

# Operation Manual

## ROBOT400 Multi-function Laser Welder for Mold Repairing



## 1. Brief Introduction:

ROBOT 400 Laser Welding system for Mold is specially developed for laser welding for mold. Also it is widely used in perforating and spot welding of gold and silver jewelry etc. The laser welding process is thermal conduction, i.e. the laser radiation heats the surface of work piece, and the surface heat diffuses to the interior through thermal conduction and melts the work piece by controlling the width, energy, peak power and repeating frequency of laser pulse to form specific molten pool. Because of its unique advantage, it is widely used in the process of all kinds of mold, gold and silver jewelry and welding of mini and small parts.

The surface of the metal will be changed by the laser, it has been heated and conducted to the deeper of metal rapidly, and the surface will be melted when the consistency of laser power is enough, some parts is momentary vaped for the high consistency, and it is come into being the weld crater.

The laser welding compares with other welding craft can realize the different kinds of materials' welding, also the welding component thermal deformation is very small, the attachment quality is high. The laser welding superiority can realize specially the very small scope heating characteristic, it is widely used with the precision component like plastic mold, gold and silver jewelry, the battery, the automobile industry, aviation industry and some other applications and so on.

## Features

- The energy, pulse width, frequency and light spot size can be adjusted in a large range to realize different welding effects. The parameters are adjusted by the lever in the seal cavity, which is simple and highly efficient.
- Golden converging cavity is imported from Germany. It is corrosion resistant and high temperature resistant, and has 8-10 years service life. The life of xenon lamp is more than 8 million times.
- Use the most advanced light shielding system to eliminate the irritation to eyes by light during working.
- Able to work for 24 hours continuously; stable performance; free of maintenance in 10,000 hours.
- Human-based design accords with ergonomics, avoiding fatigue after long time working.

## Advantage

High speed, high efficiency, deep, small deformation, small heat effect area, high welding quality, pollution free welding spot, environmental friendly.

## Application

Widely used in aviation, aerospace, sports products, jewelry, golf head, mold, medical instrument, titanium alloy denture, instrument, electronics, machinery, automobile, etc, especially for the perforating of gold and silver jewelry, spot welding, repairing, inlay and welding of claw.

## 2. Application

It is mainly used for a variety of common small precision metal parts (such as K gold, platinum, titanium, silver, copper, nickel, aluminum, magnesium, stainless steel, etc.) for welding, welding firm, weld lines appearance. Also for the repairing of precision plastic mold, mold steel for a variety of welding. Advantages of laser welding mold:

- 1, Laser welding point diameter of only 0.3mm ~ 3.0mm, the laser welding of high precision, high accuracy.
- 2, Using 1064nm wavelength laser.
- 3, The heat within the small deformation of the workpiece does not appear that there is no porosity.
- 4, Make up the traditional welding, cold welding repair welding in the fine surface deficiencies, inefficient oxidation, the workpiece does not change color.
- 5, In the narrow parts of the welding, repair welding parts of the deep cavity, the surrounding wall-bit will not hurt. Deformation is not easy to make the product or the phenomenon of depression around the weld pool.
- 6, Mold welding fine corners without burning the edges.
- 7, Dedicated argon gas, welding parts and substrate oxidation do not scorch.
- 8, Joystick control, work may be suitable for any mobile any curve.
- 9, Microscope operation, a small area at a glance.
- 10, Various kinds of imported special wire, suitable for various kinds of imported mold material after welding can be polished, etch.
- 11, Laser welding can save a lot of welding workpiece, the workpiece model pay repair materials, labor and time costs.

## 3. Specification

- 1, Laser  
Work material: Nd3 +: YAG  
Wavelength: 1064nm  
Pulsed Xenon lamp:  $\phi 8 * 297\text{mm}$   
Pulse Frequency :0-1- 50HZ

The largest single-pulse energy: 100J

Laser power: 400W

2, Spot size

Adjustable diameter :0.3-3mm

3, The optical system

Beam expander magnification: 3-5 times adjustable

Lens focal length: 150mm

4, The cooling system

With water cooling system, magnetic drive pump circulating water for cooling the laser crystal and pump light, and there was moderate traffic control and protection. Recycled water use is greater than 0.5MΩ-cm resistivity deionized water, each water 4 liters. Refrigerator away by the heat cycle, and ultimately by fan heat into the atmosphere.

5, Power Requirements: Single Phase AC 220V or 3 Phase AC 380V  $\pm 10\%$ , 12KW

6, The working environment and continuous working time

The working environment clean, no smoke, dust, away from strong vibration, temperature 10 °C -32 °C temperature is below 90%. The whole is greater than 20 hours continuous working time.

#### 4. Machine Configuration

- a. Repairing Tower
- b. Laser Cavity
- c. Laser Controller
- d. Laser Water Chiller
- e. XYZ worktable
- f. Hand panel

#### 5. Installation

#### 6. Operation

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The system is composed of the laser, power supply, optical working system, control box and the cooling system. According to the function of each parts, it can be sorted in the following parts:

- (1) Laser
- (2) Laser power supply
- (3) Optical system

- (4) Control system
- (5) Cooling system

### (1) Laser

1. The laser is the device of transforming the electricity energy to the laser energy. In this system, the laser is Nd<sup>3+</sup>:YAG laser. It is mainly composed of the following parts: (1) pump lamp (2) laser Nd:YAG rod (3) Laser cavity (4) optical resonator (6) other accessories.

Pump lamp excites the laser medium to transform the electricity energy to optical energy. The laser rod transforms the optical energy to laser energy. In this system, the pump lamp is the pulsed Xenon lamp and the laser medium is Nd<sup>3+</sup>:YAG rod.

In the cavity, the light emitted from the pump lamp is focused on the laser medium. In our system, it is the close ceramic cavity.

In the optical resonator, the laser is amplified to form the high intensity laser output. There are two high damage threshold coated plane mirrors which are set parallel in the resonator.

Only 3% of the electricity energy is transformed into laser energy during the laser working, the other electricity energy is transformed into heat and distributed in the pump lamp, laser rod, and the cavity body. To protect the laser, this heat has to be taken away. In this system, the pump lamp, laser rod and the cavity body are cooled by the circulation deionized water.

Besides the above parts, there are still the other accessories as follows:

- (1) High voltage electrode, (2) The insulating base, (3) Positioning support, (4) The adjustable mirror support, (5) Laser support.

### 2. Things to be aware of and the maintenance:

The laser system is the opto-mechano-electrically integrated. It is very precise and need to be operated by the authorized person who has the professional technology and technique .

#### A. Optical resonator

The optical resonator is composed of two coated plane mirrors which are set strictly parallel in the resonator. These two mirrors can not be touched and moved after the adjustment and keep clean, otherwise, the surface of the mirror may be destroyed. So, the laser cover can not be moved at any time. When the laser output becomes low, firstly, it has to be checked whether the surface of the mirrors are stained. If it has been stained, use the lens paper or absorbent cotton to erase softly with the cleaning liquid (the mixture of 50% no water ethanol and 50% aether). Then, check the adjustment of the resonator.

#### B. Cooling system

There are two water hoses connected to the pump lamp and the laser rod respectively. Either of the hoses is blocked, unredeemable damage may be caused. Every time when the system is reinstalled, before starting the laser, it has to be checked carefully that the water flow is correct.

#### C. Change lamp

The pulse Xenon lamp is consumable part. Its service lifetime is 10<sup>6</sup> flash times. To guaranty the normally work of the system, the lamp has to be changed when it reaches its service lifetime and the laser energy becomes low.

If the Xenon lamp is damaged or reaches the service lifetime early (can not be ignited or there is no laser output when the voltage rise to 500V), it also need to be changed.

More attention must to be paid to the two ends of the Xenon lamp during the changing:

- (1) Turn off the system, close the water and discharge the remain charges in the energy store capacitance;
- (2) Unload the electrode of the lamp;
- (3) Remove the top of the lamp, draw out the Xenon lamp carefully beside the reflecting mirror;
- (4) Clean the cover tube with the cotton and the cleaning liquid;
- (5) Verify the size of the Xenon lamp;
- (6) Insert the lamp in the cavity, close the top and mount the electrode;
- (8) Check the water leaking;
- (9) Turn on the main power supply to check the discharge;
- (10) Check the laser output power by using the single pulse mode. If the laser output power can not meet the requirement, the resonator need to be re-adjusted repeatedly;
- (11) Close the laser cover.

#### D. $\text{Nd}^{3+}$ :YAG rod

$\text{Nd}^{3+}$ : YAG rod is the core of the laser, it must be very careful to handle the rod during the installation and the using. The two end of the rod must be keep parallel strictly. If there is dirtiness on the two end surface, it has to clean the room firstly, then ask the professional service people to handle the rod. Take out the  $\text{Nd}^{3+}$ : YAG rod, clean it by using the lens paper with the cleaning liquid (the mixture of 50% no water ethanol and 50% aether). The reasons of the rod damage may be the followings:

- a. The flow of the cooling water is low or the water hose is blocked. It causes the overheat in the lamp and the laser rod and breaks the lamp and laser rod.
- b. The end surface is hurt by something hard.
- c. The coated end surface is burned out because of the dirtiness on the surface.
- d. The strong and uneven stress from the installation of the rod breaks the laser rod. So, usually, the operator can not open the laser cover and can not touch the YAG rod. If there is dirtiness on the end surfaces of the YAG rod, it has to be handled by the professional service people.

#### E. The maintenance of the cavity

The cavity is made of ceramic which has very high reflectivity. It is no need 聚 to do the maintenance. So it is no allowed to take apart.

#### F. The protection for high voltage

To start the laser, there are three voltages applied to the Xenon lamp. They are the triggering voltage: about 15~20kV; the pre-igniting voltage: about 1.7kV~2kV and the arc discharge voltage: about 500~1900 voltage. It must keep at least 15mm distance with the surrounding component. During the operating, the insulating board must be kept clean and dry to prevent the short-circuit of the high voltage.



## (2) Laser power supply

The system can be controlled by the operating panel and operating stick.

### 1. Specification

The laser power supply in this system is pulse mode power supply. The IGBT is supplied by the L-C resonating charging and the energy storing circuit. The control circuit has two SCM as the core. So the output power and the repeatability can be adjusted conveniently. The power supply can be adjusted independently or together with the control system. There are multi-inter-lock protections in this system, to shut off the main power supply in emergency situation.

### 2. Description for the electric circuit

The electric circuit is composed of the followings:

Main circuit: include the charging circuit, energy storing circuit, discharging circuit loop and pre-igniting circuit.

The control circuit: include the electric control circuit, microcomputer control circuit and all kinds of the protection circuit.

#### A. Voltage rising/rectifying circuit

By rising the single-phase voltage, the voltage rising / rectifying circuit convert the 220 ACV to 620 DCV to supply the power of the charging circuit.

#### B. The charging circuit

The charging circuit is composed of the IGBT power transistors. This kind of circuit can increase the repeatability of the charging.

#### C. The discharging circuit loop

The discharging circuit loop is controlled by the SCR. During the discharge, the discharging IGBT power transistors have to be shut off. After the charging of the energy storing circuit, the charging IGBT power transistors are shut off, waiting for sometime delay, the discharging IGBT power transistors are turned on to discharge. When the energy storing capacitor discharging finished, the discharging IGBT power transistors will be shut off automatically.

#### D. The pre-igniting and the triggering circuit

It includes the voltage rising transformer, high voltage rectifier, filter, barretter, current relay, high voltage pulse transformer and high voltage triggering circuit.

The pulsed Xenon lamp is working in the aura discharging during the pre-igniting, which has the characteristic of the negative resistance. To maintain the aura discharging of the Xenon lamp after the arc discharging, the pre-igniting circuit must have the characteristic of constant current. So the pre-igniting circuit must have very high limit resistance.

The triggering mode in this laser is inner triggered by 50Hz pulse automatically. When the pre-igniting circuit works, the high voltage pulse transformer produces the high voltage of 15,000V ~ 20,000V. When the pre-igniting begins, the triggering circuit shut off automatically and immediately.

#### E. Control circuit

The control circuit includes two parts of operating circuit and microcomputer control circuit. The operating circuit controls the water pump, pre-igniting circuit, main power supply, the power supply of the control circuit and the inter-lock protection by means of the components such as the button, contactor and relay. The microcomputer control circuit is integrated in a PCB.

#### F. Protection circuit

##### a) Pre-igniting shut-off protection circuit

When the pre-igniting circuit shut off, the pre-igniting shut-off protection circuit takes into function and sends out the fault signal.

##### b) The water flow inter-lock

When the water flow is low in the cooling system, the water flow relay breaks and shuts off the pre-igniting circuit and the main power supply, thus to stop the system.

### (3) Optical system

#### 1. Binocular microscope

To observe the working piece clearly, the binocular large caliber and long focus length microscope has been used in this system. Before the object lens, there is a coated protection glass to protect the lens from the spatter during the laser processing. The ocular can be taken down by loosen the fixing bolt for the shipping and maintenance purpose.

#### 2. Laser beam expander and the focusing system

To ensure the laser welding spot in the center of the view all the time during the focusing, the laser beam has to be co-axial with the beam path of the microscope. In this system, the laser beam and the optical path of the microscope share the same object lens. The offset of the focus point is adjusted by the up and down keys. The offset of the focus point is determined by the experiment according to the welding processing technology.

#### 4. The indication of the welding spot

Because the YAG laser is invisible infrared ray of  $1.06\mu\text{m}$ , there is a cross in the ocular, whose intersection accords to the laser spot, to indicate the laser position. Thus the laser beam can be aimed at the welding position on the piece to be welded easily.

#### 5. Caution for the optical system

(1) It is forbidden to touch the surface of the optics by hand and something hard. It is also forbidden to blow the optics by mouth. It can be blown by the special blowing ball or cleaned by the long fiber absorbent cotton ball or the lens paper, if the optics is stained.

(2) Normally, don't disassemble the optical system to prevent from the damage and the dust.

(3) Move the tube of the object lens carefully and don't touch the protect glass. Before changing the protect glass, remove the front tube of the object lens first and the press ring carefully.

### (4) Cooling system



## 1. Construction

The cooling system is the main part of the laser system. It is composed of the heat exchanger, magnetic pump, filter, water tank, switch of water flow, the temperature contactor, ABS hose and valves to form a closed circulation water system.

## 2. The principle of the cooling

The inner deionized water in the water tank is pumped by the magnetic pump to cool the YAG rod, pulse lamp, two electrodes. The heated deionized water goes through the heat exchanger and returns to the water tank. The resistivity of the deionized water must be higher than 0.5 MΩ-cm. When the deionized water becomes dirty or the resistivity of it becomes higher, the Xenon lamp may can not be ignited and the laser cavity and the glass tube may be stained. In this situation, the deionized water has to be changed immediately. ( the deionized water should be changed one time every week when the laser system is operated continuously)

In the heat exchanger, the Freon is used to take the heat away from the inner deionized water. In order to ensure the proper working of the system, there is an over temperature contactor and over flow controller in the cooling system to supervise the water in the laser. Once there is no enough water flow or the water pump does not work properly, or there is no enough water in the water tank, the laser power supply will be shut off immediately to prevent from the lamp exploding or the rod exploding.

## (5)Control System

**Notice: Before any attempt is made to operate this laser welding system, this description has to be read carefully to prevent from the incorrect operation.**

## Main control board introduction

### 1 Up board(including control chip, driver, LCD)

NO	Name	PIN	Function
1	J2	5	From left to right (1)GND, (2)communication signal 1, (3)communication signal 2, (4)+15V, (5) blank
2	J9	6	From left to right (1) GND, (2)select down, (3) OK, (4) parameter (-), (5) , (6)
3	J6	6	From left to right (1)parameter(+) , (2)select up, (3) parameter (-), (4) OK, (5) select down, (6) GND

### 2Down board

NO	Name	PIN	Function
1	J1	4	From left to right (1)blank, (2) GND, (3) +15V, (4)blank
2	J2		FOOTSEITCH (laser output) .

3	J3		From up to down, (1,2)water pressure protect, (3, 4) water tem protect or model choice
4	J4		Buzzar alarm
5	J5		From up to down, (1)sensor single, (2)GND, (3)+15V.
6	J6		From up to down, (1)sensor single, (2)GND, (3)+15V. (two lamps)
7	J7		From up to down, (1) PWM+, (2)PWM-. (3, 4) blank (two lamps)
8	J8		From left to right (1, 2) blank, (3) PWM+, (4) )PWM-.
9	J9		
10	J10		from up to down (1)blank, (2 )GND, (3)ccommunication signal 2, (4)ccommunication signal 1, (5)+15V
11	J11	5	(1) (2) (3) dir (4) pul- (5) pul+ (step motor driver)
12	J12	6	From left to right (1) GND, (2)trip signal, (3) delay charge signal (4)OK main contact signal, (5) GND, (6) gas valve.
13	J13		Shutter protection

## 5. Enviroment

### 1. Power

**3 phase, AC 380V 50Hz, Max 20KW**

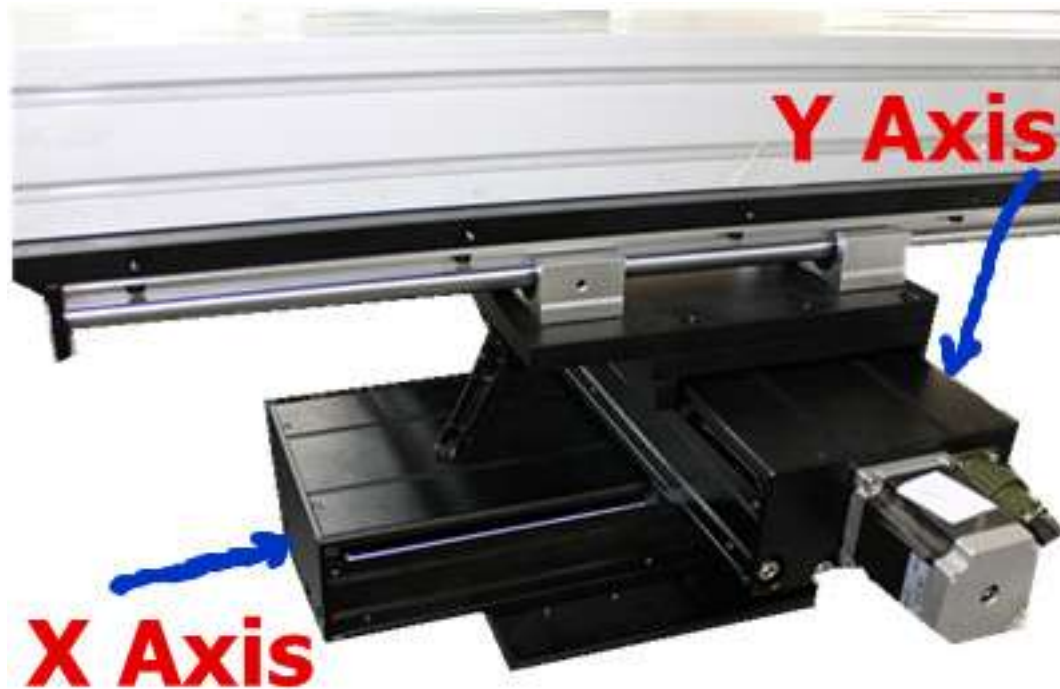
**If not , you need a Voltage transformer.**

### 2. Room Temperature: 5-35 C

### 3. Humidity: <85%

## 6 Installation

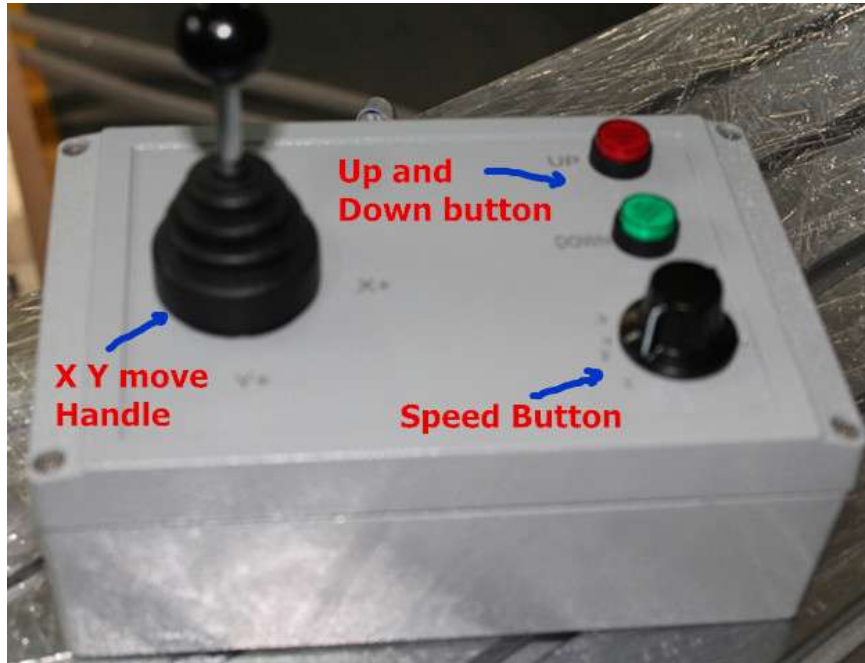
A. Fix the X Y axis table on the Rotary Stand



B. Put the Control Box on the Rotary Table



C.Connect the Operation box with the Control Box



D. Put the Laser box on the crane arm.



E. Put on the scope as following, connect the protection gas pipe:



F. Put on the LED lamp inside as following:



## 2. Connection

- A. Connect the water pipe
- B. Connect the linker between laser and Water chiller.
- C. Connect the protect gas when welding.( **Nitrogen Gas**, protect the mold turn black while welding.)
- D. Connect the Cables for Foot Switch, Control Box, Work table, Water chiller

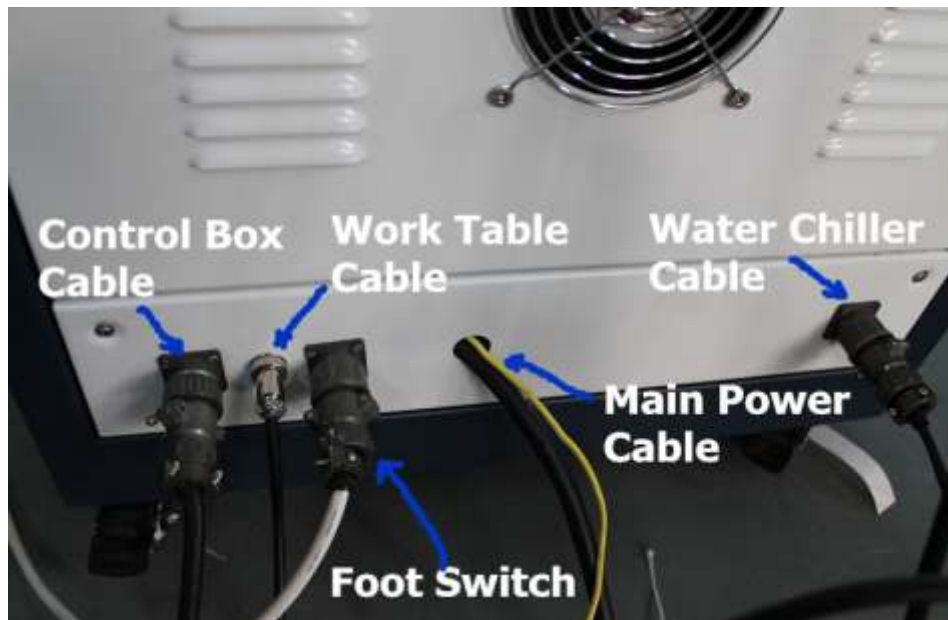


F .Fill the water in the chiller Tank until the water cover the Pipe.

A B:



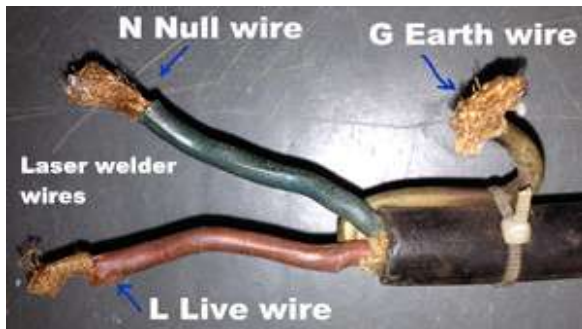
CD :



Laser welder mainpower wires:

Total power switch:





F:



FootSwitch



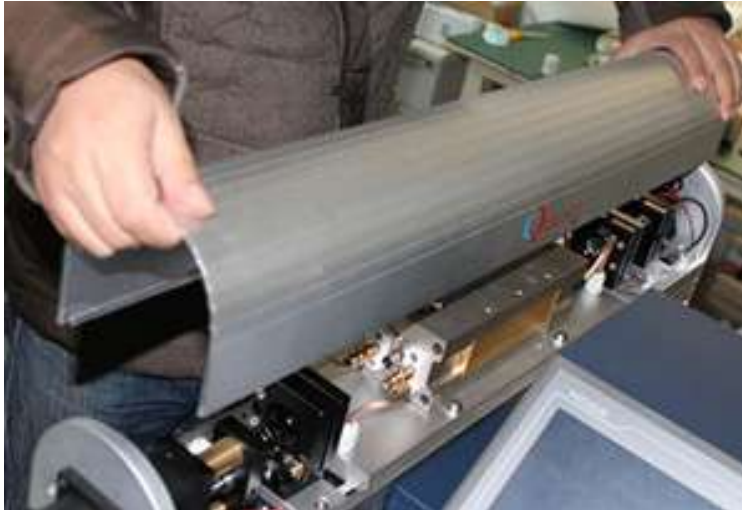
Water chiller  
connect cable with  
laser welder

Control Buttons on Laser welder:



### 3. Laser Cavity alignment

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)

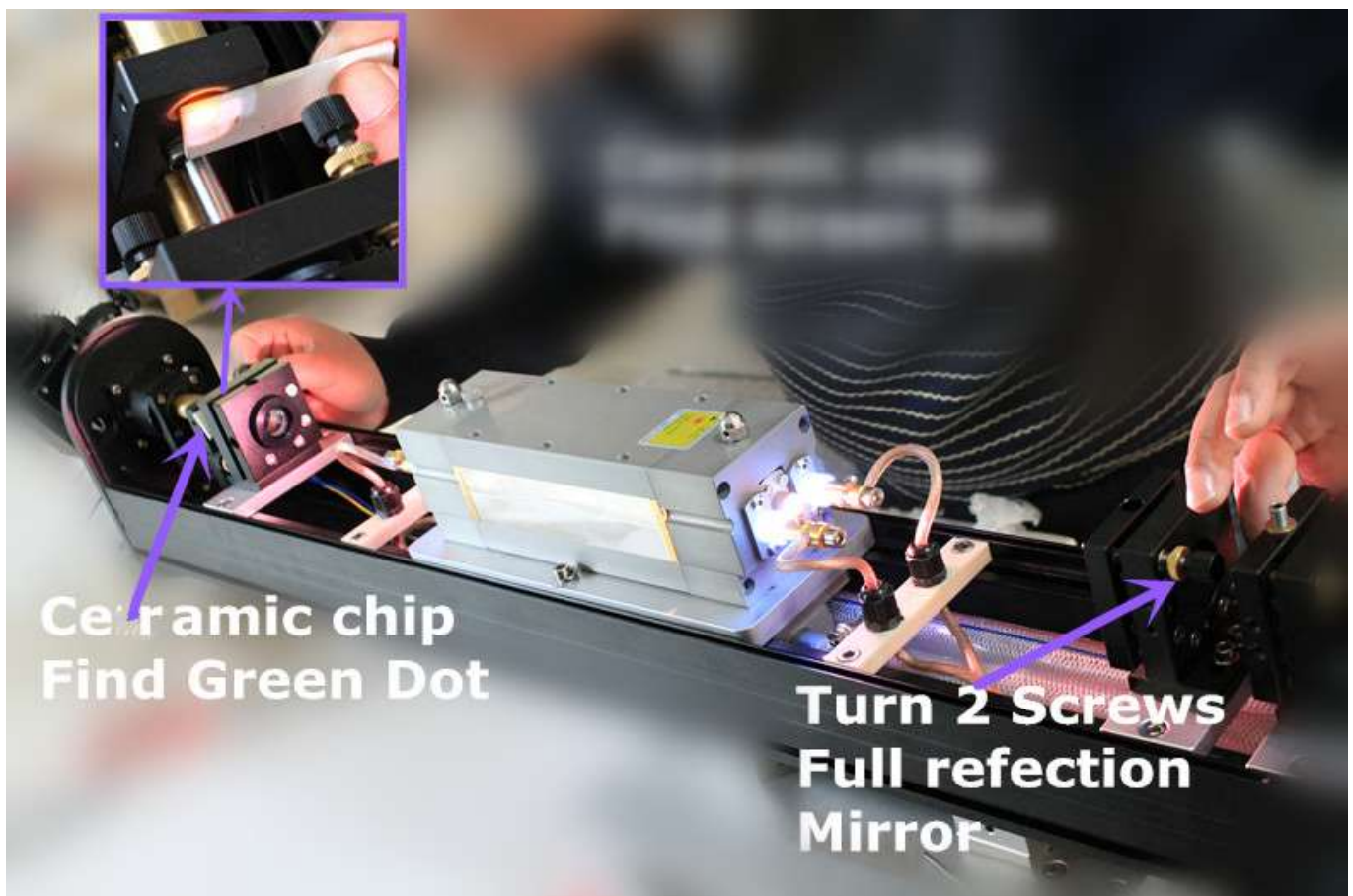
### 3.3 Laser Alignment

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

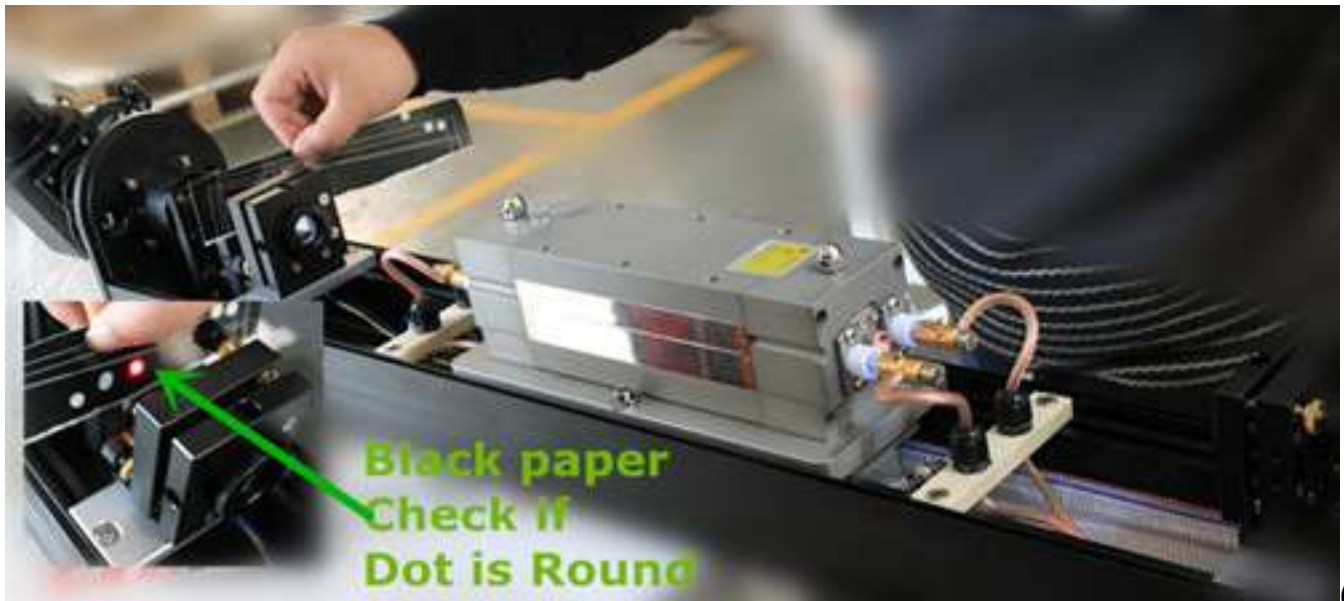
B. Hold the ceramic dimmer chip (beam watcher) and put it in front of the brass tube with your left hand. Now the laser beam can be intercepted and becomes a green dot on the chip.



(B)



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.*



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.

## 8 Operation

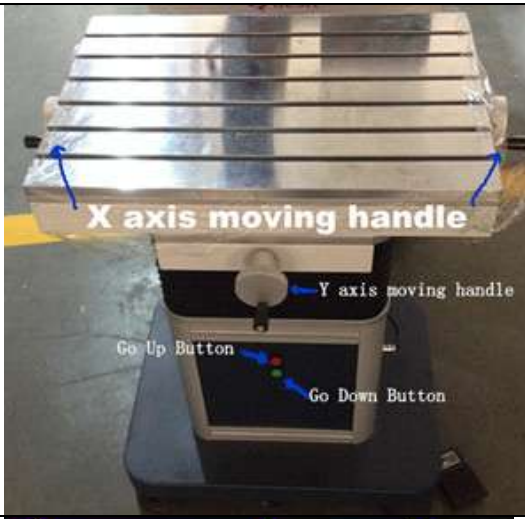


### Very important:

- 1. Before start the laser welder,must start the Water chiller for some minutes first. After the water chiller works well,then start the laser welder.**

1	Pour water into the chiller tank from the hole outside.		
2	Turn on the Water Chiller Power switch to start the Chiller ,waiting for the chiller works well, then go next step.		
3	First, <u>loosen</u> the “STOP” Emergency stop button. Turn on Laser Key Switch		
4	Press "ON" to start Waiting for about one minite, then you can hear the relay is working ,after the panel read “Normal” on left up corner, then the machine can start to work.		

<p>5</p>	<p>Adjust the parameter before Welding For “Current” “Pulse” “Freq”,just press “+ -”to increase and decrease on panel.</p> <p>“Para”</p> <p>“Light”</p> <p>“Other”</p>		
<p>6</p>	<p>Different Materials should be set different parameters.It is depending on the experience.</p>		
<p>7</p>	<p>Press the footswitch, you can see the laser welding dot.</p> <p>Before welding, you need to find</p>		



	<p>the right “Focus Distance” (Put a paper with words under the welding head, turn up and down of the table ,look through the microscope, when you can see the letters the clearest. then it is the right focus distance)</p> <p>For table, the Z axis moving is automatic, just press the red up and green down button. you can turn the handle to move X and Y axis.</p>		
8	<p>Stop the laser just on the contract as start the laser. First ,stop the laser machine.Press the OFF on panel. After the laser welder shutdown, Then shutdown the water chiller.</p>		
9	<p>Addition Handle to move the laser head</p>		

## 7. Mold Repairing

First you should choose the welding parameters according to the working piece. such as pulse width (width), frequency (freq), current (current). The parameters are adjust on the LCD control panel. The current parameter can be adjusted by the handle. The focus laser spot diameter can be adjusted by the handle. The focus laser spot diameter can be adjusted by the control panel aslo(Fa). After setting parameters, to be observed through the microscope eyepiece welding parts, welding parts can be moved up and down, so that the workpiece image can be very clearly, and hit the spot into a scaly, it can not have pits or depressions around the spot, spot beam can adjust regulator three screws in the eyepiece cross fork intersection coincides with the working parts to be welded, then depress the foot switch, the laser light to treat a welder to weld pieces.

You can also move the X-Y table by manual to weld the mold in X direction or Y direction. For Z axis, the moving is automatic, just turn the red button to go up, and green button to go down.

If you need further more information, pls do not hesitate to connect with me.



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**Wuhan Questt Asia Technology Co., Ltd**