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MORN LASER

立为激光

OPERATION MANUAL

FIBER LASER CUTTING MACHINE

MT-L1530F

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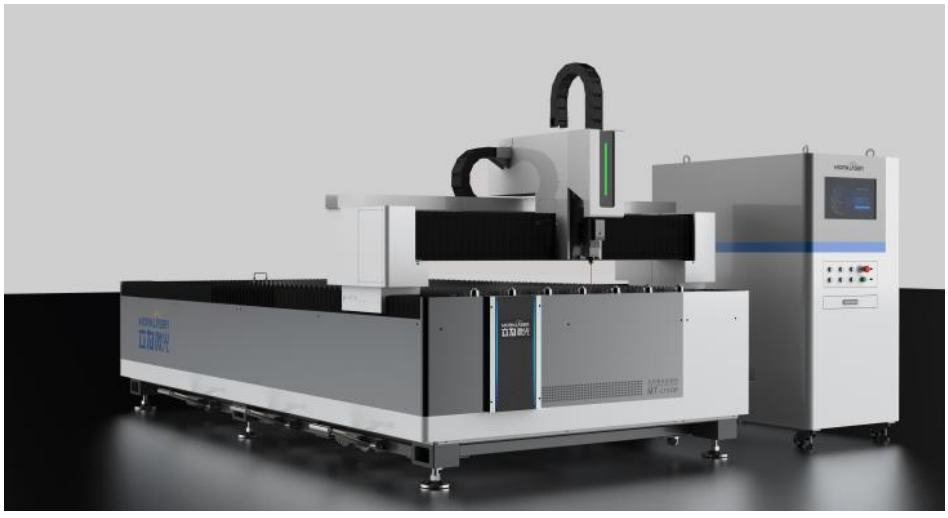
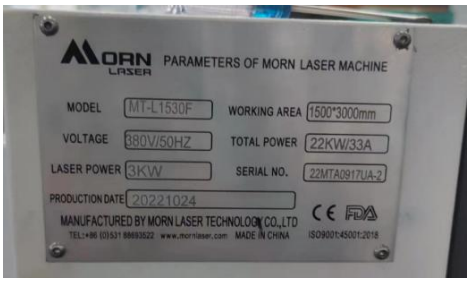




Contents

I. Preface

1.1 Welcome

Thank you for purchasing fiber laser cutting machine from Morn Laser Technology Co., Ltd. If you use the product for the first time, please carefully read the operation manual before installation and usage as well as the text involving the following content in the operation manual.

- "Danger": 

Refer to “if the correct operation is not followed, serious personal injury and even life-threatening may be caused immediately.”

- "Warning": 

Refer to “if the correct operation is not followed, serious personal injury and even life-threatening may be caused ”

- "Caution": 

Refer to likely causing personal injury or damage in case of failing to follow correct operation.

1.2 Company Profile

Morn Laser is a one-stop industrial laser solution provider for manufacturing business. We empower tens of thousands of customers around the world to grow their business with our cutting-edge laser technology, reliable service, and life-long support.

Founded in 2008 and headquartered in Jinan with offices in Hong Kong, USA, Italy, Romania, Hungary, Morn Laser is committed to challenging ever-evolving innovation and quality. Shortlisted as the Major Project of the High-end Equipment by the Shandong government in 2020, both Phase I and Phase II will produce 15,000 sets of laser machines, empowering Morn Laser to be a powerful driver for the industrial upgrading of intelligent laser equipment.

Stand locally, but serve globally, Morn Laser keeps challenging itself, producing even more efficient, precise, and future-proofing laser products to our global customers.

Live by promise, and win by quality. We strive to build value with our customers.

Morn Laser, make superior laser products, let global manufacturers benefit!

II. Product Overview

2.1 Introduction

Laser cutting is the most widely used processing method in laser processing industry. The laser cutting machine produced by our company adopts high-performance fiber laser with international advanced technology, Cypcut numerical control system, Japanese servo motors and drivers, imported gear rack, imported high-precision linear guide rail and other high-efficiency transmission mechanism. The whole machine is stable and reliable, with good dynamic performance and strong load capacity. It is a set of laser cutting system with high speed, high precision, high efficiency, high cost performance and other characteristics.

The user shall carefully read the operation manual before using fiber laser cutting machine. In case of problematic issues in the using process, please contact us timely, and we will give you a satisfactory reply to you within the shortest time.

2.2 Main Application

It is mainly used for non-contact rapid cutting, hollowing out and drilling of carbon steel plate, stainless steel plate, alloy steel, manganese steel, galvanized steel plate, aluminum plate, copper plate, pipe and other metal materials.

2.3 Equipment working and environmental requirements

<table>
<tr><th>NO.</th><th>CONTENT</th></tr>
<tr><td>1</td><td>Power supply requirements: (it is recommended to use regulated power supply)
Rated output voltage: 380V / 50Hz
Voltage stability:±5%</td></tr>
<tr><td>2</td><td>Compressed air supply device (must be equipped with an air tank and purifier)
Volume： 1.5m^3 /min
Rated pressure：1.6Mpa
Air output：1.5m^3 /min</td></tr>
<tr><td>3</td><td>Auxiliary gas
<table>
<tr><th>Gas</th><th>Purity</th></tr>
<tr><td>O2</td><td>≥99.95 %</td></tr>
<tr><td>N2</td><td>≥99.99 %</td></tr>
</table></td></tr>
</table>

2.4 Equipment installation and use environment

1. Environmental requirements for fiber laser: temperature 15-35℃, relative humidity less than 85%;

2. Field distribution cabinet: three phase four wire 380V, 50/60Hz, **above 30 kW,** with short circuit protection.

3. The equipment shall be installed with special grounding, and the grounding resistance shall not exceed 4 Ω.

4. Provide necessary lifting equipment and personnel.

5. Provide materials for on-site commissioning of equipment, such as steel plate, etc.

6. Equipment space and foundation requirements: the foundation is concrete with a minimum thickness of 300 mm; There is no seismic source

or damping groove around the foundation.

Ⅲ. Security Instructions

a) Safety management personnel should be assigned and allocated with relevant duties; operation personnel should be trained in safety operation and safety protection.

b) The laser safety management area should be designated, and warning board(s) should be provided at the entrances and exits in this area, contents of the board including: The power and type of laser machine, entry limitation, eye protection, name of safety manager, etc.

c) The operation personnel of laser machine must have specialized training to master a certain level of knowledge, and could take the relevant posts after being approved by the security manager.

3.1 Influence on Environment and Energy

3.2 Laser Safety Notice

The laser will injure human body, especially the eyes and skin. Any part of human body will be burnt in case of laser radiation. It's necessary to avoid placing any part of human body in the path of laser equipment to avoid damage resulting from wrong operation.

3.2.1 Eye and skin protection

In the process of laser processing, CO2, YAG, Fiber are generally used.

Different kinds of lasers will incur different damages to human body. Major Hazard of high-power FIBER optical maser involves burn to skin. Exposure of above-mentioned three lasers likely results in cataract and burn to skin. Therefore, at the time of laser adjustment, it's necessary to take corresponding measures as per laser category.

3.2.2 Fire Protection

Oxygen is often used at the moment of laser cutting processing, spark splashes at the time of cutting and oxygen is easy to result in fire. Therefore, no flammable or combustible articles could be put in the workspace; simultaneously relevant containment facilities shall be provided.

3.3 Electrical Safety

a) No wet hand could touch any switch so as to avoid electric shock. Locations labeled with lightning signs on the machine tool indicate high electric appliance or electrical element herein, so care must be exercised by the operator to avoid electric shock when approaching or maintaining these locations. For example: Protective cover of servo motor, junction box behind the column, machine tool transformer cabinet and electrical cabinet.

b) Please read over the machine tool manual and electrical schematic diagram for knowing functions and operational approaches of corresponding keys well.

c) Don't randomly open electrical cabinet door, **forbid set machine tool parameters, servo parameters and potentiometer changed in private** (matching with pallet changer) For any changes if required, it shall be performed by an accepted professional who has been trained by the device manufacturer. Parameters, before changes, shall be recorded for future original state restoration if necessary.

d) For laser for processing, general power supply voltage varies from thousands of volts to tens of thousands of volts and it's necessary to prevent x-ray damage incurred by electron tube under optical maser high voltage and high voltage.

e) Do not touch active components and elements in the electrical cabinet under a power-up state, including: Numerical control device, servo device, transformer and fan.

Cautions! Do not touch the terminal until more than 5 minutes waited after power disconnection. Because high voltage is left between power line terminals within a period of time after outage. Don’t touch immediately to avoid electric shock!

3.4 Protective Measures of Machine

Safety management personnel should be assigned and allocated with relevant duties; operation personnel of laser machining should be trained in safety operation and safety protection. The laser safety management area should be designated, and warning board(s) should be

provided at the entrances and exits in this area, contents of the board including: The power and type of laser of laser machine, outsiders' entry limitation, eye protection, name of safety manager, etc.

When laser processor isn't used, it's necessary to unplug switch key and assign specially-assigned personnel for custody to avoid hazard resulting from mis-operation by people without fixed duties.

Discharge the fume gas generated during processing and laser working gas outside via off-gas line, and place all gas cylinders steadily and in order.

3.5 Common Sense for Users

The operation personnel of laser cutting machine must have specialized training to master a certain level of knowledge, and could take the relevant posts after being approved by the security manager.

The operation personnel of laser cutting machines or the personnel close to the laser shall wear suitable laser protective eyeglasses and protective clothing during application. Meanwhile, the areas in which the operation personnel need to wear protective eyeglasses must have good indoor illumination so as to ensure the smooth operations of the operators.

To protect the operation personnel, processing room, protective screen, etc. shall be provided. Moreover, the processing room shall be equipped with devices that protect operation personnel and prevent laser

against diffusion; If the processing room is to be opened, the laser optical gate shall be closed.

Ⅳ. Installation and Commissioning

4.1 Delivery and Inspection

4.1.1 Precautions for unpacking

In case of packaging with wooden case, open the case as per the prompt on the surface of wooden case to avoid damage to equipment in the case. Equipment such as machine tool shall be packed with protective film and shall not be gashed with sharp object to avoid surface scratch of the equipment as well as damage to electrical installation protection pipeline. In case of damaged caused by the user, the company won't take the responsibility.

4.1.2 The content of inspection

a) Confirm whether the product in the package is the one purchased by you after opening the package.

b) Inspect whether the product is damaged in the transportation process.

c) Inspect whether all parts are complete and free from damage based on the list.

d) In case of inconsistent product type, lacking accessories or damage in the transportation process, please contact with our company

timely.

4.2 Installation Environment Requirements

For installation and fixation of machine tool, power distribution shall be conducted by professional electrician as per workshop foundation drawing and power supply wiring requirements at the moment of transportation and power distribution on the basis of lifting position. In the process of installation and fixation of machine tool, don't damage the machine tool. In case of any question, please contact with our company timely.

a) Specifications of the power supply: Three-phase and five-line system 380V 50/60Hz

b) Quality of power supply: line voltage fluctuation <5%.

c) Grounding protection: **The machine tool is grounded by a ground pile next to it** or connected to the grounding wire of the power supply and the grounding resistance shall be less than 4Ω.

d) Draughty, dust-free, non-corrosive and pollution-free site environment is required.

e) It's required that there shall be no large vibration around installation foundation with shockproof ditch dug.

f) The optical maser is required to be installed under the environmental temperature of 20ºC (refer to the instruction of laser at the time of usage).

g) Water chilling unit is the special equipment for providing circulation cooling water to optical maser, QBH and cutting head lens and circulation cooling water is required to use high-quality purified water or distilled water;

h) For prevention of fire hazards, appropriate fire extinguishers and reserved fire fighting access shall be provided in the processing site.

i) Over 1.2m shall be kept between workshop wall and left and rear sides of machine tool; Rear side of the optical maser shall be above 1.5M away from workshop wall; Water chiller and air compressor shall be placed outdoors but they shall not be more than 4M away from the optical maser.

j) The control unit, servo unit, displayer and control panel are core components of machine tool, which are demanding on the environment to some extent, and shall be kept away from electromagnetic wave interference, such as arc welding and electric discharge machine, for fear that the normal operation of machine tool is affected.

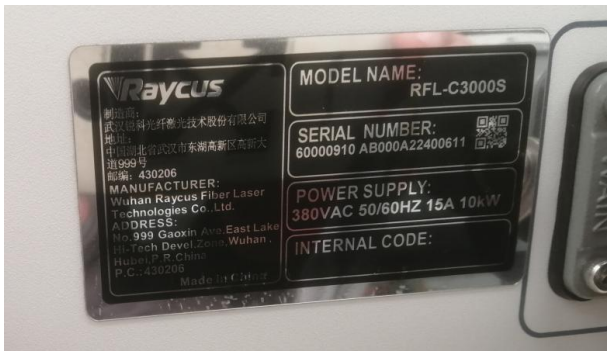
4.3 Installation Methods and Precautions

For installation and fixation of machine tool, the machine tool shall be installed pursuant to plant foundation drawing as well as arrangement principle suggested by us. No damage to the machine tool in the process of installation and fixation of the machine tool is required. In case of any question, please contact with our company timely. (taking Raycus

optical maser as an example)

Before install any parts of the machine, we need to place the machine bed on flat ground, and install the feet under the machine to adjust the levelness with gradienter.

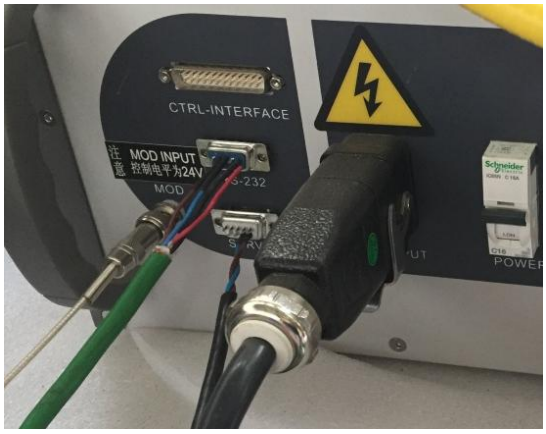
4.3.1 Laser Source



It's necessary to unpack optical maser sealing and confirm whether optical fiber cable is in good condition as well as no breakage or bending

is caused by extrusion; It's necessary to confirm whether laser head protective cover falls off and whether sealing paper self-adhesive tape protection status is in good condition; It's necessary to verify and confirm whether optical maser power line and modulating signal line are free from defect.

It's necessary to connect optical maser power line connection-peg, modulating signal line connection-peg and RS232 connector (in the electrical cabinet in the back of the bed) to the corresponding socket in back of optical maser according to the following figure. （不同激光器配接法）

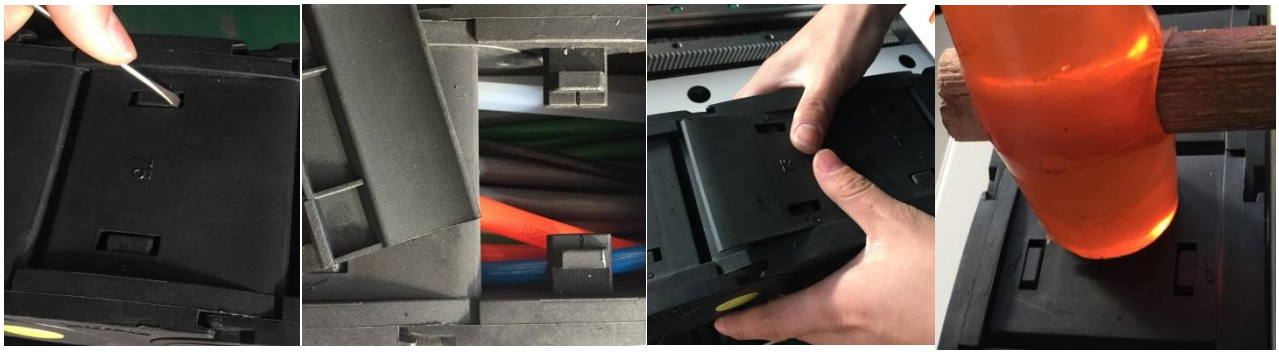


It's necessary to carry out pressure welding of power line and modulating signal line terminal to the port corresponding to terminal board in the rear electrical cabinet in light of marked line number.

Optical fiber cable shall be based on the above drawing as well as the cover plate, shield and drag chain cover along the path shown in the

drawing shall be taken down before installation of optical fiber cable.

Disassembly and assembly of the drag chain cover plate is shown in the following figure.



At the time of interluding optical fiber cable, careful operation must be conducted. It's necessary to pay special attention to the protection of the laser head, and be free from bump with sealing shield and sealing joint strip well protected; It's necessary to protect optical fiber cable from dead lift and fierce haul as well as ensure bending angle doesn't exceed 120°in case of zigzag at the corner.

At the moment of threading, it's necessary to confirm optical fiber allowance of cutting head end as well as appropriately adjust allowance of optical fiber cable at the drag chain and corner. After the completion of threading, cover plate, shield and drag chain cover of optical fiber path shall be installed to the original place, redundant optical fiber of the optical maser end shall be placed on the top of optical maser in the form of wire wrapping at the time of sealing and the ribbon can be used for appropriate fixation, but stress at the fastening point shall not be too large.

4.3.2 Water chiller

a) Installation conditions

The chiller shall be placed stably and at a certain distance from the wall. Sufficient air inlet and outlet space must be reserved at the installation position of the chiller to prevent poor heat dissipation of the chiller.

b) Machine inspection

Clean the sundries in the water tank first to ensure that the water tank is clean and free of impurities; Then check whether the joint of the

water pipe system is loose.

c) Installation method

Install the water distribution valve on the corresponding connection port of the unit, and pay attention to the direction of the inlet and outlet; Connect the inlet and outlet water pipes according to the marks on the shell of the chiller and connect them with the inlet and outlet of the laser. Do not connect the inlet and outlet directions of the water pipes wrongly. Before connecting the water pipes, ensure that the external pipelines of the chiller are free of garbage and foreign matters.

d) Water quality standard

Open the water inlet valve and add water to the water tank. The water level shall be 30mm ~ 50mm lower than the upper edge of the water tank to prevent water from overflowing from the water tank. Ordinary tap water is not allowed for the chiller, but high-quality purified water, distilled water or deionized water must be used. The laser shall be mixed with 40% propylene glycol and 60% distilled water, otherwise it will scale the refrigerator of the chiller and the radiator of the laser and damage the components of the machine. Do not add any corrosive liquid;

e) Debug the machine

Turn on the power supply, check and ensure that the indicator light of the three-phase protector in the unit is green, adjust the forward and reverse rotation of the water pump and fan, and power on for 20 minutes

to make the internal heater of the compressor preheat automatically before normal operation. Set the required temperature on the operation panel according to the requirements of the laser for the cooling water temperature.

f) Opening steps

Before startup of the machine, first turn on the water chiller for 5 minutes, until the water outlet reaches the flow and pressure required by the laser. If the cooling water in the water tank is insufficient, it shall be added in time.

g) Precautions:

1) When the water temperature reaches the controlled temperature, the chiller will automatically control the constant water temperature, and the water pump in the unit will operate as usual.

2) When starting up for the first time, the opening degree of each valve in the waterway system shall be adjusted at the same time. In the later startup process, try not to adjust each valve in the waterway system.

3) The laser can be turned on only after the temperature of cooling water and the pressure difference of inlet and outlet water reach the required value of the laser.

4.3 Cutting head (taking Raytools series cutting head as an example)

It's necessary to separate cutting head sealing, confirm whether the clash occurs to cutting head, the bolt becomes flexible and water pipe

inlet and outlet, air pipe, nozzle exit and laser head connector are under good sealing and protection as well as check whether no defect occurs to capacitor amplifier, radio frequency line, cutting head cooling water pipe, cutting head fixing bolts (4 pieces) and amplifier fixing bolts (4 pieces).

It's necessary to open the cutting head shield, check and confirm whether no defect happens to height adjustment device signal line, high-temperature water pipe (red), low-temperature water pipe (blue), air pipe, optical fiber cable and laser head as well as appropriately adjust length allowance of each line and pipe in accordance with the installation location of cutting head.

It's necessary to check laser head installation hole bolt location.

It's necessary to take out all parts in the sealing box of cutting head and put them in the near-by place for standby application as well as also prepare nonwoven cotton rod, ethyl alcohol (above 99.99% alcohol or acetone) reagent, socket head wrench, monkey spanner and paper self-adhesive tape for standby application.

Before the installation, it's a must to ensure the environment is relatively clean and free from fugitive dust with the obvious gas flow as

well as installation personnel must wear clean fixture and protective clothing.

It's necessary to carefully disassemble laser head sealing tape, slowly take down the black protective cover as well as appropriately hold your breath to observe and confirm whether the laser head end face protective glass is in good condition. In case that protective glass is blotted, it's necessary to wipe it slightly and uniaxially by nonwoven cotton rod dipped with moderate amount of ethyl alcohol (above 99.99% alcohol or acetone) agent which shall be subject to natural volatilization; In case the damage or stain cannot be wiped, it's necessary to suspend installation immediately, recover sealing status of laser head, timely contact with optical maser after-sales service personnel as well as wait for replacement.

It's necessary to carefully disassemble upper end face sealing plug of cutting head and hold your breath appropriately to observe and confirm whether the port is cleaned and in good condition. In case of stains, it's necessary to wipe it slightly by nonwoven cotton rod dipped with

moderate amount of ethyl alcohol (above 99.99% alcohol or acetone) agent which shall be subject to natural volatilization.

It's necessary to confirm the laser head connects with indication red dot as well as connection/locking indication red dot of cutting head, ensure the laser head is steadily and quickly inserted into the cutting head after alignment of red dot as well as rotate lock sleeve as per locking instructions.

Notes: At the moment of connection between laser head and cutting head, once sealing protection is disassembled, it's a must to complete confirmation, wiping, plugging and locking within a short time to avoid optical element of laser head and cutting head polluted in the process of connection installation.

After the completion of connection installation of laser head and cutting head, cutting head shall be fixed to aluminum sliding plate with fixing bolt and ensure the bolt is firm but overstrain is forbidden to avoid sliding wire.

The amplifier shall be fixed to the lateral face of cutting head with

bolts with height adjustment device signal line and radio frequency line connected. Cooling water channel and air pipe shall be conducted as per the instructions in the following figure.

3.3.4 External electrical connection and gas access



Three-phase live wire and null wire in the Three-phase and five-wire system stabilized power supply shall be accessed to corresponding connection port in accordance with the above figure.

According to type of used gas, gas pressure relief valve shall be connected to compressed gas container and air pipe.

4.4 Commissioning Method and Relevant Explanation

Machine Tool commissioning shall be conducted by professionals in strict accordance with related provisions. Before commissioning, it's necessary to know about machine tool performance and read related accompanying technical data firstly. Correct commissioning is the base for ensuring proper functioning of the machine tool. In case of any question, contact us timely and we will certainly give a satisfactory answer to you fastest.

Notes: The commissioning method includes the commissioning method after the machine tool is connected with normal electrification.

"Notes": As for usage and maintenance of water chiller, refer to operation manual of water chiller;

"Notes": As for usage and maintenance of fiber optical maser, refer to corresponding operation manual;

"Notes": As for usage and maintenance of software, refer to corresponding operation manual.

"Warning": Grounding wire of power line must be of reliable grounding, or the signal in the electric cabinet of the machine tool will be disturbed with danger incurred at the moment of electric leakage.

4.5 Nozzle Function as well as Laser Adjustment Method At the Nozzle Exit

4.5.1 Function and adjustment of nozzle

a) Nozzle

Nozzle design and jet flow situation directly influence cutting quality; Accuracy of manufacturing of the nozzle is closely related to cutting quality.

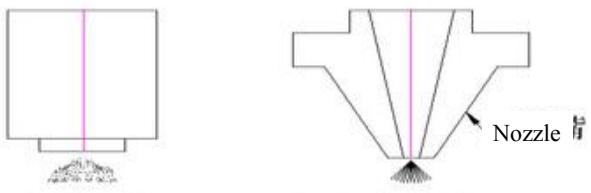
b) Main functions of nozzle include:

▲The nozzle can avoid such sundries as cutting fused stains bouncing upwards and entering the cutting head to damage the lens.

▲The nozzle can change the eruption situation of cutting gas as well

as control gas diffusion area and quantity so as to affect cutting quality.

The gas blow-out situation at the moment of installation of nozzle and no installation of nozzle is shown in the following figure.



Situation without nozzle　　Situation with nozzle

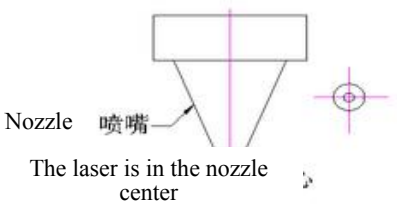
4.5.2 Step of adjusting nozzle to make a laser pass through nozzle center

Compared to CO2 laser cutting machine, fiber laser cutting machine has no light path and only needs to adjust the laser at the cutting head.

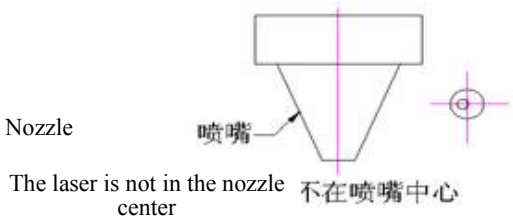
1. End face of the nozzle is smeared with a red ink paste used for seals (no red ink paste used for seals is needed at the time of cellophane tape adopted) and then white adhesive sticker is pasted to the end face

2. It's necessary to adjust the output power of optical maser (30W ~ 50W) and open mechanical optical shutter and then quickly turn on and off electronic optical shutter to observe phenomenon arising. And then it's necessary to close mechanical optical shutters and take down white adhesive sticker and don't rotate its relative location. In case of big difference between nozzle location and laser center, no central hole on the adhesive sticker can be made; Because laser center remains constant, it's necessary to adjust adjusting screw on the cutting head handle to change nozzle center and make it correspond to laser center. It's

necessary to repeat the above action until the hole on the white adhesive sticker made by the laser coincide with nozzle center and then laser center coinciding with nozzle center can be confirmed. As shown in the figure below



The laser is in the nozzle center



The laser is not in the nozzle center 不在喷嘴中心

4.6 Influence from Nozzle on Cutting Quality and Selection of Nozzle Bore Diameter

a) Relations between nozzle and cutting quality: When the nozzle center is not concentric with the center of the laser, the impacts on cutting quality include:

1) Cutting section will be influenced. When cutting gas is ejected, uneven air flow happens which make cutting section easily suffer the phenomenon of molten stains on one of two sides. The thin plate below 3mm cutting will be less influenced; the plate above 3mm the cutting will be seriously influenced and sometimes failure in cutting will occur.

2) Affecting angle quality, partial over-melted phenomenon will occur when cutting small workpiece with sharp angle or small angle, cutting plate; sharp corners may not be achieved when cutting the thick plate.

3) Piercing will be influenced. Instability and time which is uneasy to

be controlled at the time of punching will cause superfusion when the thick plate is penetrated and the penetration condition is hard to be grasped which will have less effect on thin plate piercing.

To sum up, the concentricity of nozzle center and the laser is one of the important factors of cutting quality, especially cutting the thick work piece, its effect is even greater. Therefore, the concentricity of nozzle center and laser shall be adjusted to achieve better cutting section. Notes: When the nozzle is out of shape or molten stains is on the nozzle, its influence on cutting quality is the same with that mentioned above, therefore, the nozzle shall be placed carefully without bruises to avoid deformation; Molten stains on the nozzle shall be cleared up. Nozzle quality is with relatively high precision requirements at the time of manufacturing, and the method is required to be correct at the moment of installation. In case of bad quality of nozzle causing change in various conditions at the time of cutting, it's necessary to replace the nozzle timely.

b) Selection of nozzle bore diameter

Difference of nozzle bore diameter is shown in the following figure

Nozzle bore diameter	Gas flow rate	Melt removal capacity
Small	Fast	Strong
Big	Slow	Weak

Bore diameters of the nozzle covers ϕ1.0mm, ϕ1.4mm,

ϕ2.0mm,ϕ2.5mm andϕ3.0mm. Nozzle bore diameters-ϕ1.4mm and ϕ2.0mm are often used now. As shown in the figure below

ϕ1.4mm nozzle

ϕ2.0mm nozzle

Differences:

1) Thin plate of less than 3mm: In case of adopting ϕ1.4mm, the cutting plane will be relatively thin; In case of adopting ϕ2mm, the cutting plane will be relatively thin and molten stains will easily occur to corner.

2) Thick plate of more than 3mm: Because of high cutting power, long relative cooling time arises and relative cutting time increases. In case of adoptingϕ1.4mm, due to small gas diffusion area, it's not too stable at the time of usage and it's basically usable. In case of ϕ2mm, due to large gas diffusion area and slow gas flow rate, it's stable at the moment of cutting.

3) Bore diameter with diameter being ϕ2.5mm can be only used for cutting thick plate of above 10mm. To sum up, nozzle bore diameter has a serious influence on cutting quality and piercing quality. At present, nozzles with ϕ1.4mm, ϕ2mm aperture is usually used for laser cutting.

"Notes": When nozzle bore diameter is larger, the protection of relative focusing lens will be worse. Because melt sparks fly at the time of cutting, the proportion of upward flipping will be larger, resulting in lifetime of lens becomes shorter.

4.7 Adjustment of Light Beam Focus

During the laser cutting, the relative location of beam focus and cutting sheet metal surface has a large effect on cutting quality, and it is very important to adjust the focus position. In general, trial cut can be conducted by changing focus, the focal position of corresponding steel plate will arise when there is no adhering slag on the reverse side, and the joint-cutting is thinnest,

After the change in relative location of cutting head and board, cutting head and sensor null point shall be changed accordingly, too. Slight adjustment can be completed by adjusting software cutting height; In case of large adjustment quantity, it's necessary to adjust relative position of sensor and support to complete adjustment of focal point. At the moment of doing this work, it's necessary to be careful, or downward bump will easily happen to cutting head, resulting in damage to parts.

4.7.1 Relationship between the focal point position and cutting effect

Name and focal position	**Cutting material and section features**
Zero focal length: The focus is on the surface of cutting workpiece	The method used for carbon steel and other materials. The focus is on the surface of cutting bow and arrow. As for cutting effect, the upper surface is smooth and down surface isn't smooth

Positive focal length: The focus is inside cutting workpiece	Usage mode of aluminium products and other workpieces. Comparing with the condition adopting zero focal length, with the focus located at the center, the cutting width, flow rate of cutting gas and the time of punching are greater due to the wide range of smooth surface.
Negative focal length: The focus is beneath cutting workpiece	Method used at the time of cutting corrosion resistant plate. When the stainless steel is cut, the high-pressure nitrogen is used to blow away molten slag and protect a cross section in the cutting process. Cut width will be broadened along with the increase in workpiece plate thickness.

4.8 Selection of Cutting Speed

The selection of cutting speed will vary with the texture and the thickness of the cutting plate and different cutting speed will have a great effect on the laser cutting quality. The proper selection of cutting speed not only can improve the cutting efficiency but also can achieve the good cutting quality. The impact of cutting speed on cutting quality is discussed below:

1) The impact of the too fast cutting speed on the cutting quality:

The too fast cutting speed can cause the non-cutting phenomenon, making the sparks splash. Some sections of the cutting material can be cut through while some sections can’ t.

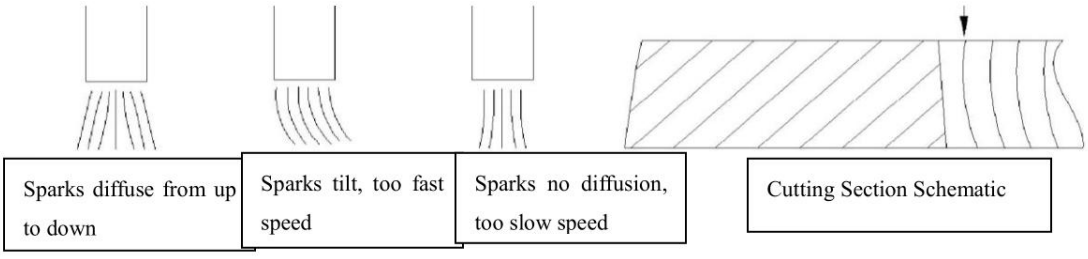
As shown in below picture, the too fast cutting speed cause the plate can’ t be cut through in time, the cutting surface have oblique lines and slags occur at bottom half.

2) The impact of the too low cutting speed on the cutting quality:

The too slow cutting speed will cause the plate over melted and the cutting surface will be very rough, the cutting kerf will become wider accordingly, and the little rounded corner or sharp corner place will melt and can’ t achieve the ideal cutting effect finally. Slow cutting speed will also lower cutting efficiency.

3) Selection of the proper cutting speed

The cutting speed can be judged from the cutting sparks, the sparks will diffuse from top to the bottom in normal cutting, and when the speed is too high, the sparks will be banked; if the sparks are not diffused, but gathered together, it indicates that the feeding speed is too low. As shown in following figure, the cutting surface of a proper cutting speed will present stable lines, and no slags will be generated at bottom half.



Cutting Sparks Effect Diagram

4.9 Explanation Regarding Selection of Laser Cutting Gas and Pressure

When choosing the auxiliary cutting gas type and gas pressure, several aspects below should be considered:

◆ Generally, the oxygen is used to cut the normal CS, pierce and cut with the low pressure.

◆ Generally, the air is used to cut the thin CS, SS and the non-metal material.

◆ Generally, the nitrogen is used to cut SS.

◆ The higher the purity of the gas, the better the cutting quality. The gas purity had better be above 99.8%

when cutting CS and the nitrogen purity had better be above 99.6% when cutting SS, the higher the

nitrogen purity, the smoother the cutting surface.

3.1 The influence of cutting gas on cutting effect

1) The gas is beneficial for heat dissipation and burning, blowing off the slags, improving the cutting surface quality.

2) the influence for cutting when the gas is insufficient

a . the melting slags occur on the cutting surface

b. the cutting can't speed up and the efficiency is influenced.

3) the influence for cutting effect when the cutting gas pressure is too high

a. When the gas flow is too strong, the cutting surface is rough and the kerf is wider.

b. When the gas flow is too strong, the cutting surface will be melted

and the cutting effect is not good.

3.2 The influence of cutting gas on piercing

1) when the gas pressure is too low, the piercing can't be easily achieved and it will cost more time.

2) when the gas pressure is too high, the piercing point will be melted and become a bigger melting hole. So for thin plate use high gas pressure to pierce and for thick plate use low gas pressure.

All in all, the selection of the cutting gas type and pressure should be adjusted by the actual situation and different cutting parameters will be used under different situation.

"Warning"-Supply pressure of nitrogen is forbidden to exceed 2MPa; Supply pressure of nitrogen is forbidden to exceed 0.9MPa, or it's easy to cause burst of air pipe.

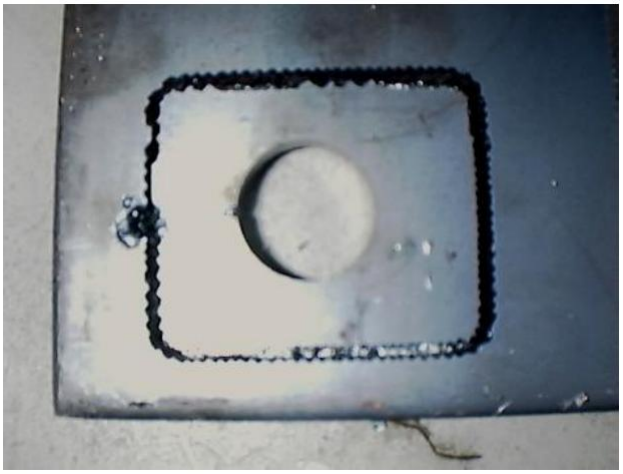
5.0 Explanation Regarding Selection of the cutting power

Different laser power has different impact on the cutting quality, the selection of cutting power shall be determined according to the texture and thickness of the plate, neither too high or too low laser power can

achieve better cutting surface.

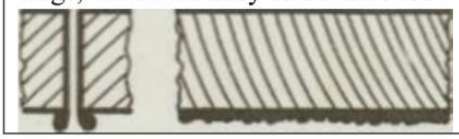
1) The plate can ’t be cut through when power is too low.

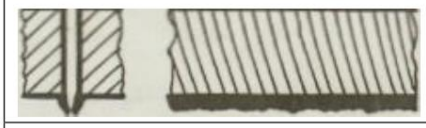
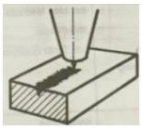
2) When the laser power is set too high, the cutting surface will be melted and the kerf will be very big and can ’t achieve a better cutting quality.



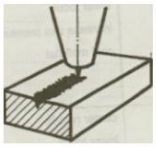
3) when the laser power is normal, the cutting surface is soft and smooth.

The cutting principles chart

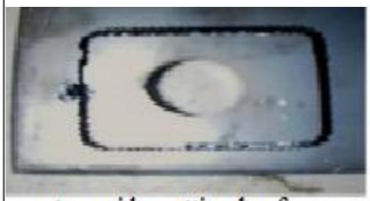
Structural steel: Cut by O2		
Defect	Possible cause	Solution
No burr; consistent leading line 	Appropriate power Proper cutting speed	
Large offset of leading line at the bottom, wider kerf at the bottom 	Too fast cutting speed Too low cutting power Too low gas pressure Too high focus	Reduce cutting speed Increase cutting power Increase gas pressure Decline focus
Drop-shaped burrs at the bottom seem like slags, which are easy to be removed 	Too fast cutting speed Too low gas pressure Too high focus	Reduce cutting speed Increase gas pressure Decline focus

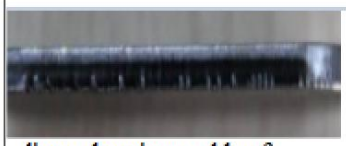
Metal burrs connected together could be removed as a whole 	Too high focus	Decline focus
Metal burrs on the bottom are hard to be removed 	Too fast cutting speed Too low gas pressure Impure gas Too high focus	reduce cutting speed Increase gas pressure Use purer gas Decline focus
Burrs only on one side 	Improper concentric laser Defects occur in nozzle exit	Make lasers concentric Replace nozzle
Material is discharged from the upside 	Too low power Too fast cutting speed	Increase power Reduce cutting speed
Inaccurate cutting surface 	Too high gas pressure Nozzle is damaged Too large diameter of nozzle Poor material	Reduce gas pressure Replace nozzle Mount proper nozzle Use material with smooth and even surface

Stainless steel: cut by N2 under high pressure		
Defect	Possible cause	Solution
Drop-shaped fine regular burrs 	Too low focus Too fast cutting speed	Raise focus Reduce cutting speed
Irregular filament-shaped burrs are found on both sides; surface of large sheet metal discolors 	Too low cutting speed Too high focus Too low gas pressure Overheated material	Increase cutting speed Decline focus Increase gas pressure Cool material

Long and irregular burrs are found on one side of cutting edge 	Improper concentric laser Too high focus Too low gas pressure Too low speed	Make lasers concentric Decline focus Increase gas pressure Boost speed
Cutting edge gets yellow	Oxygen impurities mix in nitrogen	Use high-quality nitrogen
Laser beam starts to diffuse around at the beginning	Too high acceleration Too low focus Materials melted are not discharged	Decline acceleration Raise focus Bore a round hole
Rough cut	cut Nozzle is damaged Dirty lens	Replace nozzle Clean lens; replace if necessary
Material is discharged from the upside 	Too low power Too large cutting speed Too high gas pressure	Increase power Lower cutting speed Reduce gas pressure

Case analysis

	Oxygen cutting case analysis		
	Sample picture	Possible cause	Solution
1		Lens center is not correct The nozzle exit is blocked or not round The optical path is not correct	Check the center of lens Check the state of the nozzle Check the optical path
2	 too wide cutting kerf	Too high pressure Too high focus Too high power Bad quality of material	Reduce the pressure 0.1bar every time Decline the focus 0.2mm every time Reduce the power Check the focus of the lens

3	 blue plasma, didn't cut through	low power high speed low pressure	Increase the power Low the speed Increase the pressure
4	 lines skewing and kerf wider on bottom	Too high speed Low power Too low pressure	Reduce the speed Increase the duty cycle, 5-10% every time Increase the power, 100W every time Increase the pressure step by step, 0.1 bar every time
5	 craters occur	Too high pressure Too low feed speed Too high focus Rust on the surface of the cutting plate Overheated cutting plate Impure material	Reduce the pressure Increase the feed speed Decline the focus Use high-quality material
6	 extremely rough appearance	Too high focus Too high pressure Too low feed speed Overheated material	Decline focus Lower the pressure Increase the feed speed Cool the material
7	 tough burr on botttom	Too high feed speed Too low pressure Impure gas Too high focus	Lower feed speed Increase the gas pressure Use more purer gas Decline focus
8	 first half smooth, second half rough	Too high focus	Decline the focus

	Nitrogen cutting case analysis		
	Sample picture	Possible cause	Solution
1		Too fast speed Too low focus Too low power	Lower the speed Increase the power
2	 irregular burr occurs only on one side	The center is not correct The inner bore of nozzle is not circular The optical path is not correct	Check the center Check the state of the nozzle Check the optical path
3	 rough cutting effect	Too low power Too low focus	Increase the power Raise the focus 0.1-0.2mm every time
4	 threadlike burr on bottom	Too low feed speed Too high focus Too low gas pressure Overheated material	Increase the feed speed Decline the focus Increase the gas pressure Cool the material
6		Impure nitrogen Oxygen or air mix in the gas pipe	Check the purity of the nitrogen Increase the delay time to clean the gas pipe and check the gas circuit.

V. Use and Operation

5.1 General

Before using the machine tool formally, please firstly master the relevant operation methods of the machine tool, and know the operation conditions of various parts of the machine tool, because correct operations are the effective measures for ensuring the normal operation of the machine tool and the personal safety. At the time of using the machine tool, it's necessary to carry out relevant inspection in strict accordance with preparation and inspection before usage below.

5.2 Preparations and Inspection before Usage

Preparations and inspection before use

a) It's necessary to inspect whether the machine tool lubricating oil level is within the normal scope, or add lubricating oil to be within the normal scope.

b) Or it's necessary to inspect relevant waterway and gas circuit and ensure gas circuit and waterway are unblocked and free from leakage as well as gas and cooling water are with normal quality and fail to be polluted.

c) It's necessary to inspect the coaxality of laser and air faucet as well as ensure laser beam is injected from the middle of the air faucet.

d) It's necessary to inspect whether air faucet conforms to cutting technology requirements, or replace it with proper cutting air faucet.

e) It's necessary to inspect whether auxiliary gas for cutting is normally accessed, or access corresponding auxiliary gas for cutting and ensure gas pressure has been adjusted.

5.3 Safety before Use and In Use, Safety Protection, Safety Signs and Instructions


It means it's necessary to "notice" failure in follow correct operation may lead to personal injury or damage to equipment;


It means there is a laser beam passing and passing through light beam is forbidden, or burn to human body will arise and even threat to life will occur;


This indicates that there is the risk of high voltage power supply, please do not get close to high voltage; or else such high voltage may cause electric shock to you and even threat to your life.

Precautions:

a) Anyone shall not take the eyes to directly face the ejection direction of laser (including red indicator light) at any time.

b) When the laser shutter is opened, persons and articles irrelevant to the work are forbidden to appear in the laser irradiation range.

c) The operators shall wear goggles and shall be forbidden to leave during the running of the machines.

d) In case of abnormality happening in the process of machine tool usage, it's necessary to immediately press emergency stop switch or turn off main power.

e) It is necessary to frequently check the cooling water temperature and gas pressure during use.

f) Only the operators with operation certificate can operate the equipment, and shall abide by the safe operation rules. Other irrelevant personnel shall be forbidden to operate the machine tool.

g) The optical maser of this equipment falls into Type 4 laser product, the laser is invisible, and light beam from it or its light beam after reflection and diffuse reflection may damage human body which shall be prevented by personnel on the spot who also shall prevent occurrence of fire.

h) Large damage may be incurred by waste gas generated at the time of laser cutting to operation personnel and it's necessary to ensure dust exhaust apparatus of the machine tool works normally.

i) It's necessary to often keep the equipment clean, conduct oil filling as per provisions as well as ensure reasonable lubrication; It's necessary to observe shifting system and control tools and accessories which shall not lost; it's necessary to carry out machine halt for inspection after the failure is found and give a notice for repair timely in case that you cannot dispose.

i) Electric shock injury shall be prevented, non-professional maintenance personnel shall be forbidden to check and repair the electrical control parts of the machine tool.

5.4 Startup & Shutdown Order

a) Confirm main power of optical maser, water chiller and equipment is in the off state and turn on external main power to enable dynamic electricity to access to control cabinet;

b) Inspect whether the emergency stop switch is in the loosening state;

c) Upward pull air switch and connect power supply;

d) Clockwise rotate key switch to on position;

e) Turn on IPC switch, initiate IPC and open cutting software;

f) Rotate red power switch of water chiller to on position;

f) Rotate optical maser key switch leftward to turn on power supply of optical maser; To REM position.

At the moment, startup of cutting machine is complete and the sequence of shutdown is reverse.

5.5 Software Use and Programming

Refer to operation manual for the detail about software usage which isn't expounded here. APPENDIX A "CypCut User Manual V6.3.6"

5.6 Explanation Concerning Automatic Calibration of Height Sensor

Calibration is needed at the time of replacing the nozzle or follow-up distance failing to be accurate, calibration is also called as correction of follow-up height which is as follows:

The cutting head shall be moved downward to the place about 5mm away from layout;

Selecting calibration on height adjustment device (BCS100)→calibration of floating head→confirmation;

At the moment, lower probing happens to cutting head twice, layout

position shall be checked and the whole process lasts for about 10S;

After calibration, the obvious calibration curve on the height adjustment device arises and normal curve is smooth. In case of bad calibration result, cutting effect will be influenced and it's necessary to carry out calibration anew.

To sum up, there are many factors influencing calibration result which are as follows generally: The board is unstably placed; Z-axis sliding table shakes; External electrical disturbance is too serious. Calibration results are divided into being excellent, good, moderate and bad. In case that calibration result is better than average, it can be normally used; in case that calibration result is bad, it's necessary to suppress interference and conduct calibration anew.

Ⅵ. Explanation on Maintenance and Common Fault

6.1 General

In order to ensure the normal operation of the fiber laser cutting machine, the equipment needs to be maintained daily. As the whole machine tool is composed of extremely precise components, care must be taken during routing maintenance and operation procedures of all parts must be followed strictly. Besides, the maintenance shall be made by

specially-assigned persons and rough operation is prohibited in order to avoid any damage to components.

Spare parts often prepared by the user

A) Aceton: A bottle of 500ml with a purity of 99.5% and water less than 0.3%.

b) Pledget: 5 packages. (Medical grade or optical grade)

c) Alcohol: 500ml, with a purity of more than 99.5%.

d) Dropper needle: 1 piece (for medical purposes).

e) Cotton swab: 2 packages.

f) Multi-meter: 1 unit.

6.2 Installation or Replacement Method of Interior Lens of Cutting Head

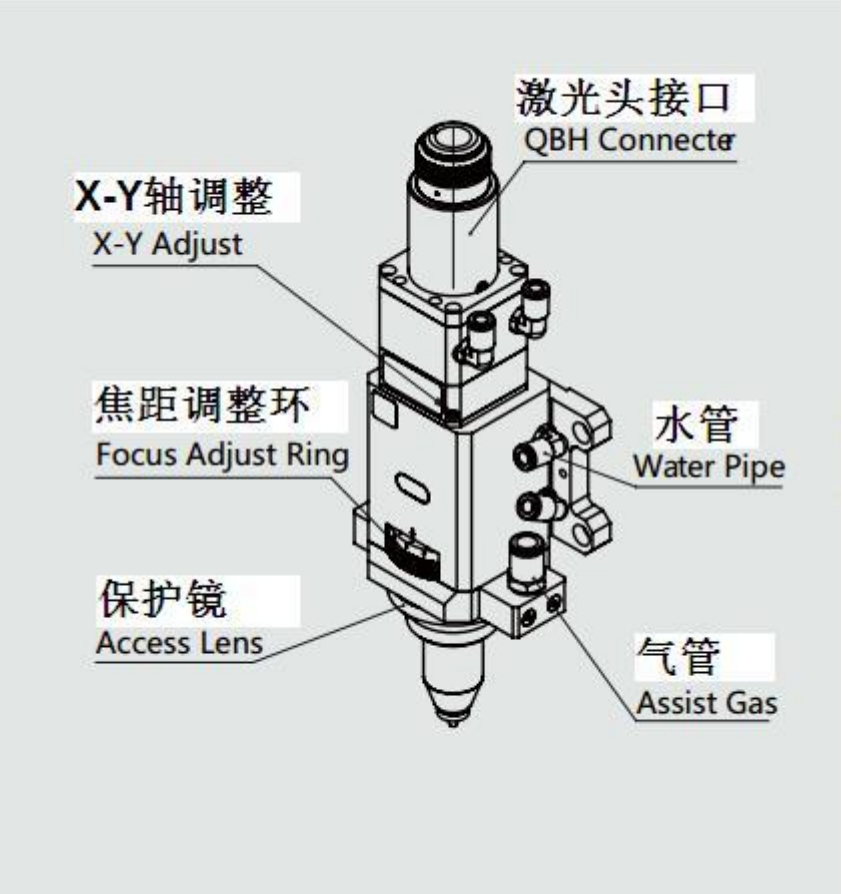
1) Before installation of optical lenses, the following items shall be noticed: Wear clean clothes, use soap or cleanser essence to clean hands and wear light, thin, clean and white gloves; It is strictly prohibited to touch the lenses with any part of the hand. Hold the lenses from the side and don't touch the coating surfaces of lenses directly when taking them.

2) Don't blow toward the lenses when assembling them. Please place the lenses on a clean table steadily with several pieces of lenses professional paper lying under them. Try to be careful when taking lenses to avoid a bruise and a fall, and never exert any force on their coating surfaces. The bases where the lenses are installed shall be clean and the

dust and dirt inside the bases shall be cleared with clean air gun before the lenses are placed into the bases gently.

When installing lenses into bases, never fix the lenses with too strong force in order to avoid lens deformation and the further influence in the quality of light beam.

4) Precautions at the time of replacing optical lenses: Be careful when taking out the lenses from the packing box to prevent damaging lenses by collision; Don't exert any force to the lenses before the wrapping paper is unpacked; When taking out the reflector and focus lens from the packing box, wear clean gloves and take them out from the side of the lenses; When removing the wrapping paper from the lens, avoid dust, etc. falling down to the lenses; After taking out the lenses, remove dust on the lenses with spray gun, and place the lenses on the paper special for optical lenses; Remove dust and dirt on the lens support frame and fixed mount, and avoid other foreign matters falling down to the lenses at the time of assembly; When installing the lenses to the base, avoid overexertion to prevent lenses deformation; After completion of lens assembly, remove dust and foreign matters on the lenses with clean air gun.



6.2.1 Step for cleaning the lens

Lens cleaning steps:

Blow off the dust on the surface of lens with air gun firstly; Then remove the dirt with a clean cotton swab; Use a new cotton swab stained with high pure alcohol or acetone to make movement along the circumference from the center of the lens to wash the lens and replace to use another clean cotton swab when the circumference washing is finished every time. Repeat the above operation until the lens is clean;

Clean cloth shall be used for cleaning lens with residual marks removed and no scratch on the mirror surface; Cleaned lens shall be taken to the place with sufficient ray of light for observation. In case of good reflection situation of lens, it means the lens have been cleaned up; in

case of bad reflection situation of lens, it means that lens shall be continuously cleaned; Install the cleaned lens into the base according to the above method. Second-hand cotton swabs are prohibited to be used for the operation.

We will equip one pack of cotton swabs special for cleaning lens together with the equipment.

6.2.2 Storage of optical lens

1) The proper storage of optical lens could maintain the good quality of the lens.

2) The temperature of storage environment is 10-30℃, and the lens may not be placed in the freezing chamber or similar environment, or else

condensation and frost would be caused when it is taken out, which would damage the lens easily. The temperature of storage environment may not exceed 30℃, or else the coating film on the lens surface may be impacted.

3) The lens shall be stored in a box in a non-vibrating environment, or else the lens could be easily deformed, thus influencing its use performance.

6.2.3 Electrical checking

Mainly inspecting stability of daily supply voltage as well as keeping electrical cabinet of the machine tool is clean and tidy as well as neat with good ventilation. Inspecting completeness and safety of partial lines.

6.2.4 Overhaul cycle

a) For repair cycle of optical maser, cooling-water machine and air compressor, repair cycle set forth in the operation manual shall be used for repair.

b) The first inspection shall be conducted after the machine tool is used for 24 hours for the first time, inspection shall be conducted anew after the machine tool is used for 100 hours, inspection shall be conducted after the machine tool is used for half a year and then inspection shall be conducted once half a year or one year (depending on customer situation).

6.3 Maintenance during Operation

Before the machine tool runs, it's necessary to inspect the machine tool as per daily inspection content. In case of abnormal sound arising in the process of machine tool running, it's necessary to carry out machine halt for inspection. After completion of machine tool running, machine halt shall be conducted as per airport machine halt sequence, workbench surface of the machine tool and surrounding area of the airport shall be cleaned up and placing unrelated things on the machine table or operation table is forbidden.

a) It's necessary to regularly inspect oil level of centralized lubrication pump of the machine tool (in case of insufficiency found, it's necessary to add lubricating oil timely), appropriately lengthen the time of manually adding oil, ensure lubricating oil can be fully added to X-axis guide rail and Y-axis guide rail and machine tool accuracy, keep all moving parts lubricating and lengthen service life of X-axis guide rail and Y-axis guide rail;

b) It's a must to clean dust on Z-axis linear guide rail and lead screw weekly and manually add engine oil;

c) It's necessary to check whether the air pipe and water pipe are damaged every week. In case of damage, it's necessary to timely notify our company's personnel for maintenance;

d) It's necessary to clean sundries and dust on air port and filter net

every week;

e) It's necessary to check the level of cooling water in the water chiller. In case of insufficiency, it's a must to carry out timely addition.

f) It's necessary to check pollution situation on the surface of focus lamp half a month and timely clean optical glasses to ensure service life.

g) It's necessary to inspect protective glass once a day which influences cutting effect;

h) It's necessary to inspect gas circuit once a month to timely remove hidden danger;

i) It's necessary to regularly inspect whether the external cable is scratched as well as whether line interface in the power distribution cabinet becomes flexible;

j) After the machine tool is installed and used for half a year, it's necessary to readjust the level of the machine tool to ensure cutting accuracy;

6.4 Maintenance for Long-term Parking

In case the machine tool is to be parked and not to be used for a long time, please smear all the moving components of the machine tool with grease and package them with anti-embroidered paper. For other parts, it's necessary to check whether there is rust formation, exercise rust removing and rust-proof treatment for rusty parts (dust-proof covers can be added if possible), and clean and check the machine tool regularly.

6.5 Description of Common Faults

6.5.1 Cutting head

A) Capacitance value turns to 0

It's necessary to check whether ceramic ring and nozzle are dirty and blocked.

B) Alarm after touching board

It's necessary to inspect whether the connection of radio frequency line is normal and whether clamp ring becomes flexible

C) Calibration abnormality

It's necessary to inspect whether encoder line becomes flexible and whether oxidization happens to the interface

6.5.2 Servo motor

A) 320 regenerative overloading

Regenerative energy exceeds capacity of regenerative resistance. It's necessary to inspect whether resistance short connection is normal or circumscribed resistance arises

B) 410 undervoltage. Main circuit power supply part in the servo unit

is inspected to be undervoltage

It's necessary to inspect servo voltage fluctuation scope is exceeded

C) 520 vibration alarm

It's necessary to check abnormal sound of the motor and motor speed at the time of running. It's necessary to lower motor speed or speed ring gain (Pn100). It's necessary to inspect whether the value of rotation inertia ratio exceeds actual value or changes a lot. It's necessary to correctly set rotation inertia ratio (Pn103)

D) 710 instantaneous maximum load and 720 continuous maximum load

In case of the motor failing to be actuated due to mechanical factor, resulting in too large load at the time of running, it's necessary to inspect whether foreign matter happens to rack and guide rail as well as running speed of the motor

E) F10 Power supply phase shortage

When the power supply of main circuit is in the state of ON and one phase from R, S and T phases is under the state of low voltage for above 1s, it's necessary to inspect whether power supply wiring is correct and whether each voltage of power supply equilibrates.

F) 101 motor overcurrent detection (current exceeding allowable current passes through the motor)

It's necessary to inspect whether cable wiring for main circuit cable is wrong or undergoes bad contact.

It's necessary to inspect short circuit or earth short circuit happens in the servo motor.

It's necessary to inspect short circuit or earth short circuit happens in the servo unit.

It's necessary to inspect high load borne by the servo motor at the time of stoppage or low-speed running.

It's necessary to confirm whether short circuit happens between UVW phases of servo motor connection terminal of servo unit as well as between UVW and ground connection.

G) 400 overvoltage (main circuit power supply part in the servo unit is detected to be of overvoltage)

Check the voltage of power supply. It's necessary to improve power supply situation as well as set surge suppressor and then connect servo unit power supply anew. In case of alarm still arising, it's possible that failure happens to servo unit. It's necessary to replace servo unit

H) 510 supervelocity (motor speed exceeds the highest speed)

It's necessary to check error of U, V and W phases of motor wiring. It's necessary to confirm wiring of servo motor.

It's necessary to inspect whether motor speed exceeds the highest speed. It's necessary to lower speed command input gain and adjust servo gain or operation conditions.

I) 740 impulse current restricts resistance overloading

It's necessary to inspect allowable times of exceeding impulse

current restriction resistance at the time of main circuit power is ON/OFF as well as lower ON/OFF frequency of main circuit power.

J) 810 Encoder backup alarm

It's necessary to inspect encoder connection as well as carry out setting of encoder.

It's necessary to inspect whether battery of encoder connector as well as connector status are correct.

K) C90 encoder communication fault

It's necessary to inspect the state of connector for encoder. It's necessary to insert the connector for encoder anew and confirm encoder wiring.

Environmental influence, improvement of usage environment and changing cable. In case of failing to be improved, it's necessary to replace servo unit.

Ⅶ. Transportation, Shipment and Storage

7.1 Package

The cooling-water machine, optical maser, accessories of laser cutting machine are packaged with wooden boxes and cartons. Other components are all packaged with PE foam plastic and protection film as

the outer layer to prevent damage of any component of the laser cutting machine caused by collision with foreign objects.

7.2 Methods and Precautions for Transportation and Shipment

a) The transport environment of the machine tool shall be free of rain, moisture, tilting, rat and hollow and secure good ventilation, environmental temperature of -10℃-+40℃ and relative humidity of no more than 80%. For transportation and storage of no more than 24h, the allowed environment temperature is 70℃. Long-term outdoor storage is prohibited. If any product requires temporary storage because of any reason, in addition to the above requirements, the storage place and package conditions shall be checked at any time to avoid damage of the machine tool.

b) No one is allowed to climb or stand on or put heavy object on the package box.

c) No one is allowed to drag or move the product by cable connected to the product.

d) It is strictly prohibited to collide or scratch the panel and display.

e) The product package box shall be free of moisture, long-term sunlight exposure or rain.

f) The machine tool shall be carefully suspended or lifted during installation and any collision is prohibited. The wire rope is not allowed to

touch the machine tool and otherwise, soft object shall be used for separation.

7.3 Conditions, Life and Precautions for Storage

The storage environment of the machine tool shall be free of rain, moisture, tilting, rat and hollow and secure good ventilation, environmental temperature of -10℃-+40℃ and relative humidity of no more than 80%. For transportation and storage of no more than 24h, the allowed environment temperature is 70℃. Long-term outdoor storage is prohibited. If any product requires temporary storage because of any reason, in addition to the above requirements, the storage place and package conditions shall be checked at any time to avoid damage of the machine tool.

Appendix B Electrical Schematics (Only for reference, pls ask your sales person to provide the update one after machine shipping)