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Wuhan Questt Asia Technology Co., Ltd

Operation Manual

Laser Welding Machine

Signage400H

Wuhan QUESTT ASIA Technology Co., Ltd

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Chapter 1 Machine Introduction

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1-1 Prospect of AD metal letters/signage welding industry:

With the booming of global advertising industry, metal letters has been more and more popular because of its colorfulness, attractiveness, heating-proof, frozen-proof, no deformation, no fadedness (8-10 years color preservation), corrosion proof, rain-proof, and spontaneous combustion proof and some other good features. AD metal letters are made of stainless steel, aluminum, copper or other metal sheet being cut, polished, hemmed, and welded. The core feature of AD metal letters is being rustproof, with long life span and dimensional looks. It's widely used in LED illuminated billboard, exterior/interior signs, branding, door plate and etc.

Regular combination and fixing of metal letters are done via glue, rivets or soldering, but all of them have big defects. Metal letters combined by glue always get loose with time goes by, especially at outdoors. Fixing by rivets sounds good, but not good-looking. Soldering is never a green way of fixing metal letters because of the poisoning gas produced when processing.

However, laser welding technology makes two metal sheets become one only by a few melting spots. From any aspect, laser welding is the best solution and the greenest.

1-2 Application:

Applied for the welding of various metal letters, LED illuminated letters, customized metal signage, and exterior billboards.

1-3 Features:

1. Red light fast positioning, CCD display, microscope optional
2. Adjustable working table allows welding from small size to big size of work piece
3. Fast working speed; professional jig ensures the focus fixed and makes welding easier without using CCD or microscope
4. Slight distortion and affect by heating.
5. Capable of partial heating process.
6. Able to deal with complex, profiled, or tiny letters.
7. Low noise and no pollution.
8. Ultrafine positioning rod makes the welding of tiny corner easier without changing spot position
9. New metal processing technology brings higher quality of end products.

Chapter 2 Machine main parts and operation instruction

2-1 Machine preview:



Attention:

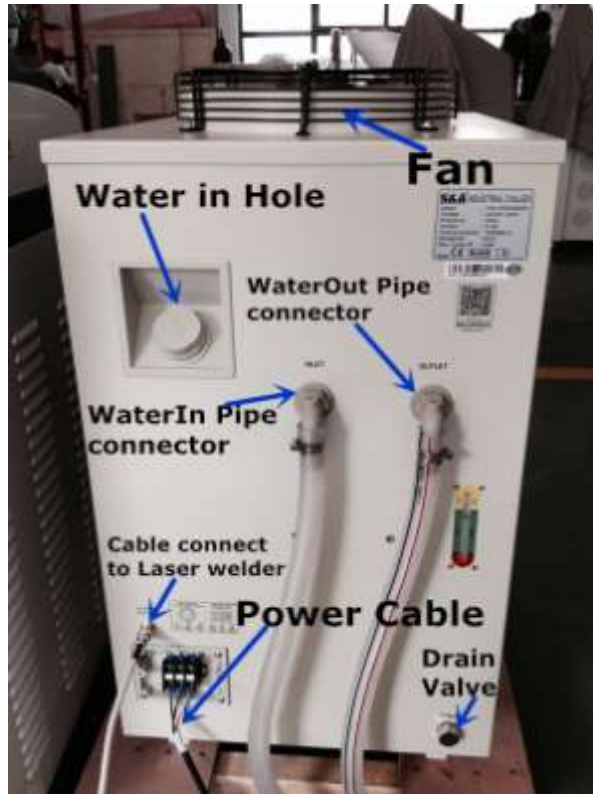
1. The laser system requires 380V 50HZ power supply. Water cooling system requires 220V 50HZ power. Any damage caused by misconnect is not obliged by seller.
2. Current ranges from 60-200A, and pulse ranges from 1ms -5ms. The frequency is 4Hz for spot welding and 20Hz (or above) for continuous welding.
3. Make the laser chamber up and down by twisting the wheel-bar until you find the beam lightest, roundest and sounds loudest. That means the best laser is ready with correct focal length. To avoid penetration of material, you may decrease the current or enlarge the facula to weaken single power.
4. Do not energize equipment before installation to avoid electric shock or other dangerous accidents.
5. The standard protection mat is plastic. When it's worn out, glass plate of exactly same size with the table would be recommended.
6. The water inside the chiller has to be replaced once a month. Deionized water is preferable, but drinking water is also fine.

2-2 Hardware installation:

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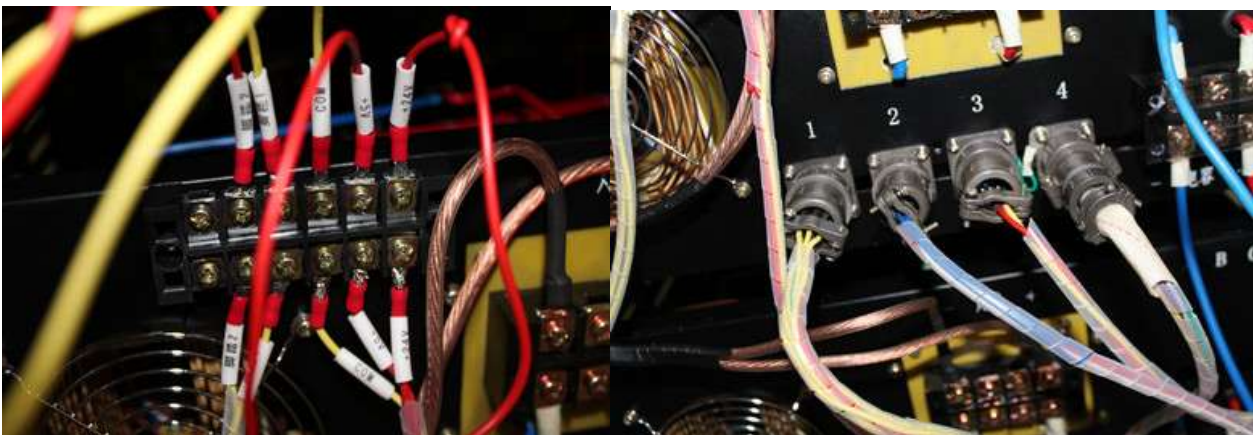
- 1) Link one water tube to "OUTLET", and another to "INLET", then fix the bolts tight.(A and A or B and B for one group),full fill the water tank .

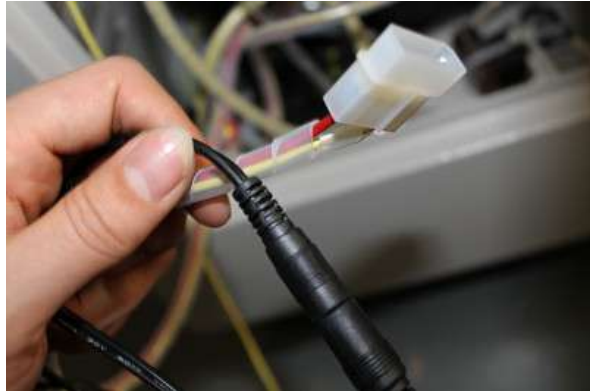
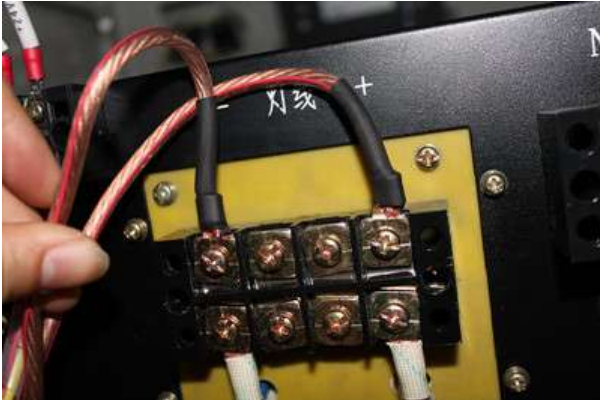


- 2) Connect all the cables in Power Supply box , Flow Alarm at the back of master and foot switch



- 3) Power Line





Two groups of line as shown on access, Two sets of lines without position requirements

4) Adjust laser cavity to the most suitable place and tighten the four screws



5) Red light locator switch



6) Connection of CCD and laser head



The laser system requires 380V 60HZ power supply. Water cooling system requires 220V 60HZ power.

Attention: It requires 6 square mm wires, and 60A air switch.



7) Twist the two knobs to make fine tuning of laser head's horizontal position



- 8) Twist the wheel handle to adjust the vertical position of laser head



- 9) Press the wall tape and cover tape together with your finger, pull them back against positioning rod, make sure the red dot is just on the seam to be welded, then trigger the laser with foot pedal.
- 10) For fiber laser gun, turn to Fiber Mode first, press the red button with your finger, then the laser beam will come out.



2-3 Machine operation

A. Turn on the machine

1. Turn on air switch
2. Turn on the water chiller switch (Attention: Set the water temperature no more than 30 Celsius degree.)
3. Pull and twist emergency stop button
4. Turn on key switch
5. System initializing, press OK when it reads OPEN in left-top corner of screen.
6. After the lamp is turned on for 90 seconds, you can hear the sound when the relay of the machine casing is closed and a sound of “beep” from the buzzer, which means the laser lamp, is lightened. The word “Close” will appear in the left-top corner, which means the machine is working normally. And you may adjust the parameters now.

B. Turn off the machine

1. Move cursor to CLOSE, and then press OK. The word “Close” will be displayed. A sound will be heard when the relay in the machine casing is disconnected.
2. Turn the KEY switch counter-clockwise to OFF position;
3. Turn off Emergency Stop
4. Turn off water chiller after 1 minute wait
5. Shut off General Power supply.

2-4 Parameter specifications:

Current: Laser current value

Regulate range: 50A ~600A

Pulse: Single laser release time

Adjusting range: 0.1ms~15ms

Frequency: Welding times per second

Adjusting range: 0.5Hz ~ 50Hz



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Facula: Positive and negative defocus from 0.1~3.0mm

Attention: This option is locked. Please adjust facula by turning the grey knob on the other end of laser cavity.

2-5 Control Panel

Precautions:

Please read instructions carefully before starting up the Laser Welding Machine.

Operation instructions

The two Select buttons are used for selecting the menu on the screen; the change of the parameters is controlled by the Adjust button on the panel. When the cursor is moved to the corresponding place, the related button can be pressed to set the required parameters.

Width:

It displays the pulse width of the laser discharging per millisecond, minimum value 0.1 and maximum value 20. The wider the pulse width is, if the working voltage is the same, the higher output energy of laser will be. Press the Up/Down key on the control panel for one time, the pulse width of laser discharging will be increased or decreased by 0.1 millisecond.

Frequency:

It displays the frequency of laser discharging, with the unit of HZ. The higher the frequency is, more times laser will shoot in unit time. Press the Up/Down key on the control panel for one time, the pulse width of laser discharging will be increased or decreased by 1HZ.

Light shielding:

When the pedal switch is closed and the word “laser” is displayed in the screen, the liquid crystal light valve can shield the flashing light. Under non-work conditions, the word “laser” won't be displayed.

Working current:

It displays the discharging current for the laser. When the pulse width is identical, the higher the working voltage is, the higher laser output energy will be. Press the Up/Down key on the control panel for one time, the discharging current for the laser can be increased or decreased by 1A, ranging from 50—600A.

Chapter 3 Technical index

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3-1 Laser:

Working material: $\phi 8 \times 145\text{mm}$, Nd^{3+} : YAG

Wavelength: 1064 μm

Pulse xenon lamp: $\phi 8 \times 270$

Pulse frequency: 0~20ms, gradational adjustable

Max single pulse energy: 100 joule

Max. laser power: 400W

3-2 Technical parameters

Model	400W
Laser working substance	Nd^{3+} : YAG Crystal & ceramic resonance cavity
Max. single-pulse energy	100J
Max. peak power	14KW
Laser wavelength	1064nm
Focal facula diameter	$\phi 0.10\text{-}3.0\text{mm}$ adjustable
Rated output power	400W
Min. molten pool	0.3mm
Pulse width	0.5ms-15ms adjustable
Pulse depth	$\leq 3\text{mm}$
Pulse frequency	1-50HZ adjustable
Observing system	CCD
Weight	319Kg

3-3 Welding point size:

Diameter: 0.1~3mm, adjustable

3-4 Optics system:

Extending ratio: 4 times

Focus-length of lens: 170mm

3-5 Cooling system

The equipment employs water cooling system in which the magnetic pump drives the circulating water to cool the laser crystal and pumping lamp, with overheat and overflow protection. The deionized water with resistance rate more than 0.5M Ω -cm is used as the circulating water, 4 liters for each time. The circulating heat is taken away by the refrigerating machine and finally discharged into the outside atmosphere by the fan.

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3-6 Power supply: single phase AC 380V \pm 10%, water chiller 220V \pm 10%,50Hz

3-7 Working environment and continuous operation time

Working environment should be clean, oily fog and dust free, far from violent vibration, with operating temperature 10°C-32°C and humidity \leq 90%. Continuous operation time for the whole machine can be more than 8 hours.

Chapter 4 Overall structures and maintenance

The integral machine is composed of five parts, namely, the control cabinet, cooling system, power cabinet, laser and optics processing system.

The equipment can also be divided into five parts in terms of functions, which are:

- 1) Laser;
- 2) Laser power supply;
- 3) Optics system;
- 4) Controlling system;
- 5) Cooling system.

4-1 Laser

(1) Structure

The laser is a device that converts the electrical energy into the laser energy. This machine employs Nd³⁺: YAG Laser, consisting of the following parts:

- a) **Pumping lamp:** it converts the electrical energy into the optical energy that can activate the substances for laser processing. The machine adopts pulse xenon lamp with repetition rate of XMC7-125. Both the electrode and quartz glass tube surface need to be cooled during working.
- b) **Laser crystal:** it converts the optical energy into the laser energy. This machine employs the crystal $\phi 8 \times 145$ mm Nd³⁺: YAG as its working substance.
- c) **Condensing cavity:** it focuses the light from the pumping lamp onto the working materials.
- d) **The optical resonant cavity** can provide optical feedback, allowing the laser to be magnified to form high strength laser for output. This machine employs the plane and parallel cavity made up of flat mirrors with ceramics as its medium. The full reflector's transmissivity is less than 0.4%, output reflecting mirror's transmissivity is 85%.
- e) **Other parts:** high voltage electrode, insulation base plate, positioning bracket, adjustable diaphragm frame and laser holder.

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(2) Precautions and maintenance

As the machine is highly precise equipment whose discharging features the high pulse voltage and charging features the large capacity, and the laser focusing energy is highly centralized, the operators must obtain professional knowledge and skills before they work on the machine.

A. Optical resonant cavity

The two medium diaphragms of optical resonant cavity are absolutely parallel to the laser bar's end face, touching or random adjustment is not allowed. Do not open the outer hood of the laser randomly and keep the optics surface highly clean. Otherwise, the high-energy laser will damage the diaphragm layer. When the laser output energy is lowered down, the operator should first check whether the medium diaphragm is clean. If any dirt, he can use lens paper or cotton wool moistened by the cleaning agent (liquid mixture with ethanol absolute and ethanol respectively occupying 50%, the same when mentioned in the following part) to clean it gently. Then check the resonant cavity to see if it is misadjusted.

B. Cooling system

The laser has one water inlet pipe and one outlet pipe, respectively connected to the cooling channels of the lamp and bar. Unsmooth water flow at any part will cause large loss. Each time when the equipment is assembled, the operator should check the water flow at each path and make sure no fault exists before starting up the laser.

C. Xenon lamp replacement

The average service time of the pulse xenon lamp is 10^8 times of blinking if it works under its rated power and belongs to the consumptive pieces. To ensure the normal performance of the machine, the lamp must be replaced when it has reached its rated blinking times (about 10^8 times) and the energy becomes low.

In cases that the xenon lamp is damaged or its service time is shorted due to other causes (for example, it can't pre-illuminate or no energy output is available when the voltage is increased to 500V), the xenon lamp should also be replaced.

As the strength of the sealing at the lamp's two ends is relatively low and apt to being damaged, special caution should be offered when substituting the lamp. The following procedures should be followed:

- a. Turn off the machine, cut off the water supply and discharge the remaining electricity on the energy-storage capacitor;
- b. Remove the electrodes of lamp;
- c. Remove the gland of lamp, carefully pull out the lamp from the side of the full reflector;
- d. Use cotton moistened by cleaning agent to clean the sleeving;
- e. Check to see if the appearance, size and other aspects of the new lamp is conforming;
- f. Install the new lamp into the chamber, press the gland tight and mount the electrodes;
- g. Connect to the water supply and check the sealing of each part to see if they are reliable;
- h. Turn on the main power to check whether the lamp can discharge normally;

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- i. Try single spot operation, check whether the output energy of laser meet the requirements. If the output is not ideal, repeatedly adjust the resonant cavity;
- j. Cover the laser with outer hood.

D.Nd³⁺: YAG crystal is the core part of the laser, and is fairly expensive. Therefore it should be installed with great care. The two end faces of Nd³⁺: YAG crystal bar is absolutely parallel to each other and has high cleanliness. If there is any pollutant on the end faces, the luminous efficiency will be lower, the facula mode will deteriorate, or even can't illuminate normally. In that case, the space housing this machine must be cleaned and professionals should be called for related treatment. Take out the Nd³⁺: YAG crystal bar, use lens paper or absorbent cotton moistened by cleaning agent (liquid mixture with ethanol solution and another respectively occupying 50 %,) to remove the dirt gently. The causes leading to the damage of crystal bar can be described as follows:

a.The flow of cooling water is over or interrupted, the energy input into the lamp makes the lamp and bar overheated, which results in the cracking of the lamp and bar;

b.The end face is bumped, scratched or even damaged by hard object;

c.As the diaphragm layer is polluted , the bar is damaged when the high strength laser passes by;

d.The bar is pressed too tightly or the applied force is uneven when it is installed, the over high interior stress breaks the bar. In this case, the operator should not open the hood of the laser, nor operate the YAG bar. If the end face is found polluted, professionals should be called for the related treatment.

E.The condensing cavity doesn't need maintenance work. Normally, it is not allowed to dismantle the condensing cavity.

F. Over voltage protection

There are three kinds of voltage applied to the pulse xenon lamp in succession, namely, trigger voltage about 13-18 kv, pre-burning open-circuit voltage 1500-1800 v and arc-discharge voltage about 500-2500 v. Therefore, the lamp electrode should not get too close to other metal objects, and a distance of more than 15mm should be kept. The insulation panel's surface should be kept dry and clean so as to avoid pollutions which may lower down the insulation performance to bring short circuit.

4-2 Laser Power supply

This machine can be operated either through the keys on the control panel or the joystick.

(1) Principle

The laser power supply system with repetition rate is employed, the L—C resonance charging is adopted for the charging circuit. The capacitance-inductance energy storage network is used for supplying the power for the lamp. The control circuit is centered by the

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single-chip microprocessor, which can be used to adjust the output energy of power and the repeated frequency. The system also features its multiple linked protections, ensuring the emergency stop of the power under abnormal conditions.

(2) Electric circuit

The electric circuits are made up of the following parts:

Main return circuits: including the charging circuit, energy storage network, discharging circuit and pre-burning and trigger circuit.

Controlling circuits: including the electric controlling circuit, microprocessor controlling circuit and different kinds of protection circuits.

A. Step-up/rectification circuit: it employs the single-phase stepping up, which converts AC 220V into DV 500V that supplies power to the charging circuit.

B. Charging circuit

The charging circuit is composed of the IGBT switch tubes. Such a charging mode will increase the repetition rate of the circuit.

C. Discharging circuit

The discharging circuit can be controlled by the silicon controlled switch that must be kept shut off. After the energy storage network is charged, the silicon controlled switch is shut off, then after the delayed time, the discharging can be realized by turning on the silicon controlled switch. Once the energy storage capacitance is fully discharged, the silicon controlled switch will be automatically shut off.

D. Pre-burning and trigger circuit

It is made up of the step-up and transforming circuit, high voltage bridge rectifier, filter, current-limiting resistor; current relay, high voltage pulse transformer and high voltage trigger circuit.

As the pulse xenon lamp is in the state of normal glow discharge when it is pre-burned, it has the nature of negative resistance. To ensure the normal glow discharge of the xenon lamp after the arc-discharge is finished, the pre-burning circuit must have the nature of high current source and its current-limiting resistor must be relatively high. The internal triggering mode is employed for this machine, with 50Hz automatic triggering. Once the pre-burning switch is closed, the high voltage pulse transformer will generate high voltage of 15-20 kv to be applied onto the resonance cavity. As long as the pre-burning is established, the trigger circuit will be disconnected immediately.

E. Protection circuit

a) Pre-burning disconnection protection

When the pre-burning current is shut off, the discharging circuit will have failure, the protection circuit will be activated to send out failure signal.

b) Flow interlocking protection

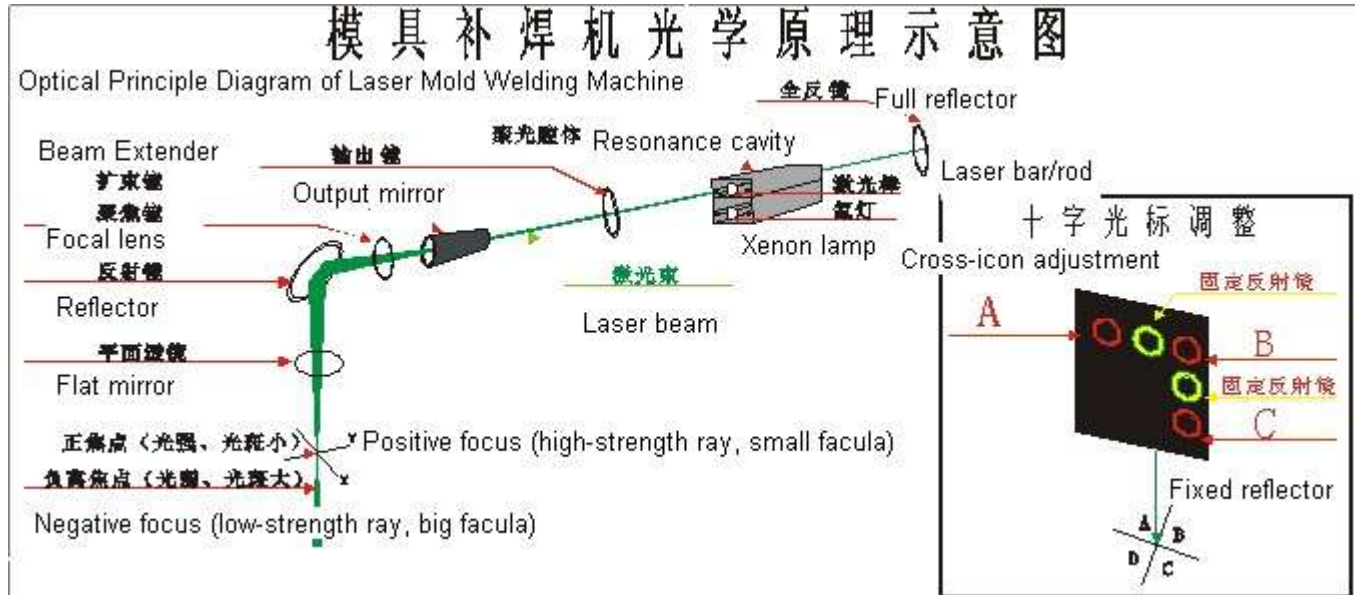
When the flow of the circulating water inside the cooling system is insufficient, the flow

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breaker will be opened and the pre-burning circuit and main circuit will be disconnected, resulting in the shutoff of the whole machine.

4-3 Optical system



Impact of Focus Setover on Welding Quality

The laser welding normally needs a certain degree of off-focus operation, for the welding point can be vaporized into a hole if the power density at facula center of laser focus is excessively high. The planes that are not with the laser focus will have relatively even distribution of power density.

Two off-focus modes are available: positive off-focus and negative off-focus. If the focal plane is above the work piece, it is called positive off-focus, contrarily; it is called negative off-focus. According to the theory of geometrical optics, when the positive off-focus distance is the same as the negative off-focus distance, the power density on corresponding planes will approximate to each other. However, the shape the obtained molten pool is different. Under the circumstance of negative off-focus, the large penetration depth could be reached, which is related to the forming of the molten pool. Experiments show that when the material is heated by laser for 50~200us, it begins to be molten, forms the liquid-phase metal and the evaporation appears to form the pressure-applying vapor that spurs at extremely high speed with dazzling white light. At the same time, the high density gas moves the liquid-phase metal to the edge of the molten pool to form the dent at the center of the molten pool. Under the circumstance of negative off-focus, the power density inside the material is even higher than the surface, which is apt to cause stronger melting and vaporizing that

pass the optical energy into the in-depth part of the material. Therefore, in actual applications, if the large penetration depth is required, the negative off-focus operation should be carried out. When thin materials are welded, the positive off-focus operation is needed.

(1) Microscope/ CCD

This machine employs the binocular zoom stereo microscope, featuring its clear and stereo vision. The coated protection glass is added in front of the object lens to avoid the pollution which can be caused by the splashing metal articles during processing. For transportation and storage, the ocular can be removed by loosening the fixing screws.

(2) Laser extending and focusing system

The machine employs the design that both the laser and microscope's beam path share the same object lens. The focus setover is determined by the welding process and adjusted by the off-focus handle, with procession graduation marks.

(3) Welding point indication

There is a reticle in the object lens, the intersection point of which is overlapped with the laser point. Through the intersection point of the reticle, the laser beam can be aligned to the welding part during work.

(4) Precautions

- A. The surface of optical parts can't be contacted or wiped with hand, cotton yarn or hard object, nor blown with mouth. The blowing ball can be used to remove the dust on them. If there is any pollutant, the operator can use cotton wool or lens paper moistened by cleaning agent to clean them
- B. To avoid damage, do not dismantle the parts. Otherwise, dust or smoke may enter into the inside of the optical system.
- C. When the protection glass needs to be replaced, the object lens and the press ring should be removed. Replacement work should be done with great care.

4-4 Cooling system

(1) Structure

The cooling system is enclosed water circulation system composed of heat exchanger, magnetic pump, filter, water tank, flow switch and temperature contactor, valve and other parts.

(2) Working principle

The magnetic pump pumps the deionized water in the water tank that will cool the working material (YAG bar), xenon lamp, lamp electrode of the laser. The deionized water with absorbed heat will pass by the heat exchanger discharging the heat and flow back to the water tank.

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The resistance rate of the deionized water is required to be higher than 0.5MΩ—cm. After some time of use, the deionized water's resistance rate will be lowered down and it may have impurities, dirt or turbidity that will make the xenon lamp not lightened or pollute the laser cavity and glass tube, and lower the luminous efficiency. If so, the used deionized water should be substituted immediately (if the machine is continuously operated, the deionized water in the system should be replaced once a week).

The heat exchanger works through the Freon to exchange the heat for the cooling water and carry away the heat in the purified water. A flow controller and over-temperature contactor are installed in the cooling system to monitor the water that comes into the laser. Once the flow of the circulating water is insufficient or the water pump in the system works abnormally, the power for the laser should be turned off immediately so as to avoid the accident that can be caused by the explosion of the lamp bar.

parameters (for reference)

Material	Current (A)	Pulse (MS)	Frequency(HZ)
0.3MM SS	50	1-2	5-10
0.5MM SS	60	1-2	5-15
0.8MM SS	70	1-2	5-30
1.2MM SS	80	1-2	5-30
0.3MM Titanium	50	1-3	5-10
0.8MM Titanium	60	1-4	5-30
0.5MM Zinc	80	1-4	5-10
1.0MM Zinc	100	1-4	5-15
0.3MM Aluminum	100	1-3	3-10
0.5MM Aluminum	120	1-3	3-10
0.8MM Aluminum	140	1-3	3-10
1.2MM Aluminum	160	1-3	3-10
1.5MM Aluminum	180	1-3	5-15
0.6MM Brass	100	2	5-10
1.0MM Brass	110	2	5-15

The parameters aboved are based on 200W channel letter laser welder. Should for 300W and 400W machine, the current and pulse width should be decreased, the min. current is 50A. Should the laser is strong, then reduce pulse width, or enlarge the facular.

Whatever the material is, the best welding is the proper facular when focus length is correct. There will be

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clear welding sound when get the right facular. Should low voice welding, lower down the facular and vice versa.

Attachment 2: Common Troubleshooting

Fault	Possible Reasons	Proper Solutions
Machine won't work with the power on	1. Flow alert is not connected 2. AC fault	1. Check the water chiller connection 2. Check the total power supply
Xenon lamp won't light up with the power on	1. Lamp is broken 2. Lamp tube gets black 3. Pre-ignition circuit failure 4. Lamp's service life runs out 5. Lamp poles fall off	1. Replace a new lamp 2. Change the water in the chiller 3. Check the volts according to the circuit map 4. Replace a new lamp 5. Check and plug the poles
Cooling fan won't work with the power on	Fan power failure	Replace a new fan
Output energy reduce	1. Water polluted 2. Lamp worn out 3. Condenser cavity worn out	1. Change the water in the chiller 2. Replace the lamp 3. Clean or replace the condenser cavity

If the above steps do not correct the malfunction, do not disassemble. Please do not hesitate to contact us and please operate under the guidance of our engineers.

Attachment 3: Laser Alignment

If the optical path get loosen after long-distance transport, or if the output spot is not round any more because of the operator misuse, you need to re-adjust the optical path. Generally we need to use of a ceramic dimmer, a piece of black paper also works if you don't have the dimmer.

A. Take off the cover of the laser welder chamber.



(A)

B. If the two electrodes of xenon lamp have take off during transportation. Connect them first. The operation should be very careful, softly turn on the screws. Otherwise, the lamp will broken.

(When you change the lamps, first take off ,then connect the two electrodes head)



(B)

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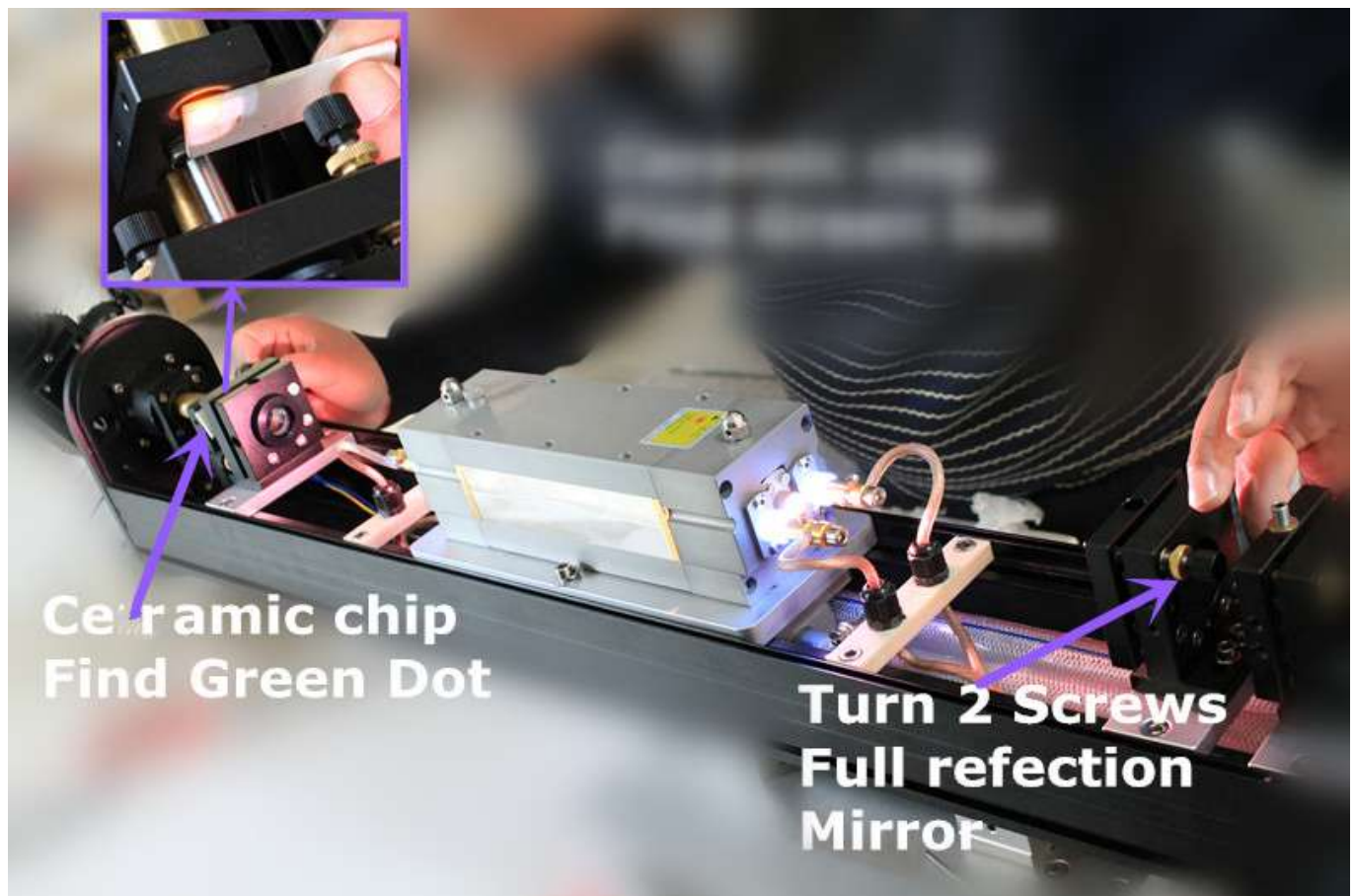
3.3 Laser Alignment

This is not a must-do when you firstly receive this machine. Only when you find the laser spot is not round any more or the laser energy becomes very weak, you may consider to do laser alignment.

A. Start the laser welder by twisting the key switch and set parameters as:

Curt=100A / Wid =1ms / Fre =10 Hz

B. Hold the ceramic dimmer chip (beam watcher) and put it in front of the brass tube with your left hand.
Now the laser beam can be intercepted and becomes a green dot on the chip.



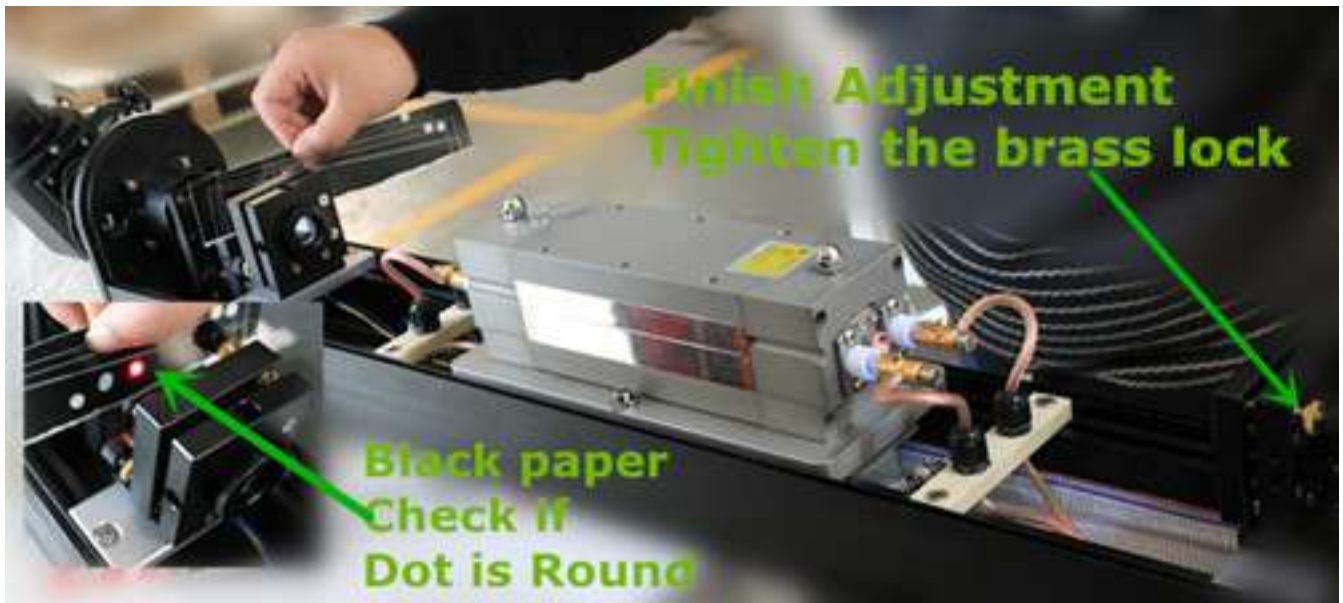
C. Adjust the two black screws as the following picture with your right hand until you find the green dot roundest and brightest. This means the laser beam quality is very good.

After that, you can use a black paper ,mark some dot, check if the marked dots are round and even. **Here, the Frequency should be 1HZ.**

After finish laser alignment, remember to fix the 2 screws you just turned, tighten the brass screw.Very important!

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(C)

Note:

We have align the laser beam before shipping,so after you got the machine, no need to align the laser beam. If needed, just a slight change.

If there are any damage or big movements of the inside parts (especially the mirrors and chamber), then maybe you need a big adjustment.

To find the laser beam, **the frequency should be 10HZ**. Keep press the foot switch, turn around the two screws of the full reflection mirror,use the beam watcher to find green dot.

After find the green dot on ceramic chip, then do as the above alignment operation to make the green dot the roundest and brightest.

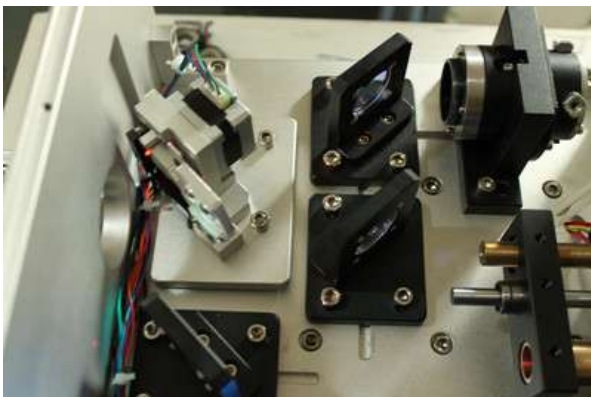
Laser Alignment in Fiber Mode

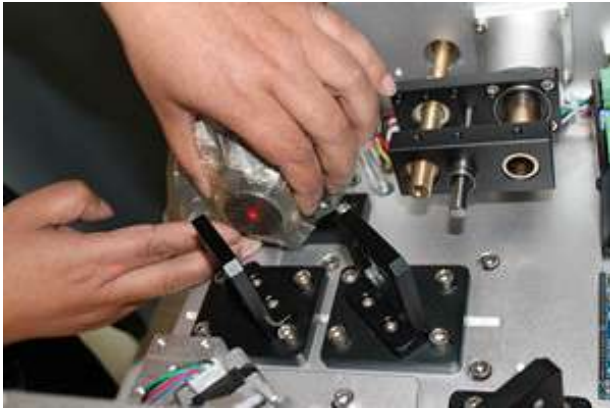
When laser beam is delivered through fiber cable, we have to make sure the output beam comes out from exactly center of the fiber core. If there is any deviation, the output energy will be affected or even worse the fiber cable will be burnt. Now let's learn how to check and align.

1、 Switch to Fiber Mode



2、 Remove the cover of the sliver optical box and place the observing lens as following figures

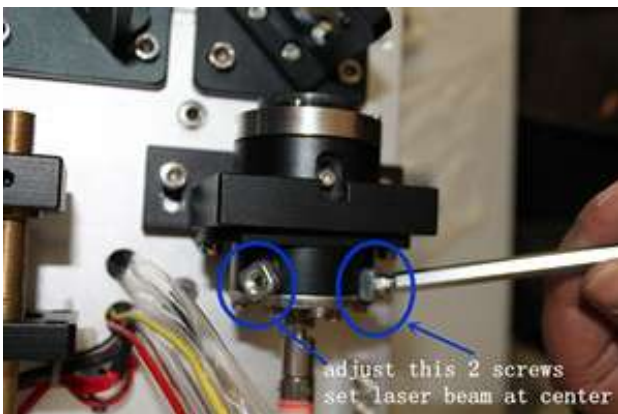


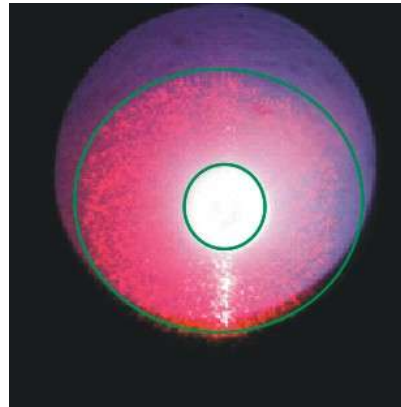


- 3、 Point the fiber head to a bright place and see through the lens on the top, you may find an enlarged image of cross-section of the fiber (white spot) and the red light indicator(red spot).



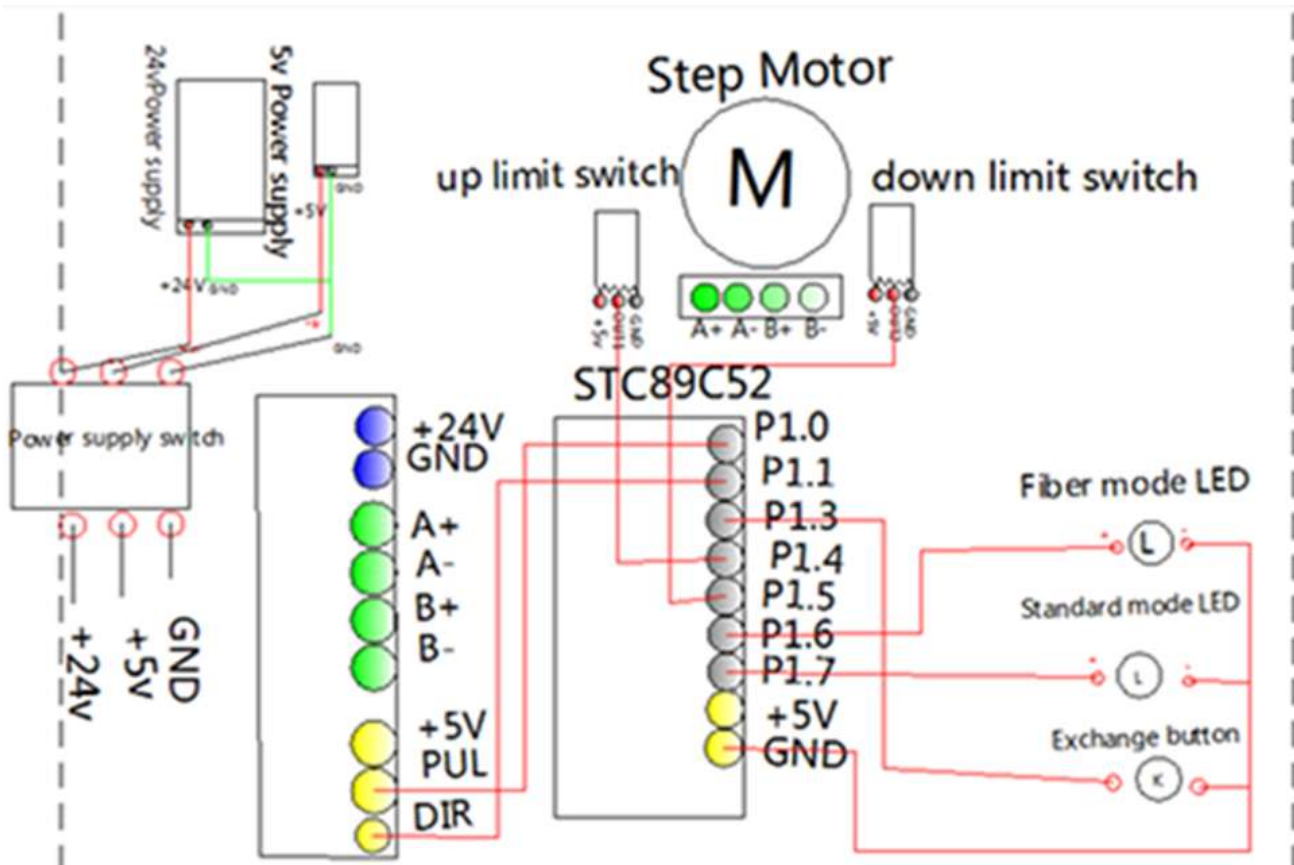
- 4、 Adjust the six screws around the reflecting lens slightly until the small white spot is in the very center of the big red spot. Also adjust the 2 screws as following photo Now we can get laser output beam of best quality.





5、Close the cover of the box.

Wiring Diagram For Fiber Parts



Power supply switch cable drawing

