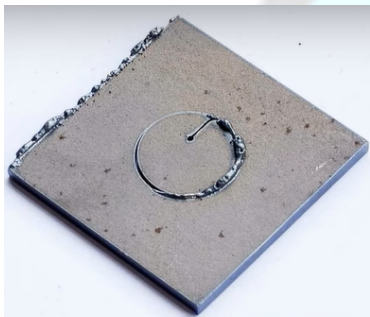
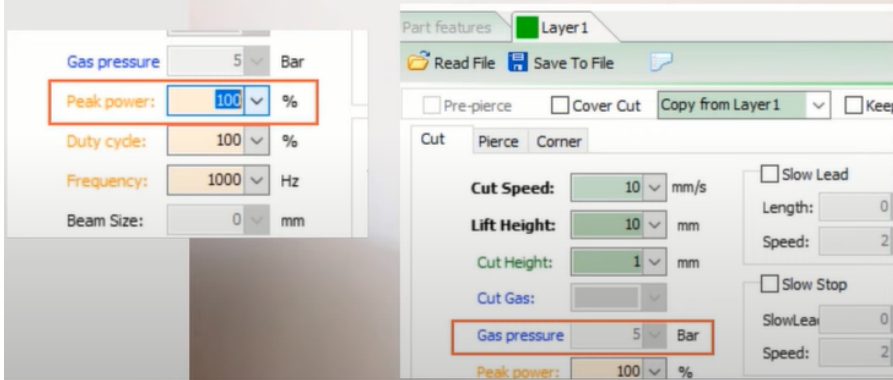
### **3: Too much slag and not cutting through:**

- reduce cutting speed
- increase nozzle size
- increase gas pressure



#### 4: Overburning

- Reduce peak power
- reduce gas pressure
- Increase cutting speed.



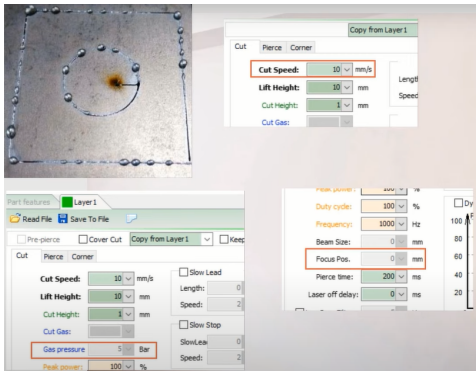
#### 5: Cutting well on one side and bad on the other.

- Reduce cutting speed
- Clean protective lens or change it
- The nozzle orifice may be blocked by particles, rather change the nozzle if that's the case
- Laser beam may be offset from the nozzle centre, you will need to align it.



#### 6: Small fine lines at the bottom:

- Increase cutting speed.

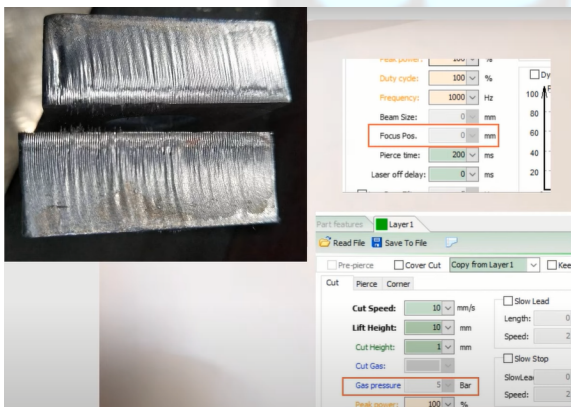


### 7: Metal residue on surface:

- Reduce the speed
- Increase the gas pressure
- Adjust the focus position.

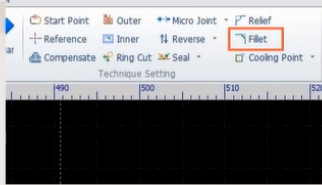


### 8: Reduce cutting speed



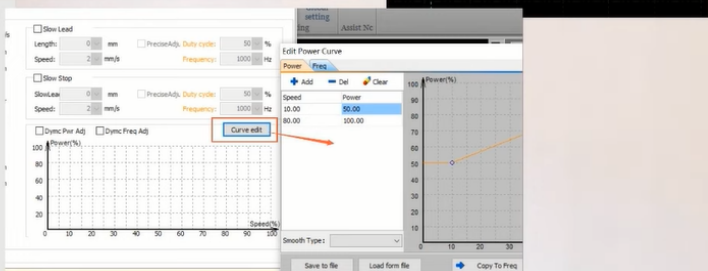
### 9: Bevelled cut and lines:

- Adjust focus position
- Reduce the gas pressure

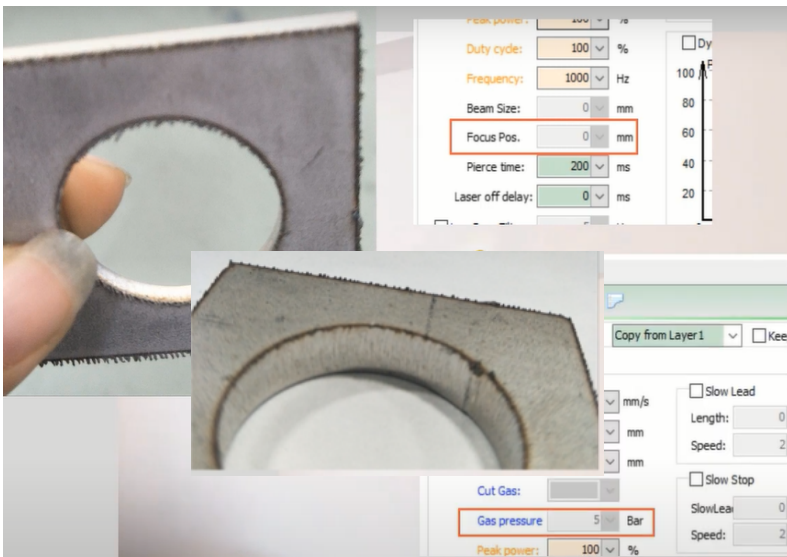


### 10: Overburn at the corner

- Normally the corner speed will be too much
- Use chamfers (fillet function) instead of corners if allowed.
- Use the ringcut function
- Use power curves to reduce speed on curves

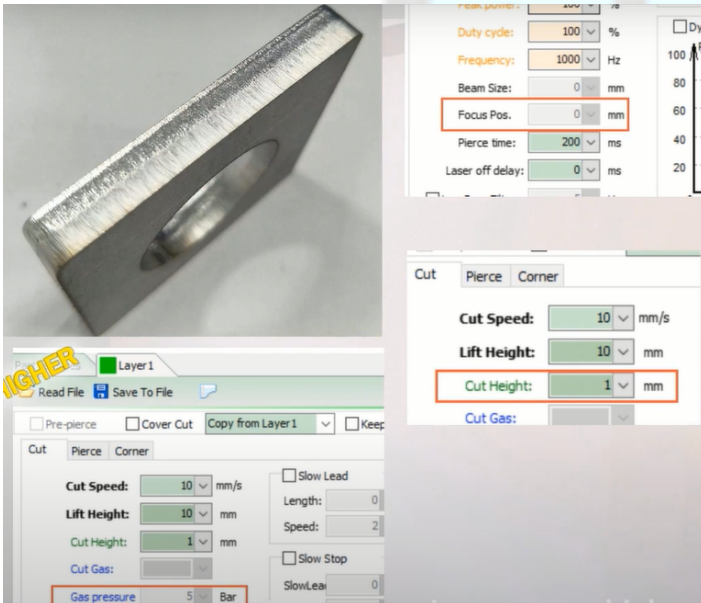


## STAINLESS STEEL:



### 1: Burr on underside:

- Increase focus position.
- Increase gas pressure.
- Reduce cutting speed



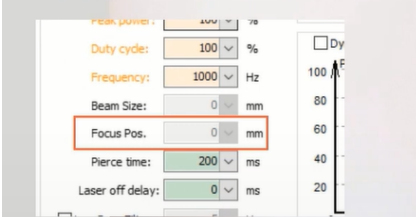
### 2: uneven cut surface:

- adjust focus position try to reduce
- reduce gas pressure
- raise nozzle height



### 3: burnt on the bottom end

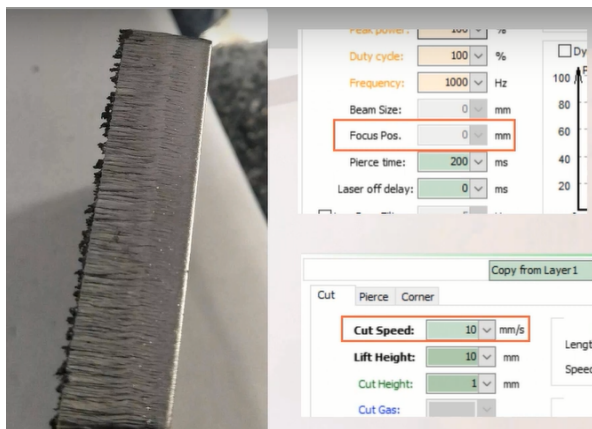
- lower focus position





#### 4: Wider and uneven cutting gap:

- Damaged/ dirty protective lens.
- Clean or replace it.



#### 5: Rough cutting edge

- Adjust speed
- Lower focus position



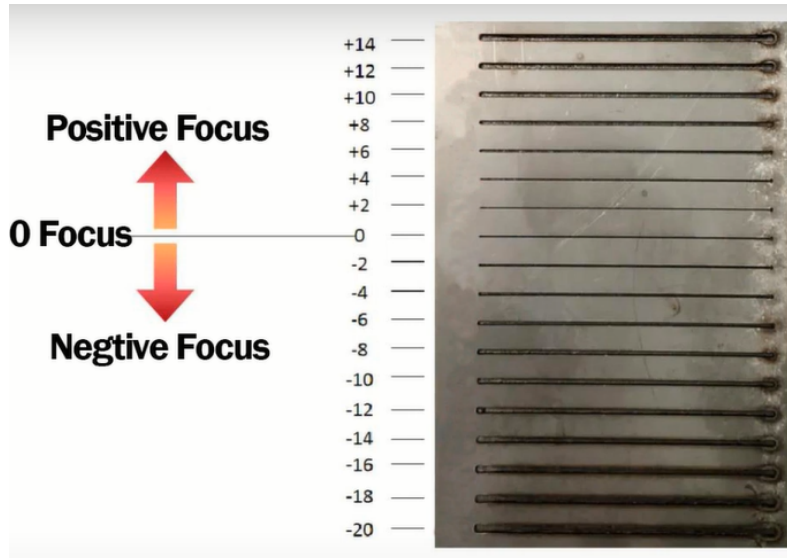
#### 6: Uneven colour on edges:

- Check nitrogen gas purity
- Check for any leakages into or out of the air pipes

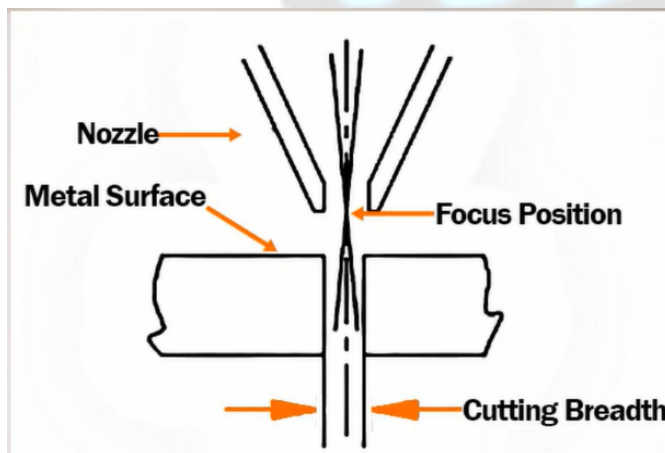
***NB: The parameters for stainless steel also apply to brass and aluminium alloy, but because of the higher reflection, you might want to lower the speed a bit on brass that is >3mm.***

## FOCUS POSITION SETTING:

This's one of the key parameters in laser cutting and directly affects the laser being able to cut through with good quality or not

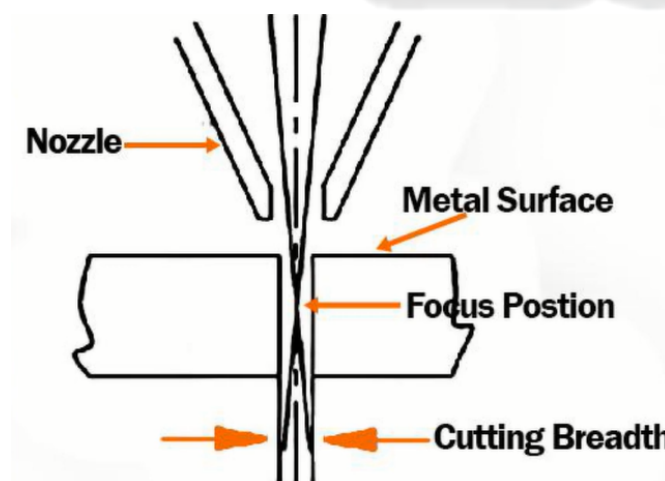


As you can see here, the more offset it's from the focus position, the wider the cutting gap and reduced cutting power.



### **POSITIVE FOCUS POSITION:**

- Used for cutting **carbon steel with oxygen.**
- Here the focus position is set on top of the material so that the heat can work hand in hand with oxidation to cut through the material.



### **NEGATIVE FOCUS POSITION:**

- Used for cutting stainless steel, brass, aluminium... with compressed air or nitrogen as auxiliary gas.
- The focus position is set inside the material.
- Normally all the Pierce values for focus position on any material should be negative so that the pierced hole can be as small as possible.

Cutting Model	Materials	Auxiliary Gas	Focus
Melting Cut	Stainless Steel	N <sup>2</sup> /Compressed Air	Negative
	Carbon Steel	N <sup>2</sup> /Compressed Air	Negative
	Aluminum/Brass	N <sup>2</sup> /Compressed Air	Negative
Oxidation Cut	Carbon Steel	O <sup>2</sup>	Positive
Pierce			Negative

**NB: ZERO FOCUS** just means that the focus position is on the material surface.

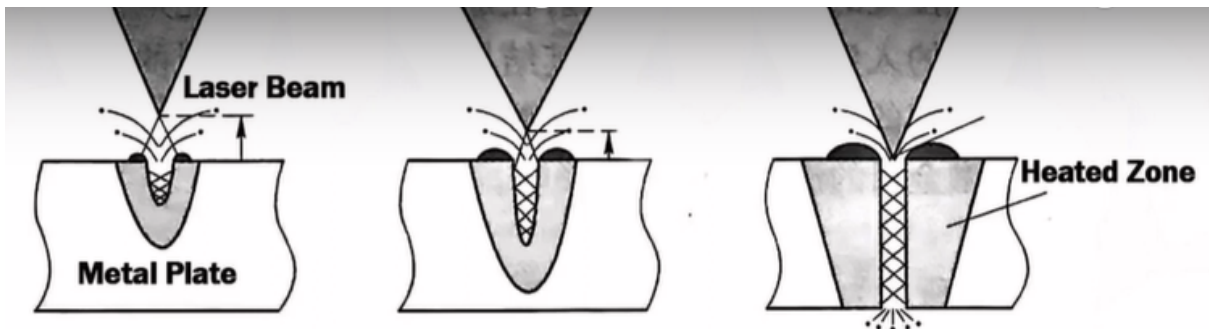
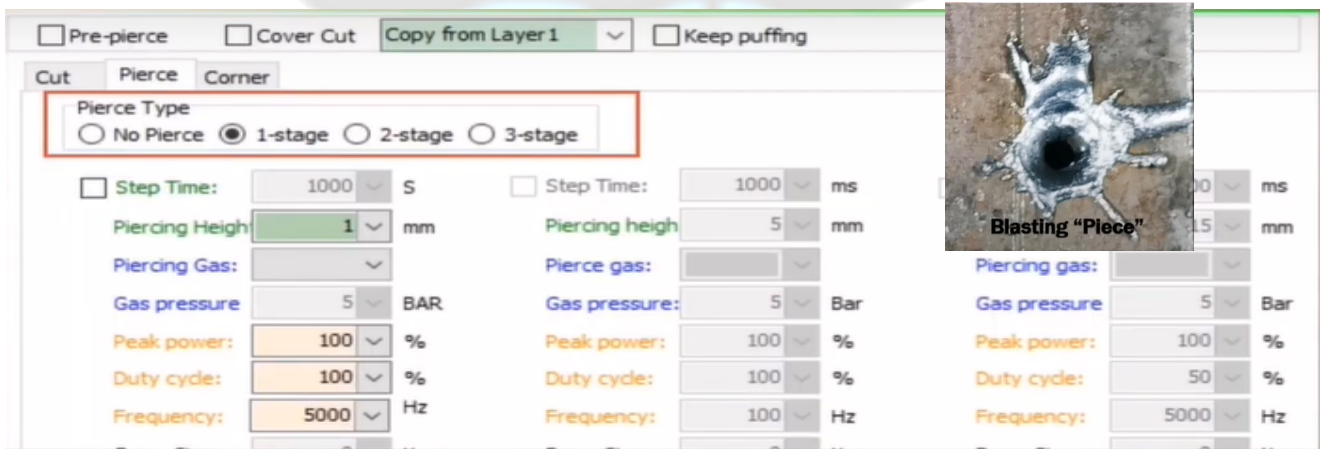
**PIERCE SETTINGS:**

Important hole cut through into the starting point of the material

1: Pre-pierce will help reduce over-burning as it will only cut after performing the function, thus giving the laser head sufficient time to cool before it starts the next piece on the job.

2: Nozzle height for pre-pierce should be higher than the cutting height

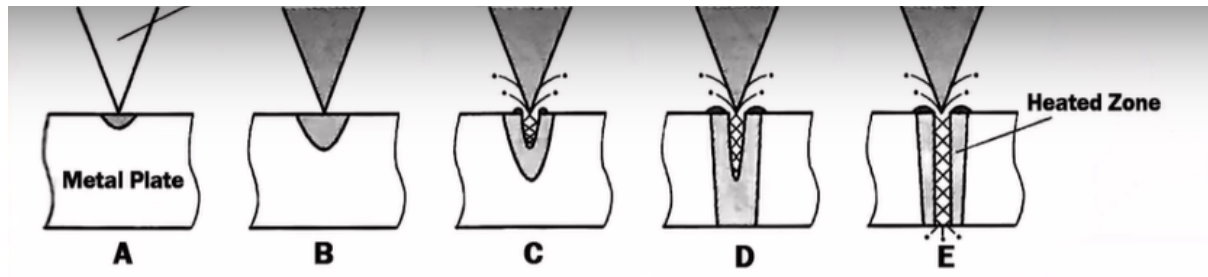
3: The total running time of the jobs is increased by the pre-pierce function as it has to do this before any new contour and also a lot of errors are prone to occur.



The above is a **blasting pierce** which is not in multiple stages and the results are normally like in the picture on the right. With the size of the hole being directly proportional to the metal thickness.

Because of the slag, this function is not required for machines with high accuracy requirements.

We also have **gradual-pierce** which uses a laser pulse with high peak power and a low duty cycle to melt and vaporise a small metal amount. This happens progressively until the sheet is perforated. The diagram is shown below:



This process takes a relatively longer time as compared to a blasting pierce but the results are however much cleaner. As shown in the picture on the right:

In actual cutting however, a combination of the two types of pierce will be used, especially in 3 stage piercing.



#### **HOW TO CHOOSE A SUITABLE PIERCE TYPE:**

- If the machine power is less than 3000W:
  - 6-12mm: 2-stage pierce with the first one being a blasting pierce and the second one, a gradual pierce.
  - >12mm: 3 stage pierce with the first as blasting pierce and the second and third as a gradual pierce (here we set the duty cycle <50)
- 6000W
  - 12-16mm: 2 stage pierce
  - >16mm: 3 stage pierce

***NOTE: There's a definite figure on what the value for pierce setting is, so a good practice is trial and error starting with no pierce to 3 stage.***

: Two- Three stage pierce is mostly used for cutting carbon steel with oxygen gas

: Normally, one stage pierce is good enough for cutting stainless steel, Aluminum, brass, etc.. using compressed air/ nitrogen gas.

#### **Reasons for bland and uncut through holes on blast pierce could be:**

1. High duty cycle
2. High Oxygen air pressure
3. High frequency
4. No stop blowing or the blowing time between multi-stage perforations is too short.

#### **How to increase perforation quality:**

1. Increase peak power
2. Lower the focus so that it's at the metal surface.
3. Change the oxygen pressure of the pierce to match the cutting one or just switch from oxygen to compressed air.
4. Increase the stop blowing time between multiple stage perforation.
5. To reduce the blowing pressure

	Peak Power	Duty Cycle	Frequency	Focus	Pressure	Blow Time
1	100%	80%	500kHz	-6mm	1 bar	200ms
2	100%	50%	500kHz	-6mm	1 bar	200ms



### FUNCTION OF PWM (Pulse Width Modulation) OR DUTY CYCLE:

- Used to control the analog circuit by using the microprocessor digital output
- Laser outputs mainly include continuous and pulse mode where the former emits laser continuously and the latter emits it at fixed intervals.
- Basically, for any fixed peak power, the duty cycle is directly proportional to the laser output power, i.e, if I have a 1000W laser supply at 100% peak power and 50% duty cycle, that means that my laser beam output power is 500W.

**NB:** From the next page you'll find basic cutting parameters that are good starting examples for first time users. Please be reminded that these are not rule of thumb in fiber laser operation but just basic guidelines which you are able to tweak as you see fit. The same applies for all the above information as well.

## **BASIC CUTTING PARAMETERS:**

### **1, 500W Cutting Parameters**

#### 1.1 QBH Single Module 500W 25µm Cutting Parameters (Collimation-75mm, Focus-125mm)

500W Laser Source(25µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	0.8	12	500	N <sub>2</sub>	12	1.5S	0	1
	2	3.5	500	O <sub>2</sub>	0.6	1.2D	+3	1
	3	2	500	O <sub>2</sub>	0.6	1.2D	+3	1
	4	1.5	500	O <sub>2</sub>	0.6	1.5D	+3	1
	5	1.0	500	O <sub>2</sub>	0.6	2.0D	+3	1
	6	0.8	500	O <sub>2</sub>	0.6	2.5D	+3	1
Stainless Steel	0.5	24	500	N <sub>2</sub>	12	1.5S	0	0.8
	1	12	500	N <sub>2</sub>	12	1.5S	0	0.5
	2	2.7	500	N <sub>2</sub>	12	2.0S	-1	0.5
	3	0.7	500	N <sub>2</sub>	14	2.0S	-1.5	0.5

Note: The red font parameters in the table are proofing parameters. They are greatly affected by various factors in actual processing. They are only suitable for small batch production. Large batch production is not recommended. It is recommended to use higher power lasers.

### **2, 1000W Cutting Parameters**

#### 2.1 Single Module 1000W Core-25µm Cutting Parameters (Collimation-100mm, Focus-125mm)

1000W Laser Source(25µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	0.8	18	1000	N <sub>2</sub>	10	1.5S	0	0.8
	1	10	1000	O <sub>2</sub>	10	1.2D	+3	0.8
	2	4	1000	O <sub>2</sub>	2	1.2D	+3	0.8
	3	3	1000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	4	2.3	1000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	5	1.8	1000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	6	1.5	1000	O <sub>2</sub>	0.6	1.5D	+3	0.8
	8	1.1	1000	O <sub>2</sub>	0.6	1.5D	+3	0.8
	10	0.8	1000	O <sub>2</sub>	0.6	2.5D	+3	0.8
Stainless Steel	0.8	20	1000	N <sub>2</sub>	12	1.5S	0	0.8
	1	13	1000	N <sub>2</sub>	12	1.5S	0	0.5
	2	6	1000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	3	1000	N <sub>2</sub>	12	3.0S	-1.5	0.5

	5	0.6	1000	N <sub>2</sub>	16	3.0S	-2.5	0.5
Aluminum	0.8	18	1000	N <sub>2</sub>	12	1.5S	0	0.8
	1	10	1000	N <sub>2</sub>	12	1.5S	0	0.5
	2	5	1000	N <sub>2</sub>	14	2.0S	-1	0.5
	3	1.5	1000	N <sub>2</sub>	16	3.0S	-1.5	0.5
Brass	1	9	1000	N <sub>2</sub>	12	2.0S	0	0.5
	2	2	1000	N <sub>2</sub>	14	2.0S	-1	0.5
	3	0.8	1000	N <sub>2</sub>	16	3.0S	-1.5	0.5

Note: The red font parameters in the table are proofing parameters. They are greatly affected by various factors in actual processing. They are only suitable for small batch production. Large batch production is not recommended. It is recommended to use higher power lasers.

## 2.2 Single Module 1000W Core-25μm Piercing Reference

1000W Laser Source(25μm)--10mm Carbon Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	1000	100	100	12	1	100	0	50ms
Media	1000	45	100	8	0.6	600	-4	50ms
Low	1000	40	100	4	0.6	2500	-5	

1000W Laser Source(25μm)--5mm Stainless Steel by N <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	1000	100	1000	12	10	100	0	0ms
Media	1000	50	1000	10	10	500	-5	0ms
Low	1000	45	1000	4	10	1000	-6	

The piercing parameters are taken as an example of the limit thickness of carbon steel / stainless steel that can be penetrated at the current power; the piercings are sorted in order, the highest is the first, and so on....

## 3, 1500W Cutting Parameters

### 3.1 Single Module 1500W Core-50μm Cutting Parameters (Collimation-100mm, Focus-125mm)

1500S Laser Source(50μm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	1	20	1500	N <sub>2</sub>	12	1.5S	0	0.8
	2	5	1500	O <sub>2</sub>	2	1.2D	+3	0.8
	3	3.6	1500	O <sub>2</sub>	0.6	1.2D	+3	0.8
	4	2.5	1500	O <sub>2</sub>	0.6	1.2D	+3	0.8
	5	1.8	1500	O <sub>2</sub>	0.6	1.2D	+3	0.8
	6	1.4	1500	O <sub>2</sub>	0.6	1.5D	+3	0.8
	8	1.2	1500	O <sub>2</sub>	0.6	1.5D	+3	0.8
	10	1	1500	O <sub>2</sub>	0.6	2.0D	+2.5	0.8
	12	0.8	1500	O <sub>2</sub>	0.6	2.5D	+2.5	0.8
	14	0.65	1500	O <sub>2</sub>	0.6	3.0D	+2.5	0.8
	16	0.5	1500	O <sub>2</sub>	0.6	3.0D	+2.5	0.8

Stainless Steel	1	20	1500	N <sub>2</sub>	10	1.5S	0	0.8
	2	7	1500	N <sub>2</sub>	12	2.0S	-1	0.5
	3	4.5	1500	N <sub>2</sub>	12	2.5S	-1.5	0.5
	5	1.5	1500	N <sub>2</sub>	14	3.0S	-2.5	0.5
	6	0.8	1500	N <sub>2</sub>	16	3.0S	-3	0.5
Aluminum	1	18	1500	N <sub>2</sub>	12	1.5S	0	0.5
	2	6	1500	N <sub>2</sub>	14	2.0S	-1	0.5
	3	2.5	1500	N <sub>2</sub>	14	2.5S	-1.5	0.5
	4	0.8	1500	N <sub>2</sub>	16	3.0S	-2	0.5
Brass	1	15	1500	N <sub>2</sub>	12	1.5S	0	0.5
	2	5	1500	N <sub>2</sub>	14	2.0S	-1	0.5
	3	1.8	1500	N <sub>2</sub>	14	2.5S	-1.5	0.5
	4	1	1500	N <sub>2</sub>	16	3.0S	-2	0.5

### 3.2 Single Module 1500W Core-50µm Piercing Reference

1500W Laser Source(50µm)--16mm Carbon Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	1500	100	100	12	1	100	0	50ms
Media	1500	45	100	8	0.6	600	-4	50ms
Low	1500	40	100	4	0.6	2500	-5	

1500W Laser Source(50µm)--6mm Stainless Steel by N <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	1500	100	1000	12	10	100	0	0ms
Media	1500	50	1000	8	10	500	-5	0ms
Low	1500	45	1000	4	10	1000	-6	

The piercing parameters are taken as an example of the limit thickness of carbon steel / stainless steel that can be penetrated at the current power; the piercings are sorted in order, the highest is the first, and so on....

## 4, 2000W Cutting Parameters

### 4.1 Single Module 2000W Core-50µm Cutting Parameters (Collimation-100mm, Focus-125mm)

2000S Laser Source(50µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	1	25	2000	N <sub>2</sub>	14	1.5S	0	0.8
	2	5.2	2000	O <sub>2</sub>	1.6	1.0D	+3	0.8
	3	4.2	2000	O <sub>2</sub>	0.6	1.0D	+3	0.8
	4	3	2000	O <sub>2</sub>	0.6	1.0D	+3	0.8
	5	2.2	2000	O <sub>2</sub>	0.6	1.2D	+3	0.8

	6	1.8	2000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	8	1.3	2000	O <sub>2</sub>	0.5	2.0D	+2.5	0.8



	10	1.1	2000	O <sub>2</sub>	0.5	2.0D	+2.5	0.8
	12	0.9	2000	O <sub>2</sub>	0.5	2.5D	+2.5	0.8
	14	0.8	2000	O <sub>2</sub>	0.5	3.0D	+2.5	0.8
	16	0.7	2000	O <sub>2</sub>	0.5	3.5D	+2.5	0.8
	18	0.5	2000	O <sub>2</sub>	0.6	4.0D	+3	0.8
	20	0.4	2000	O <sub>2</sub>	0.6	4.0D	+3	0.8
Stainless Steel	1	28	2000	N <sub>2</sub>	10	1.5S	0	0.8
	2	10	2000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	5	2000	N <sub>2</sub>	12	2.0S	-1.5	0.5
	4	3	2000	N <sub>2</sub>	14	2.5S	-2	0.5
	5	2	2000	N <sub>2</sub>	14	3.0S	-2.5	0.5
	6	1.5	2000	N <sub>2</sub>	14	3.0S	-3	0.5
	8	0.6	2000	N <sub>2</sub>	16	3.0S	-4	0.5
Aluminum	1	20	2000	N <sub>2</sub>	12	1.5S	0	0.8
	2	10	2000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	4	2000	N <sub>2</sub>	14	2.0S	-1.5	0.5
	4	1.5	2000	N <sub>2</sub>	14	2.5S	-2	0.5
	5	0.9	2000	N <sub>2</sub>	16	3.0S	-2.5	0.5
	6	0.6	2000	N <sub>2</sub>	16	3.0S	-3	0.5
Brass	1	18	2000	N <sub>2</sub>	12	1.5S	0	0.5
	2	8	2000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	3	2000	N <sub>2</sub>	14	2.5S	-1.5	0.5
	4	1.3	2000	N <sub>2</sub>	16	3.0S	-2	0.5
	5	0.8	2000	N <sub>2</sub>	16	3.0S	-2.5	0.5
	6	0.4	2000	N <sub>2</sub>	16	3.5S	-3	0.5

Note: The red font parameters in the table are proofing parameters. They are greatly affected by various factors in actual processing. They are only suitable for small batch production. Large batch production is not recommended. It is recommended to use higher power lasers.

#### 4.2 Single Module 2000W Core-50µm Piercing Reference

2000W Laser Source(50µm)--20mm Carbon Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off & Blowing
High	2000	100	200	12	1	200	0	200ms
Media	2000	45	150	8	0.7	400	-4	200ms

Low	2000	55	15	4	0.6	3000	-6	
-----	------	----	----	---	-----	------	----	--

2000W Laser Source(50µm)--8mm Stainless Steel by N <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	2000	100	1000	12	10	100	0	0ms
Media	2000	50	1000	8	10	500	-5	0ms

Low	2000	40	1000	4	10	1000	-6	
-----	------	----	------	---	----	------	----	--

### 5, 3000W Cutting Parameters

#### 5.1 Multi-module 3000W Core-100µm Cutting Parameters(Collimation-100mm, Focus-150mm)

3000W Laser Source(100µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	1	30	3300	N <sub>2</sub>	12	1.5S	0	0.8
	1	10	1500	O <sub>2</sub>	10	1.5S		0.8
	2	5.2	1800	O <sub>2</sub>	1.6	1.2D	+3	0.8
	3	4.5	1800	O <sub>2</sub>	0.6	1.2D	+3	0.8
	4	3.6	2400	O <sub>2</sub>	0.6	1.2D	+3	0.8
	5	3.2	2400	O <sub>2</sub>	0.6	1.2D	+3	0.8
	6	2.6	3000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	8	2.2	3000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	10	1.1-1.3	1800-2200	O <sub>2</sub>	0.5	3.0D	+2.5	0.8
	12	0.9-1.1	1800-2200	O <sub>2</sub>	0.5	3.5D	+2.5	0.8
	14	0.8-0.9	2200-3000	O <sub>2</sub>	0.5	3.5D	+2.5	0.8
	16	0.7-0.8	2200-3000	O <sub>2</sub>	0.5	4.0D	+2.5	0.8
	18	0.65-0.7	2200-3000	O <sub>2</sub>	0.5	4.0D	+2.5	0.8
	20	0.55-0.6	2200-3000	O <sub>2</sub>	0.6	4.0D	+3	0.8
	22	0.5-0.55	2200-3000	O <sub>2</sub>	0.6	4.0D	+3	0.8
Stainless Steel	1	35	3000	N <sub>2</sub>	10	1.5S	0	0.8
	2	13	3000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	7	3000	N <sub>2</sub>	12	2.5S	-1.5	0.5
	4	5	3000	N <sub>2</sub>	14	2.5S	-2	0.5
	5	4	3000	N <sub>2</sub>	14	2.5S	-2.5	0.5
	6	3	3000	N <sub>2</sub>	14	3.0S	-3	0.5
	8	1.2	3000	N <sub>2</sub>	16	3.5S	-4	0.5
	10	0.8	3000	N <sub>2</sub>	16	4.0S	-5	0.5
Aluminum	1	25	3000	N <sub>2</sub>	12	1.5S	0	0.8
	2	15	3000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	8	3000	N <sub>2</sub>	14	2.0S	-1.5	0.5
	4	5	3000	N <sub>2</sub>	14	2.0S	-2	0.5
	5	3	3000	N <sub>2</sub>	16	3.0S	-2.5	0.5

	6	2	3000	N <sub>2</sub>	16	3.5S	-3	0.5
	8	0.8	3000	N <sub>2</sub>	16	3.0S	-4	0.5
Brass	1	22	3000	N <sub>2</sub>	12	1.5S	0	0.5
	2	12	3000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	5	3000	N <sub>2</sub>	14	2.5S	-1.5	0.5
	4	3	3000	N <sub>2</sub>	14	3.0S	-2	0.5

	5	2	3000	N <sub>2</sub>	14	3.0S	-2.5	0.5
	6	1.3	3000	N <sub>2</sub>	16	3.0S	-3	0.5
	8	0.6	3000	N <sub>2</sub>	16	4.0S	-4	0.5

Note 1: When taking oxygen for cutting 1mm carbon steel , because oxygen is a gas of combustion-supporting, during high-speed operation, it is easy to generate slag and difficult to remove, resulting in speed cannot be improved, so adjust the power to a range that can match the current speed.

Note 2: The power used for commissioning and the speed of commissioning will be different according to the gas purity and the quality of the board.

## 6, 4000W Cutting Parameters

### 6.1 Multi-module 4000W Core-100µm Cutting Parameters (Collimation-100mm, Focus-150mm)

4000W Laser Source(100µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	1	35	4000	N <sub>2</sub>	12	1.5S	0	1
	1	10	1500	O <sub>2</sub>	10	1.5S	+3	0.8
	2	5.2	1800	O <sub>2</sub>	1.6	1.2D	+3	0.8
	3	4.5	1800	O <sub>2</sub>	0.6	1.2D	+3	0.8
	4	3.5	2400	O <sub>2</sub>	0.6	1.2D	+3	0.8
	5	3.2	2400	O <sub>2</sub>	0.6	1.2D	+3	0.8
	6	2.8	3000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	8	2.3	3600	O <sub>2</sub>	0.6	1.2D	+3	0.8
	10	2	4000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	12	1.2	1800-2200	O <sub>2</sub>	0.5	3.0D	+3	0.8
	14	1	1800-2200	O <sub>2</sub>	0.5	3.5D	+3	0.8
16	0.8	2200-2600	O <sub>2</sub>	0.5	3.5D	+3	0.8	

	18	0.7	2200-2600	O <sub>2</sub>	0.5	4.0D	+3	0.8	
	20	0.65	2200-2600	O <sub>2</sub>	0.5	4.0D	+3	0.8	
	22	0.6	2200-2800	O <sub>2</sub>	0.5	4.5D	+3	0.8	
	25	0.5	2400-3000	O <sub>2</sub>	0.5	5.0D	+3	0.8	
Stainless Steel	1	40	4000	N <sub>2</sub>	10	1.5S	0	0.8	
	2	20	4000	N <sub>2</sub>	12	2.0S	-1	0.5	
	3	12	4000	N <sub>2</sub>	12	2.0S	-1.5	0.5	
	4	7	4000	N <sub>2</sub>	12	2.5S	-2	0.5	
	5	4.5	4000	N <sub>2</sub>	14	2.5S	-2.5	0.5	
	6	3.5	4000	N <sub>2</sub>	14	3.0S	-3	0.5	
	8	1.8	4000	N <sub>2</sub>	14	3.0S	-4	0.5	
	10	1.2	4000	N <sub>2</sub>	16	4.0S	-5	0.5	
	12	0.8	4000	N <sub>2</sub>	16	4.0S	-6	0.5	
Aluminum	1	30	4000	N <sub>2</sub>	12	1.5S	0	0.6	
	2	20	4000	N <sub>2</sub>	12	2.0S	-1	0.5	
	3	13	4000	N <sub>2</sub>	14	2.0S	-1.5	0.5	
	4	7	4000	N <sub>2</sub>	14	2.5S	-2	0.5	
	5	5	4000	N <sub>2</sub>	14	2.5S	-2.5	0.5	
	6	3	4000	N <sub>2</sub>	16	3.0S	-3	0.5	
	8	1.3	4000	N <sub>2</sub>	16	3.0S	-4	0.5	
	10	0.8	4000	N <sub>2</sub>	16	3.5S	-5	0.5	
	Brass	1	28	4000	N <sub>2</sub>	12	1.5S	0	0.6
		2	15	4000	N <sub>2</sub>	12	1.5S	-1	0.6
3		8	4000	N <sub>2</sub>	14	2.0S	-1	0.6	
4		5	4000	N <sub>2</sub>	14	2.5S	-2	0.5	
5		3	4000	N <sub>2</sub>	14	3.0S	-2	0.5	
6		2.5	4000	N <sub>2</sub>	16	3.0S	-2.5	0.5	
8		1	4000	N <sub>2</sub>	16	3.0S	-4	0.5	
10		0.6	4000	N <sub>2</sub>	16	3.5S	-5	0.5	

### 6.2 Multi-module 4000W Core-100µm Piercing Reference

4000W Laser Source(100µm)--25mm Carbon Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	4000	100	200	12	1	100	0	300ms
Media	4000	45	200	8	0.6	200	-5	300ms

Low	4000	50	200	4	0.6	3000	-6	
-----	------	----	-----	---	-----	------	----	--

4000 Laser Source(100µm)--12mm Stainless Steel by N <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	4000	100	1000	12	10	100	0	0ms
Media	4000	50	1000	8	10	500	-6	0ms
Low	4000	45	1000	4	10	1500	-8	

The piercing parameters are taken as an example of the limit thickness of carbon steel / stainless steel that can be penetrated at the current power; the piercings are sorted in order, the highest is the first, and so on....

## 7, 6000W Cutting Parameters

### 7.1 Multi-module 6000W Core-100µm Cutting Parameters(Collimation-100mm, Focus-150mm)

6000W Laser Source(100µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	1	10	1500	O <sub>2</sub>	10	1.5S	+3	0.8
	2	5-5.5	1800	O <sub>2</sub>	2	1.2D	+3	0.8
	3	3.6-4.2	2400	O <sub>2</sub>	0.6	1.2D	+3	0.8
	4	3.3-3.8	2400	O <sub>2</sub>	0.6	1.2D	+3	0.8
	5	3-3.6	3000	O <sub>2</sub>	0.6	1.2D	+3	0.8
	6	2.7-3.2	3300	O <sub>2</sub>	0.6	1.2D	+3	0.8
	8	2.2-2.5	4200	O <sub>2</sub>	0.6	1.2D	+3	0.8
	10	2.0-2.3	5500	O <sub>2</sub>	0.6	1.2D	+4	0.8
	12	0.9-1	2200	O <sub>2</sub>	0.6	3.0D	+2.5	0.8
	12	1.9-2.0	6000	O <sub>2</sub>	0.6	1.2D	+5	0.8
	14	0.8-0.9	2200	O <sub>2</sub>	0.6	3.5D	+2.5	0.8
	14	1.4-1.7	6000	O <sub>2</sub>	0.6	1.4D	+5	1
	16	0.8-0.9	2200	O <sub>2</sub>	0.6	4.0D	+2.5	0.8
	16	1.2-1.4	6000	O <sub>2</sub>	0.6	1.4D	+6	1
	18	0.65-0.75	2200	O <sub>2</sub>	0.6	4.0D	+2.5	0.8
	20	0.6-0.7	2400	O <sub>2</sub>	0.6	4.0D	+3	0.8
	22	0.55-0.65	2400	O <sub>2</sub>	0.6	4.0D	+3	0.8
	25	0.5	2400	O <sub>2</sub>	0.5	5.0D	+3	1
Carbon Steel	1	45	6000	N <sub>2</sub>	12	1.5S	0	0.8
	2	25	6000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	14	6000	N <sub>2</sub>	14	2.0S	-1.5	0.5
	4	8	6000	N <sub>2</sub>	14	2.0S	-2	0.5
	5	6.4	6000	N <sub>2</sub>	16	3.0S	-2.5	0.5
	6	5	6000	N <sub>2</sub>	16	3.5S	-3	0.5
Carbon Steel	1	40	6000	Air	10	1.5S	0	0.8
	2	28	6000	Air	10	1.5S	-1	0.5
	3	18	6000	Air	10	1.5S	-1.5	0.5
	4	13	6000	Air	12	1.5S	-2	0.5
	5	9	6000	Air	12	1.5S	-2.5	0.5

	6	6	6000	Air	12	1.5S	-3	0.5
Stainless Steel	1	60	6000	N <sub>2</sub>	10	1.5S	0	0.8
	2	30	6000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	18	6000	N <sub>2</sub>	12	2.5S	-1.5	0.5
	4	12	6000	N <sub>2</sub>	14	2.5S	-2	0.5
	5	8	6000	N <sub>2</sub>	14	3.0S	-2.5	0.5
	6	5	6000	N <sub>2</sub>	15	3.0S	-3	0.5
	8	3.8	6000	N <sub>2</sub>	15	3.0S	-4	0.5
	10	2	6000	N <sub>2</sub>	15	3.5S	-6	0.5
	12	1.2	6000	N <sub>2</sub>	16	3.5S	-7.5	0.5
	14	1	6000	N <sub>2</sub>	16	4.0S	-9	0.5
	16	0.6	6000	N <sub>2</sub>	18	4.0S	-10.5	0.5
	18	0.5	6000	N <sub>2</sub>	20	5.0S	-11	0.3
20	0.3	6000	N <sub>2</sub>	20	5.0S	-12	0.3	
Aluminum Alloy	1	50	6000	N <sub>2</sub>	12	1.5S	0	0.8
	2	25	6000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	16	6000	N <sub>2</sub>	14	2.5S	-1.5	0.5
	4	10	6000	N <sub>2</sub>	14	2.5S	-2	0.5
	5	6	6000	N <sub>2</sub>	14	3.0S	-3	0.5
	6	4	6000	N <sub>2</sub>	16	3.0S	-3	0.5
	8	2	6000	N <sub>2</sub>	16	3.0S	-4	0.5
	10	1.2	6000	N <sub>2</sub>	18	3.5S	-4.5	0.5
	12	0.7	6000	N <sub>2</sub>	18	4.0S	-5	0.5
	14	0.5	6000	N <sub>2</sub>	18	4.0S	-5	0.3
16	0.4	6000	N <sub>2</sub>	20	5.0S	-8	0.3	
Brass	1	40	6000	N <sub>2</sub>	12	1.5S	0	0.8
	2	20	6000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	14	6000	N <sub>2</sub>	14	2.5S	-1	0.5
	4	9	6000	N <sub>2</sub>	14	3.0S	-1.5	0.5
	5	5.5	6000	N <sub>2</sub>	14	3.0S	-2	0.5
	6	3.8	6000	N <sub>2</sub>	16	3.0S	-2.5	0.5
	8	1.8	6000	N <sub>2</sub>	16	3.5S	-3	0.5
	10	1	6000	N <sub>2</sub>	16	3.5S	-3	0.5

## 8, 8000W Cutting Parameters

### 8.1 Multi-module 8000W Core-100µm Cutting Parameters(Collimation-100mm, Focus-200mm)

8000W Laser Source(100µm)								
Material	Thickness (mm)	Speed (m/min)	Power (W)	Gas	Pressure (bar)	Nozzle	Focus (mm)	Height (mm)
Carbon Steel	1	40-45	8000	Air	10	1.5S	0	1
	2	30-35	8000	Air	12	2.0S	0	0.5
	3	20-25	8000	Air	13	2.0S	-1	0.5
	4	15-18	8000	Air	13	2.5S	-1.5	0.5
	5	10-12	8000	Air	13	2.5S	-2	0.5
	6	8-9	8000	Air	13	2.5S	-2	0.5
	8	5-5.5	8000	Air	13	3.0S	-3	0.5
	10	2.3	6500	O <sub>2</sub>	0.6	1.2D	+6	1
	12	2	7500	O <sub>2</sub>	0.6	1.2D	+7	1
	14	1.8	8000	O <sub>2</sub>	0.6	1.4D	+8	1
	16	1.6	8000	O <sub>2</sub>	0.6	1.4D	+9	0.8
	20	1.3	8000	O <sub>2</sub>	0.6	1.6D	+9	0.8
	22	0.65	8000	O <sub>2</sub>	0.7	1.8D	+9	0.8
		25	0.45	8000	O <sub>2</sub>	0.7	1.8D	+10
	30	0.25	8000	O <sub>2</sub>	1.3	1.8D	+11	1.2
	40	0.18	8000	O <sub>2</sub>	1.5	1.8D	+11.5	1.2
Stainless Steel	1	60	8000	N <sub>2</sub>	10	2.0S	0	1
	2	35	8000	N <sub>2</sub>	12	2.0S	0	0.5
	3	24	8000	N <sub>2</sub>	13	2.0S	0	0.5
	4	15	8000	N <sub>2</sub>	12	2.0S	-1	0.5
	5	10	8000	N <sub>2</sub>	15	2.5S	-1	0.5
	6	8	8000	N <sub>2</sub>	8	3.5S	-2	0.5
	8	5	8000	N <sub>2</sub>	7	5.0S	-2	0.5
	10	3.5	8000	N <sub>2</sub>	6	5.0S	-3	0.5
	12	2.5	8000	N <sub>2</sub>	6	6.0S	-4	0.5
	14	2	8000	N <sub>2</sub>	6	7.0S	-6	0.3
	16	1	8000	N <sub>2</sub>	6	7.0S	-8	0.3
	18	1.5	8000	N <sub>2</sub>	14	5.0S	-9	0.5

	20	0.8	8000	N <sub>2</sub>	6	7.0S	-11	0.3
	25	0.4	8000	N <sub>2</sub>	6	7.0S	-13	0.3
	30	0.22	8000	N <sub>2</sub>	10	5.0S	+7	0.3
	40	0.15	8000	N <sub>2</sub>	15	7.0S	+8	0.3
Stainless Steel	1	60	8000	Air	10	2.0S	0	1
	2	35	8000	Air	10	2.5S	0	0.5
	3	25	8000	Air	10	2.5S	0	0.5
	4	16	8000	Air	10	3.5S	0	0.5
	5	10	8000	Air	10	3.5S	0	0.5
	6	8	8000	Air	10	3.5S	0	0.5
	8	5.5	8000	Air	10	3.5S	0	0.5
	10	3.5	8000	Air	10	3.5S	-1	0.5
	12	2.5	8000	Air	10	5.0S	-4	0.5
	14	2	8000	Air	10	5.0S	-6	0.5
	16	1	8000	Air	10	5.0S	-8	0.5
	18	0.8	8000	Air	10	5.0S	-9	0.5
	20	0.7	8000	Air	10	5.0S	-11	0.3
	25	0.5	8000	Air	10	5.0S	-13	0.3
	30	0.3	8000	Air	10	5.0S	-15	0.3
Aluminum Alloy	1	45	8000	N <sub>2</sub>	12	2.0S	0	0.8
	2	30	8000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	25	8000	N <sub>2</sub>	12	2.0S	-1	0.5
	4	15	8000	N <sub>2</sub>	12	2.0S	-2	0.5
	5	10	8000	N <sub>2</sub>	14	2.5S	-3	0.5
	6	7	8000	N <sub>2</sub>	14	2.5S	-3	0.5
	8	4	8000	N <sub>2</sub>	14	2.5S	-4	0.5
	10	2.5	8000	N <sub>2</sub>	14	5.0S	-5	0.5
	12	2	8000	N <sub>2</sub>	16	5.0S	-5	0.5
	14	1.2	8000	N <sub>2</sub>	16	5.0S	-6	0.5
	16	1	8000	N <sub>2</sub>	16	5.0S	-7	0.5
	18	0.8	8000	N <sub>2</sub>	16	5.0S	-8	0.5
	20	0.6	8000	N <sub>2</sub>	16	7.0S	-9	0.3
	25	0.5	8000	N <sub>2</sub>	16	7.0S	-10	0.3
		30	0.3	8000	N <sub>2</sub>	18	7.0S	+7
Brass	1	40	8000	N <sub>2</sub>	12	2.0S	0	1
	2	27	8000	N <sub>2</sub>	12	2.0S	-1	0.5
	3	18	8000	N <sub>2</sub>	12	2.0S	-1	0.5
	4	11	8000	N <sub>2</sub>	12	2.0S	-2	0.5
	5	8	8000	N <sub>2</sub>	14	2.5S	-3	0.5
	6	6.5	8000	N <sub>2</sub>	14	2.5S	-3	0.5
	8	3	8000	N <sub>2</sub>	14	2.5S	-4	0.5
	10	1.5	8000	N <sub>2</sub>	14	5.0S	-5	0.5
	12	1	8000	N <sub>2</sub>	14	5.0S	-5	0.5
	14	0.8	8000	N <sub>2</sub>	16	5.0S	-8	0.5



	16	0.6	8000	N <sub>2</sub>	16	5.0S	-11	0.3
Copper	1	30	8000	O <sub>2</sub>	5	2.0S	-0.5	1
	2	20	8000	O <sub>2</sub>	5	2.0S	-1	0.5
	3	14	8000	O <sub>2</sub>	6	2.0S	-2	0.5
	4	8	8000	O <sub>2</sub>	8	2.0S	-2	0.5
	5	5	8000	O <sub>2</sub>	8	2.5S	-3	0.5
	6	3	8000	O <sub>2</sub>	8	2.5S	-3	0.5
	8	1.5	8000	O <sub>2</sub>	10	3.0S	-4	0.5
	10	0.7	8000	O <sub>2</sub>	12	4.0S	-5	0.5

Note 1: The power used for commissioning and the speed of commissioning will be different according to the gas purity, plate quality and other aspects.

Note 2: The red font parameters in the table are proofing parameters. They are greatly affected by various factors in actual processing. They are only suitable for small batch production. Large batch production is not recommended. It is recommended to use higher power lasers.

Note 3: In the copper cutting, oxygen is the only gas suitable, air or nitrogen cannot be used for cutting.

### 8.2 Multi-module 8000W Core-100µm Piercing Reference

8000 Laser Source(100µm)--20mm Carbon Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	8000	45	80	16	1	200	-3	200ms
Media	8000	35	80	12	0.9	600	-4	300ms
Low	8000	18	80	4	0.6	400	-4	

8000W Laser Source(100µm)--30mm Carbon Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	8000	70	100	16	1	200	-5	200ms
Media	8000	37	80	15	0.7	2000	-5	300ms
Low	8000	45	120	13	0.7	2000	-5	

8000W Laser Source(100µm)--20mm Stainless Steel by N <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	8000	24	80	20	0.8	150	-8	200ms

Media	8000	37	80	15	0.7	2000	-5	300ms
Low	8000	45	120	13	0.7	2000	-5	

8000W Laser Source(100µm)--20mm Stainless Steel by N <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	8000	24	80	20	0.8	150	-8	200ms
Media	8000	35	100	15	6	2000	-8	200ms
Low	8000	50	80	4	6	500	-8	

8000W Laser Source(100µm)--30mm Stainless Steel by O <sub>2</sub> (Reference only)								
	Power (W)	Duty %	Frequency Hz	Nozzle Height	Pressure (bar)	Piercing Time	Focus (mm)	Laser-off &Blowing
High	8000	70	1000	15	1.2	3000	3	0ms
Media-H	8000	70	1000	12	1.2	2000	3	0ms
Media-L	8000	65	800	10	1	1000	-10	
Low	8000	60	800	10	1	800	-18	

The piercing parameters are taken as an example of the limit thickness of carbon steel /

