PTA Hardfacing Technology and Application Introduction

Shanghai Domu Industrial Co., Ltd. is a high-tech company specialized in the automatic welding machine of research, development and sales, .Now we get a leader in the market through experience for ten years in the industry.. At present, have set up the base of industry research by cooperating with Ji Lin University and so on. Meanwhile we own the senior manufacturing engineer and designers with the initiative spirit to device development. A super team devoted to provide the professional solution and service. So far, the authorized patent we applied for is up to more than ten items. Our core technology of welding make up for the gap domestic and overseas that bring out the benefit of social and economy..

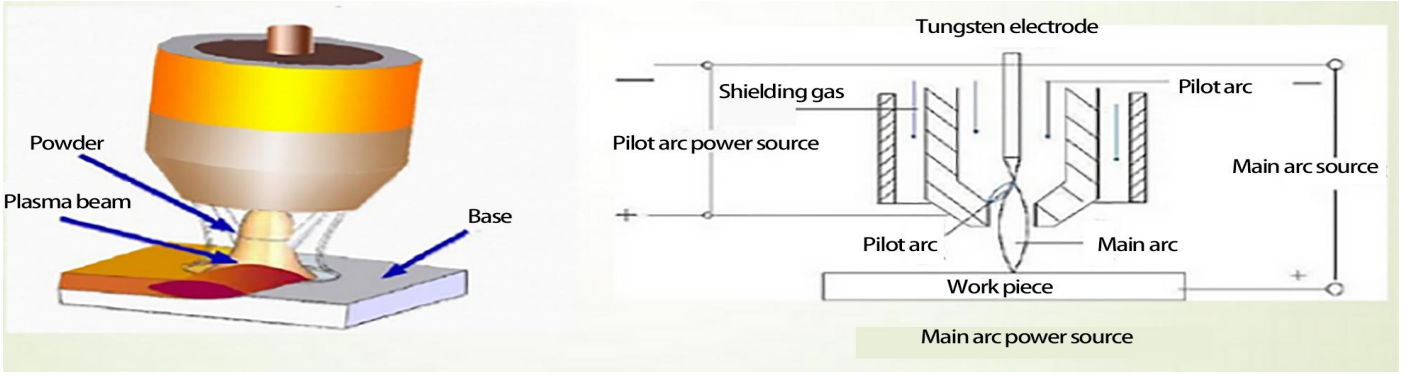
Context Headings

- PTA Hardfacing Brief Introduction;
- PTA Equipment Brief Introduction;
- PTA Powder Application and Selection
- Comparing with Conventional Arc Surfacing Technology
- PTA Industrial Application

1. PTA Hardsurfacing Brief Introduction

1.1 Mechanism

As an advanced surface modification technique, Plasma Transferred Arc(PTA) hardsurfacing is increased-widely applied for protection or/and refurbishment of metallic wear , such as adhension, abrasion,corrosion ,erosion, fatigue, cavitation etc. by using argon as plasma generating gas, a pilot gas(non-transferred arc) was easily ignited at the beginning, plasma arc as heat resource, alloy powder were feeding into the arc then melting as metallurgical bond layer finally.



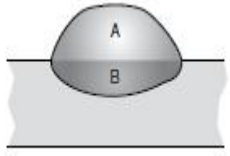
1.3 PTA Characteristics

- 1、Cladding layer is connected with work piece by a high strength bonding as metallurgical bond form
- 2、Low and controllable dilution which can be under 5%,less heat input ,means less deformation
- 3、High density and good welded appearance, less machining job if any machining require
- 4、Powder can be mixed and selected in accordance with specific wear resistance require.
- 5、Easy to integrate and combine with automatic hard and soft ware, increase efficiency and products quality .

Dilution

- According to welding metallurgy, while welding some of parent material elements， it will be dissolved into the welding pool and diluting its composition

Dilution is calculated as follows: % dilution = $\frac{B}{A+B}$ x 100



1.2 Forming Mechanism of Plasma Arc

Plasma arc is a kind of high engry,density and temperature ion arc,which is compressed by a free arc.there are 3 major compression method as:

1 **Mechanical compression**

To use the orifice diameter of the nozzle to restrain the plasma arc makes the energy density and temperature of the arc column increased -- mechanical compression effect.

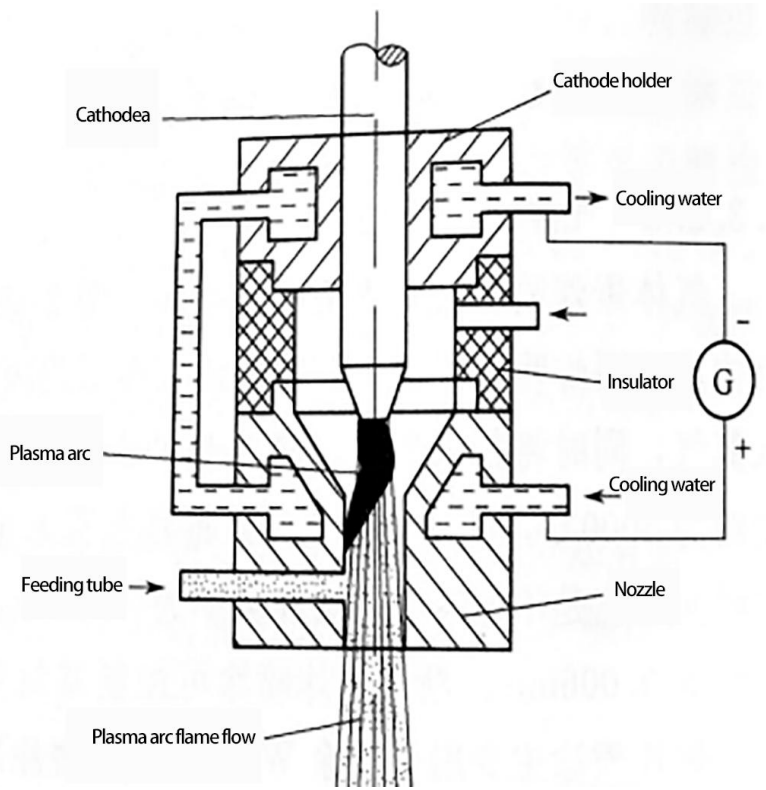
2 Thermo compression

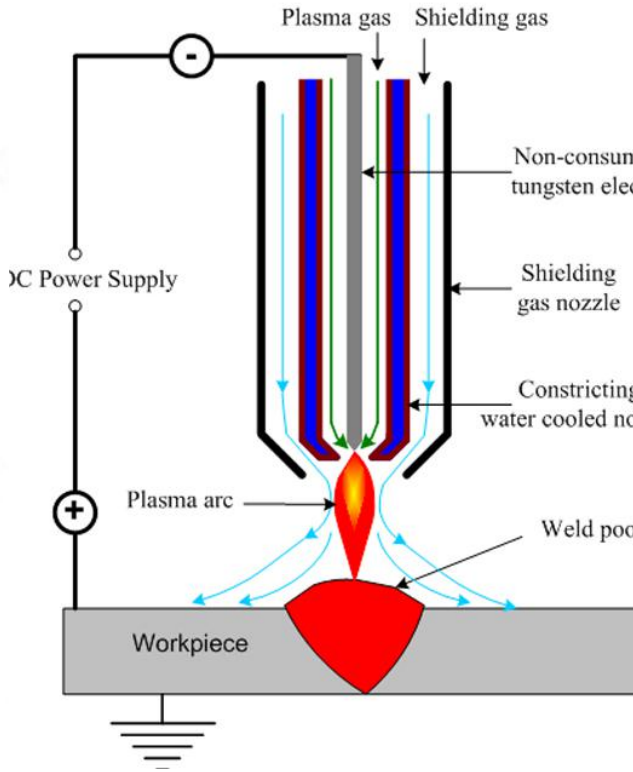
The nozzle is with a certain flow of cooling water to reduce the temperature of the nozzle.When the arc column passes through the nozzle orifice, a layer of cold air film is formed on the inner wall of the nozzle due to the lower temperature, of which the conductive section decrease. And the current density and temperature to further increase -- hot compression effect.

3. Magnetic shrinkage

Magnetic shrinkage The magnetic field generated by the arc current makes the arc column to contract centripetal to reducing its section.The higher the current density, the stronger the shrinkage effect -- magnetic shrinkage effect.

Plasma arc illustration





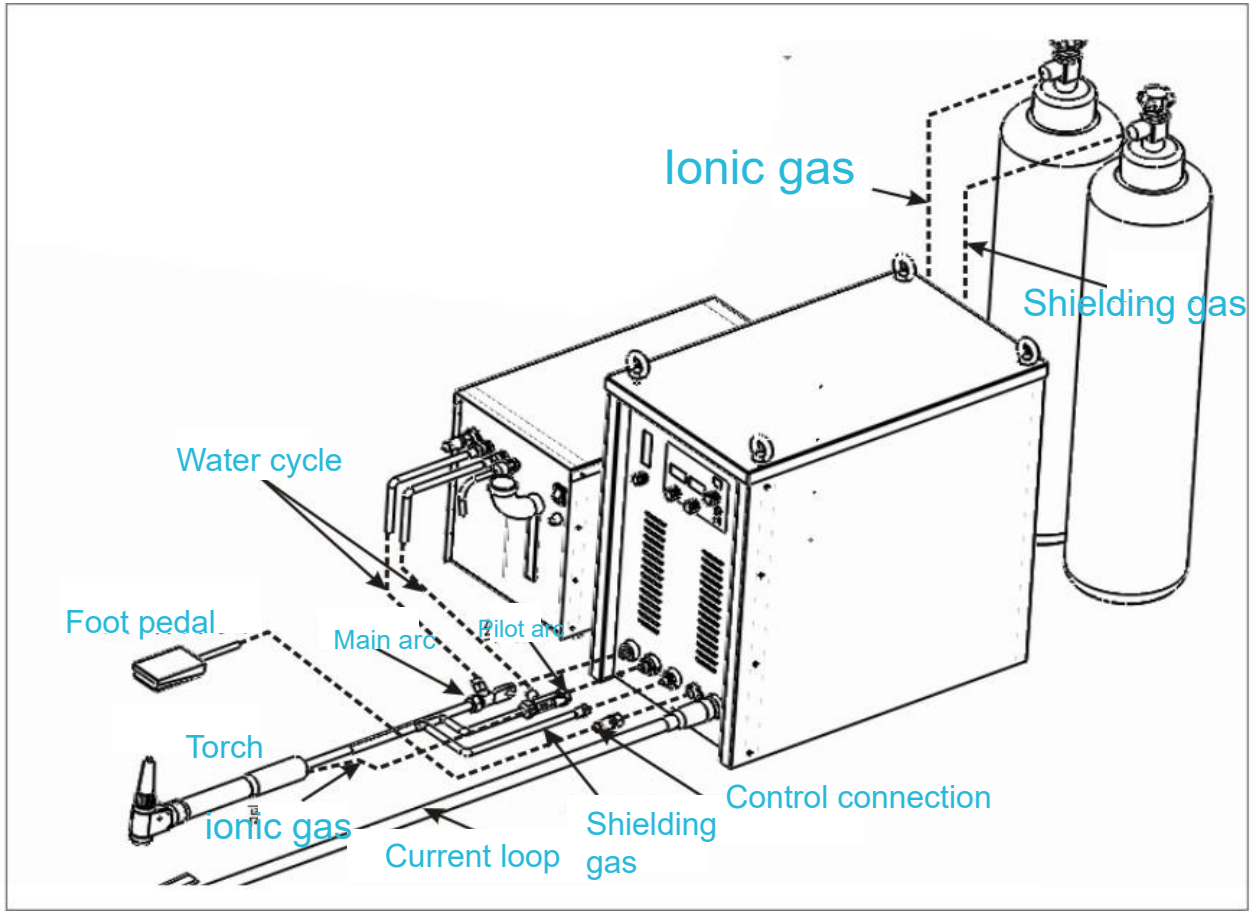
Plasma Cladding Equipment Structure

Plasma generator

Feeding system

Torch

Structure drawing

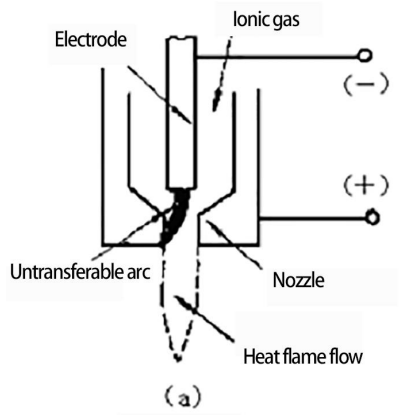


2.2 Plasma cladding power supply introduction

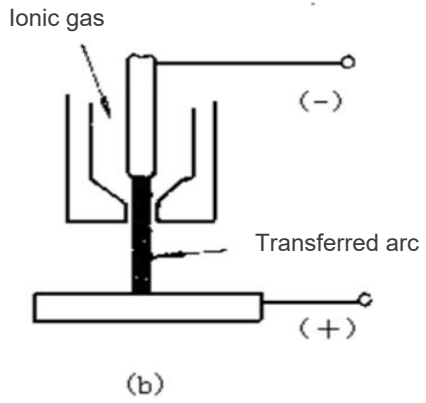
Plasma power mainly composed of transfer arc and non-transfer arc.

It Is to draw the transfer arc (main arc) through the non-transfer arc (dimensional arc)

- Typical PTA operations begin with the striking of the pilot arc, followed by the initiation of the transfer arc,
- The pilot arc is struck between the constrictor nozzle and the tungsten electrode, using a high- frequency generator, and creates a low-resistance “pathway” from the electrode tip to the workpiece.
- The transfer (plasma) arc, when ignited, follows this low-resistance pathway to the workpiece, creating a weld pool at the substrate. Deposition occurs when the metallic powder is carried through the plasma arc, where it is melted and deposited into the weld pool.
- Kennametal

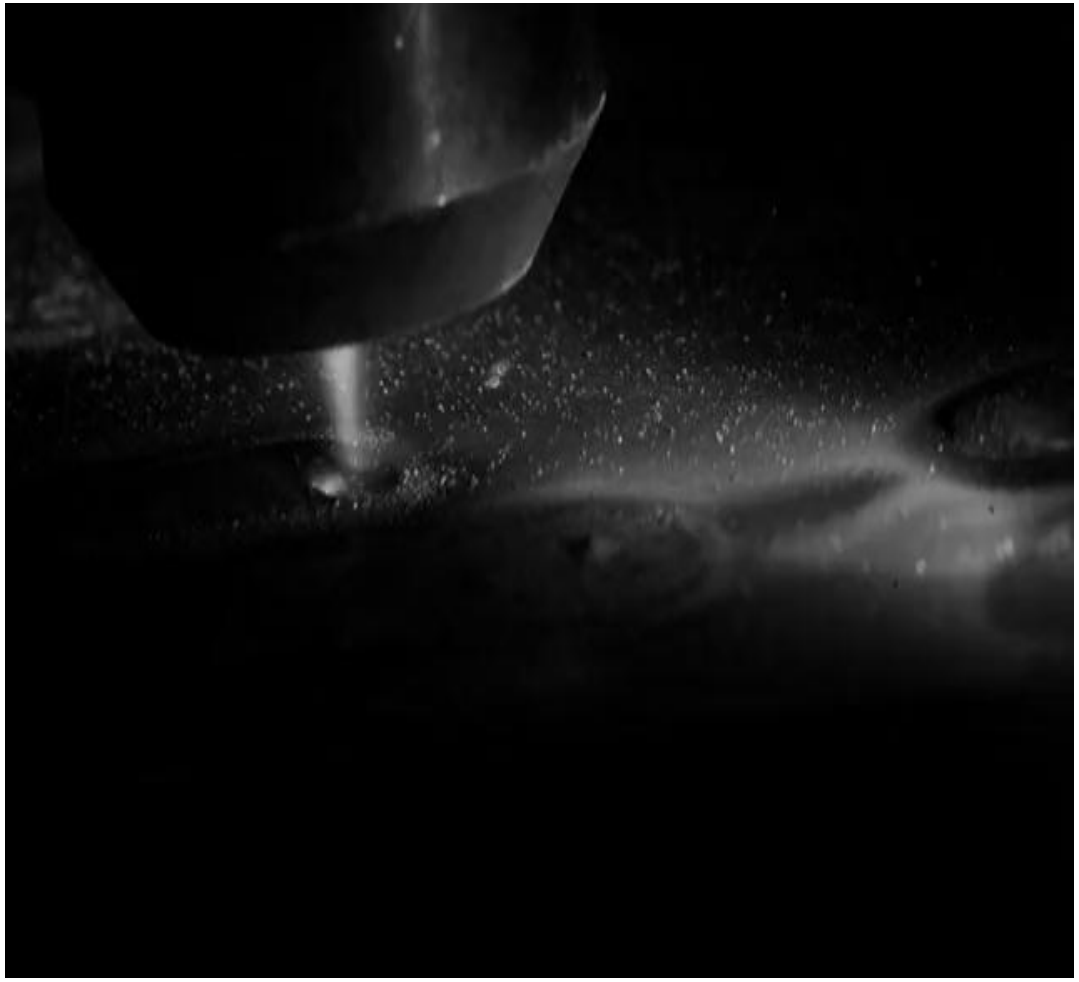


Untransferable arc

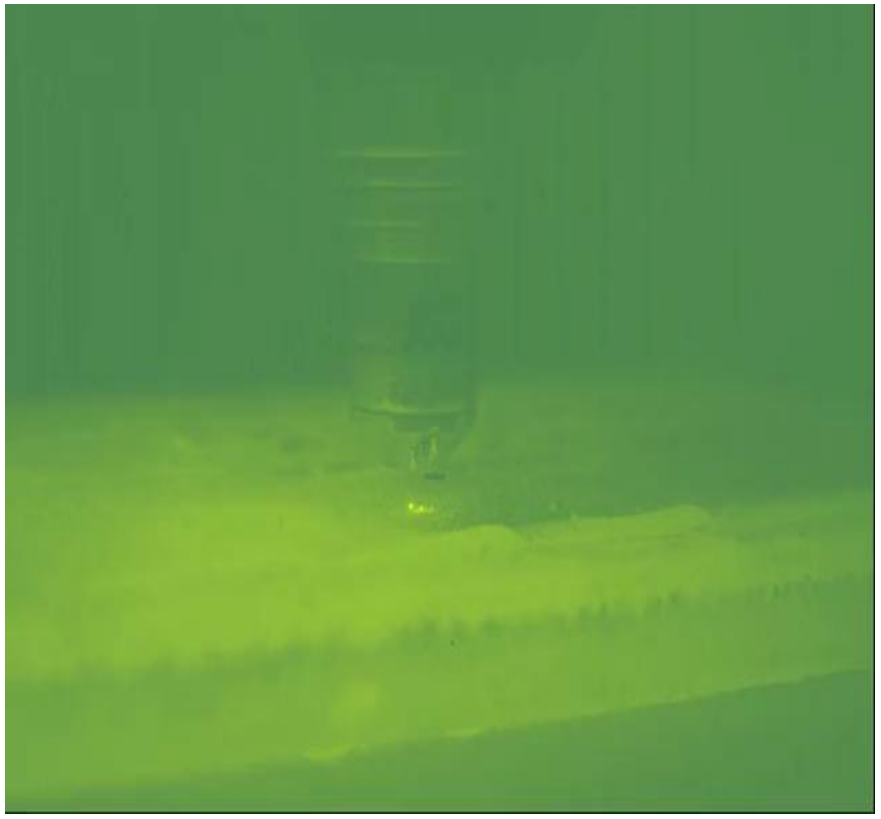


Untransferable arc

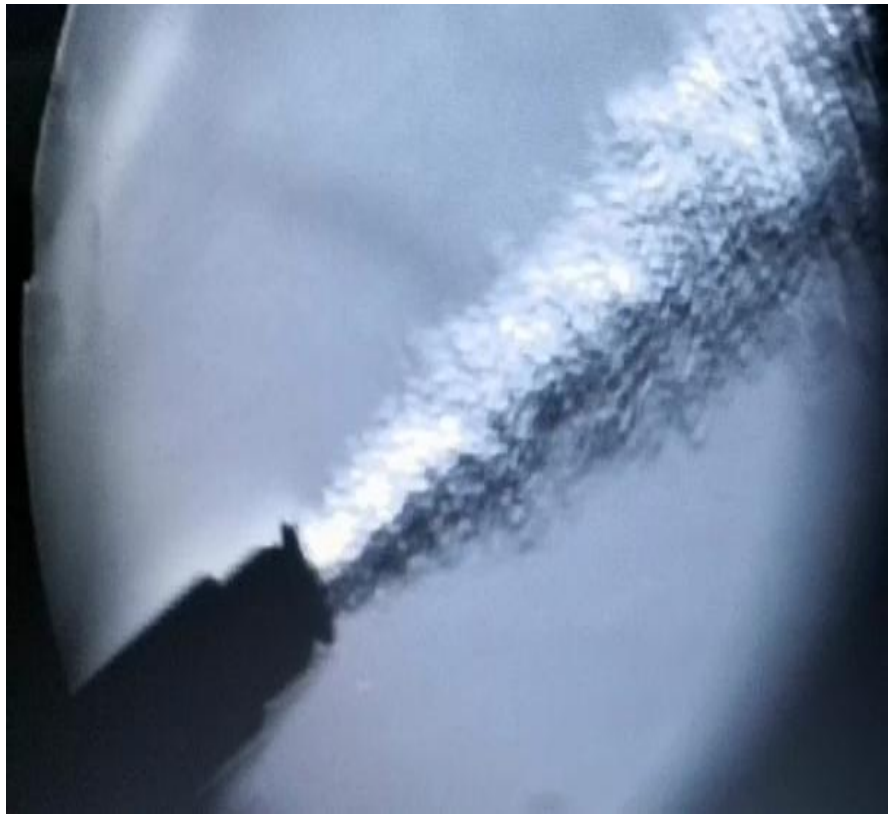
2.2 Photography



Precise inspection to torch



Infrared imaging



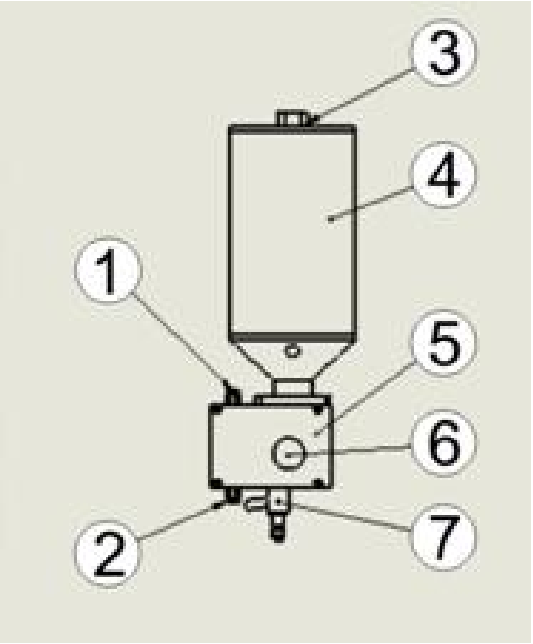
Vancurm gas flow

2.3 Powder feeder

Operating principle

The working principle of the powder feeder is to drive the powder wheel to rotate through the transmission motor and to send the alloy powder to the torch by the gas

Adjusting the speed of the motor can be changed the volume of feed powder.



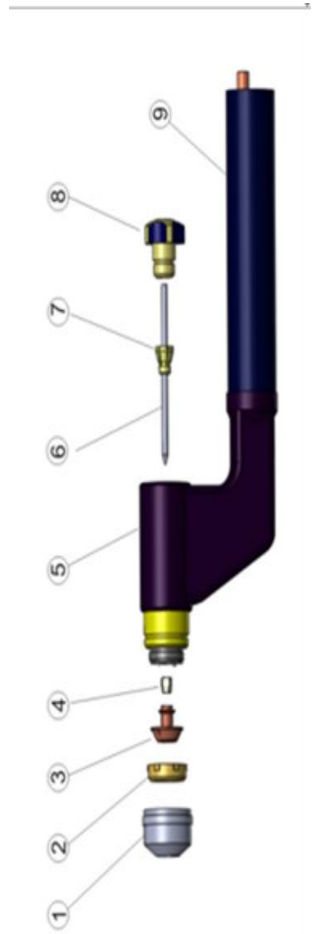
The name of the parts

1、Inlet
2、Outlet
3、Additing
4、Reservoir
5、Body
6、Window
7、Release valve

2.4 Torch

The torch is the core unit 。
it is consised of the system of recycled water , circuit, gas circuit and powder pipe.
It mesures the servicer life of torch relevant to high temperature resistance ,gas tightness and insulativity ,
The torch with casting is well received by the market.
The parts：

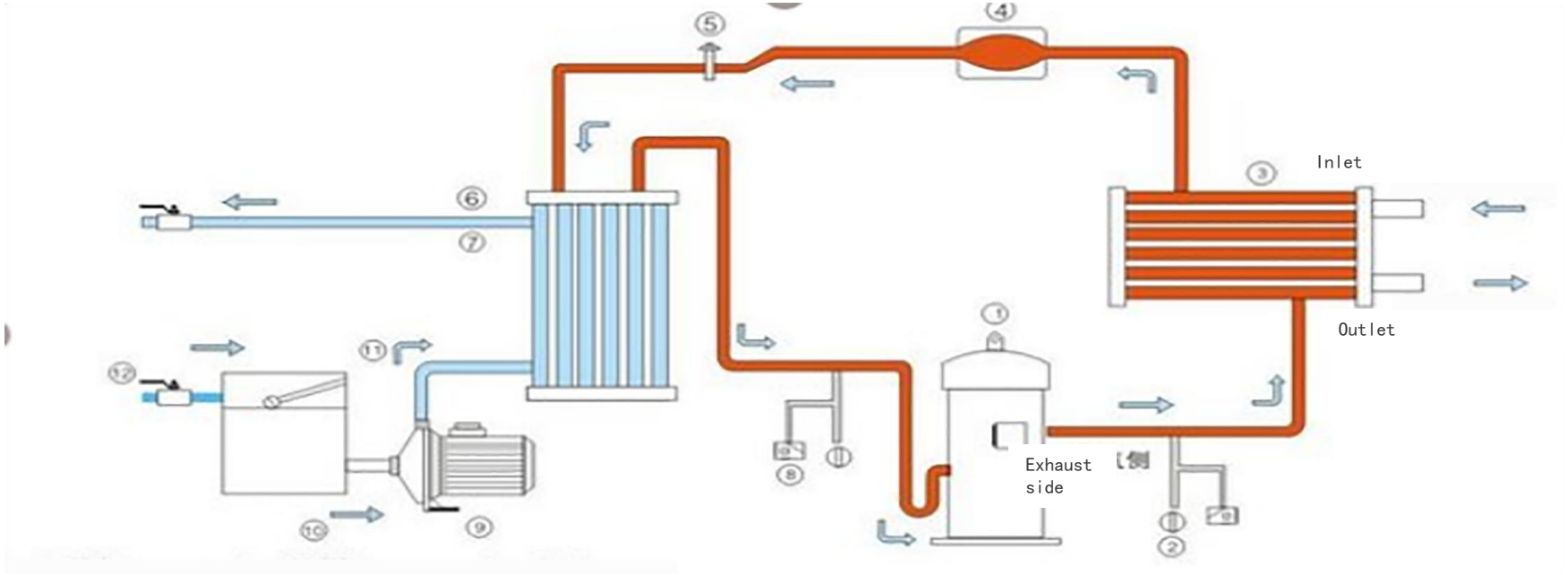
1 Shielding nozzle
2 Coper locking ring
3 Copper nozzle
4 Focus ring
5 Torch body
6 Eletrode
7 Clamper
8 Cap
9 Handle



2.4 Cooling System

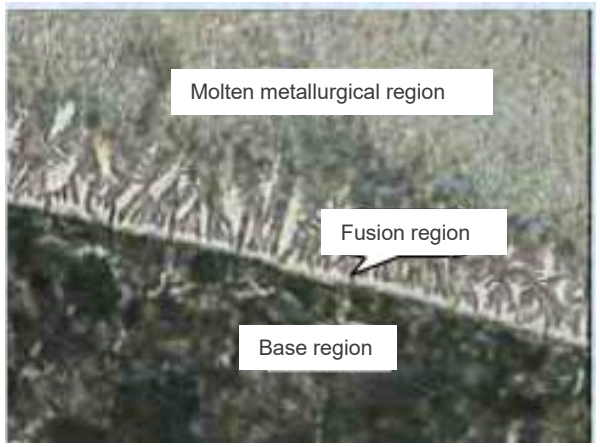
Normally there are two kinds of chiler , air cooling and liquid cooling, liquid cooling is widely applid in PTA . It has a good performance to torch.

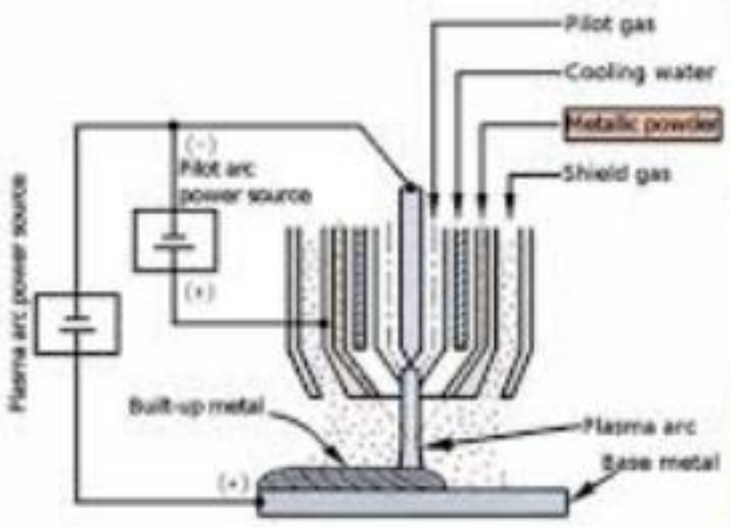
Pour proper water into tank, the water is cooling via the refrigerator, then it has been sent to target device by pump , After that, the tempreture of the cooling water rise after the heat is taken away. Last, it goes back to tank to get to the cooling. The temprature is between 9-15.



1. Compressor
2. High pressure controller
3. Condensator
4. Dry filter
5. Expansion valve
6. Antifreeze switch
7. Evaporator
8. Low voltage controller
9. Pump
10. Water tank
11. Float switch
12. Ball valve

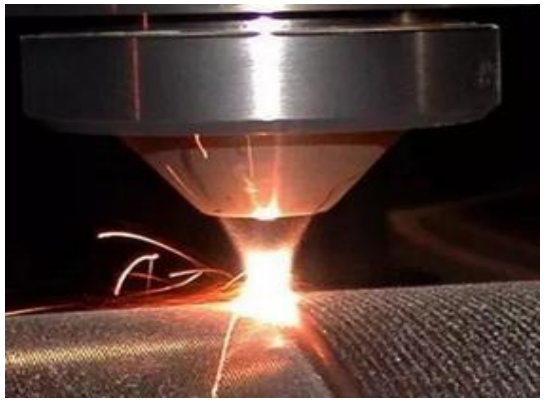
2.4 Features of process





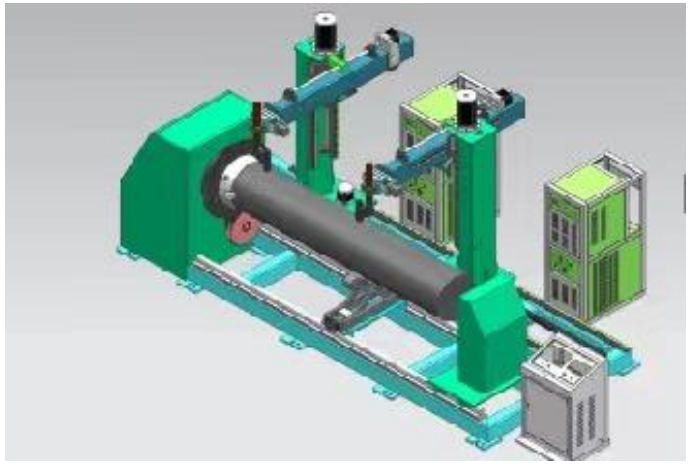
2.4 Differences of PTA and Laser

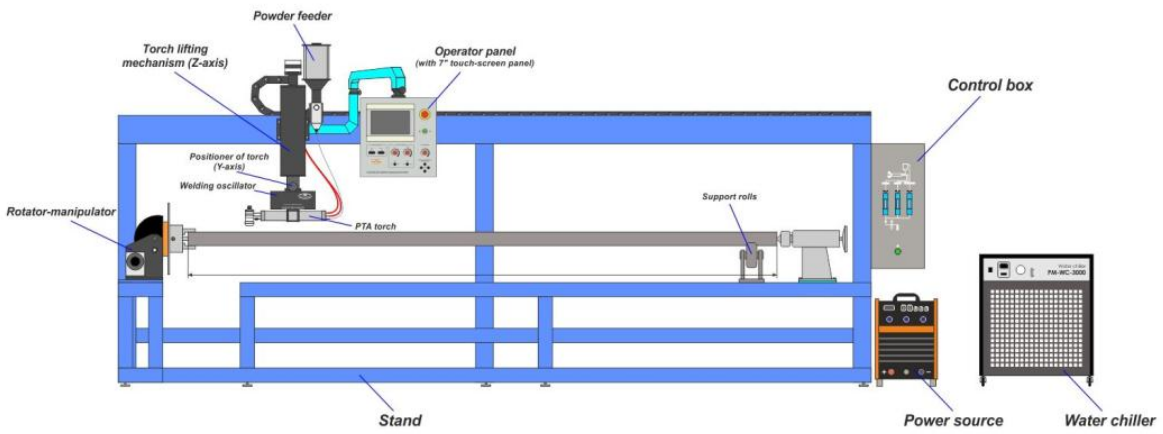
PTA	Laser
NI+35Wc	NI60
HRC62	HRC60

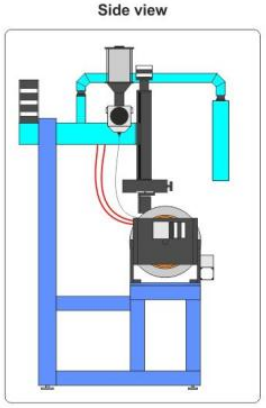


PTA Laser

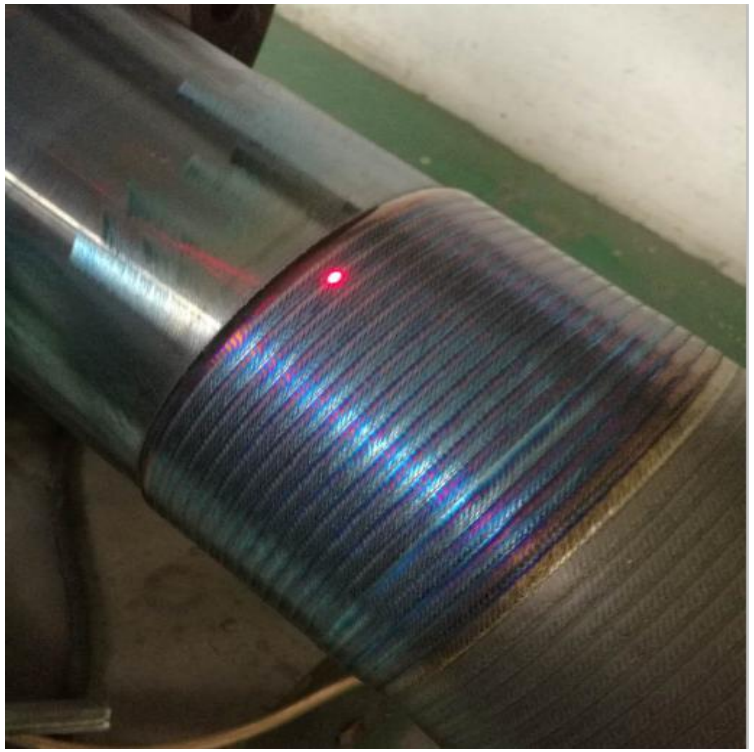
2.4 PTA Automatic Equipment







2.4 Comparison of PTA and SAW

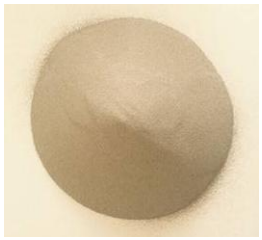


PTA

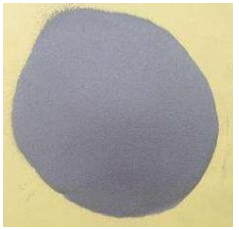
SAW

2.5 PTA Powder Application and Selection

Normally it is according to the working enviroment and needs to select the powder. There are four types of the powder.



Fe
Iron-base



Ni
Nickel
base

Co
cobalt
base

Cu
copper
base

3.1 Iron Base Powder

Fe-base powder is come from Fe-C alloy with addition appropriate amount of Boron, Sillcon , normally apply for under 500 degree temperature and gentle acid or alkaline corrosion application, nevertheless its comprehensive propoty is not as well as Ni and Co base powder, its ram material are widely provided and manufacturing cost is lower.

Fe-base powder can be dinvide into 2 groups as: stainless steel and high carbon high chromium

The cald layer of austenitic stainless steel self fluxing alloyed powder is structure from austenite and variant carbide ,with moderate wear resistant and erosion resistant ability, better than normal austenite SS such as 1Cr18Ni9Ti, 2Cr13.

High carbon and high chromium alloyed powder consist of high percentage of carbon and chromium ,and some carbide ,boron compounds , with a good hardness and wear resistant, but not so excellent machining ability.

3.1 Iron Base Powder

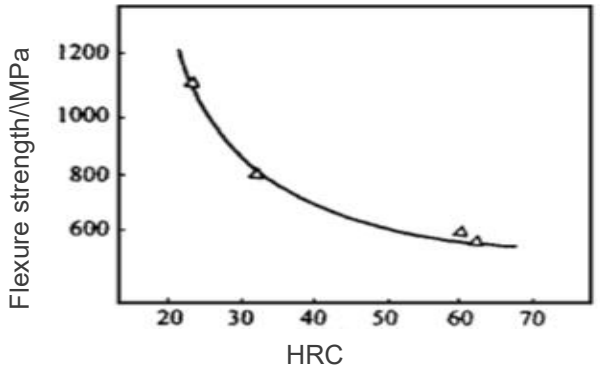
Powder	Hardness	Component							Technology	Fineness	Application
			Cr	Si	Fe	Mo	Ni	Mn	B			
Fe1	35-400.15		22	4.5	Remain	2	13		1.6	PTA / Laser	100/270	Valve
Fe2	38-440.15		22	4.5	Remain	2	10		1.8	PTA / Laser	100/270	Valve seat
Fe5	62-674.5		40	1.0	Remain			0.971.8		PTA / Laser	100/270	Drill joint
Fe90	50-550	0.15	13.5	1.3	Remain				1.6	PTA / Laser	100/270	Drill joint
Fe6	58-60	0.8	7.5	2	Remain		32		4	OXY spray / PTA	100/270	Ventilator blade
Fe45	40-46	0.6	7.5	2	Remain		22		3	OXY spray / PTA	100/270	Paper mill
Fe304	HB190	0.03	18	0.1	Remain		10	0.3		PTA / laser / Ultrasonic spray		Paper mill
Fe316L	HB 190	0.03	17	0.2	Remain	2.5	12	0.5		PTA / laser / Ultrasonic spray	100/270.300/500	Paper mill

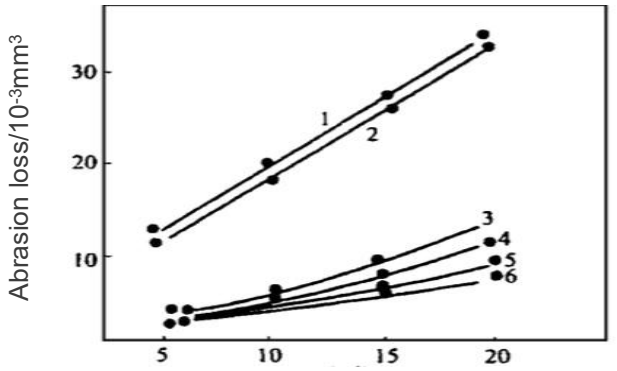
3.2 Nickel Base Powder

The powder can be devided into 2 groups which are Ni-B-Si and Ni-Cr-B-Si.

The microstructure of cladding layer of Ni-B-Si alloy is composed of Ni-Si solid solution (Y phase), various borides (Y 'phase) and Y - Ya' eutectic phase.The alloy has low hardness, good toughness, high temperature resistance, wear resistance, corrosion resistance and easy machining. diffuse distribution

The microstructure of cladding layer of Ni-Cr-B-Si self - melting alloy is complex.It is composed of nickel-chromium solid solution, nickel boride, chromium boride and other 'phases, and carbide of chromium, carbide of boron, carbide of tungsten and other hard phases.This kind of alloy still has high hardness, wear resistance and corrosion resistance at 500℃.





Comparison of wear resistance between alloy and 45° steel

3.2 Ni Base Powder

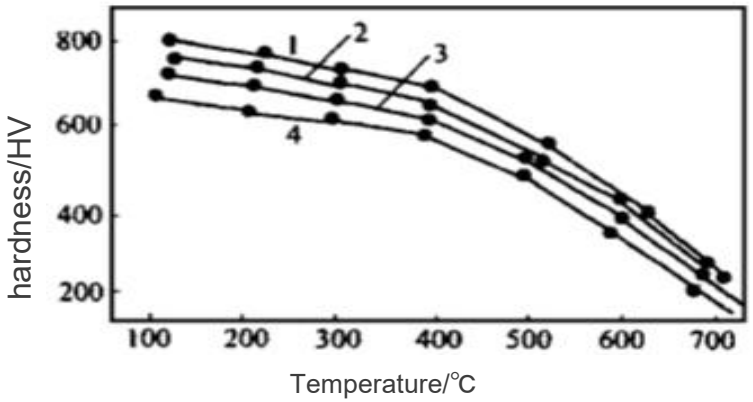
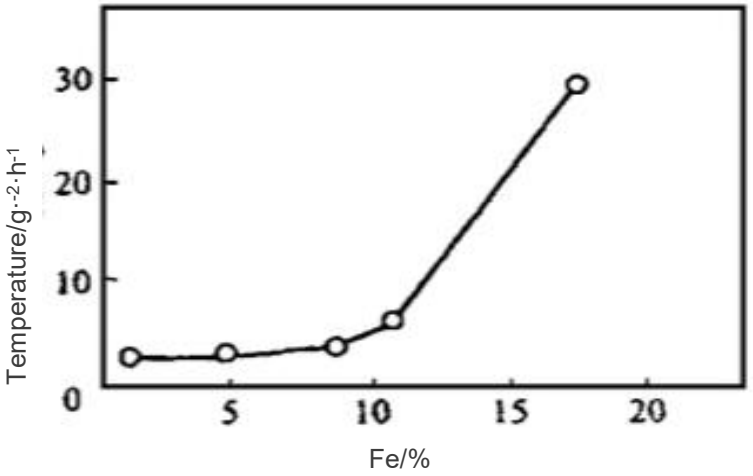


Image 5 Ni60,12496 heatt hardness of alloy
1.Ni 60 Cap component
2.12496 (Switzerland)
3. Ni 60 limit component
4. Ni 60 Minimum component



Corrosion rate of nickel base alloys with different iron contents in solution at room temperature

3.2 Nickel Base Alloy Powder

Test method:EN ISO 15614-7:2017 & ISO 6507-1:2005method
Test result:
The locations of hardness test points are shown in Figure 3,
Hardness values are listed in Table 2.
Approx.
0.040 in.(1mm)

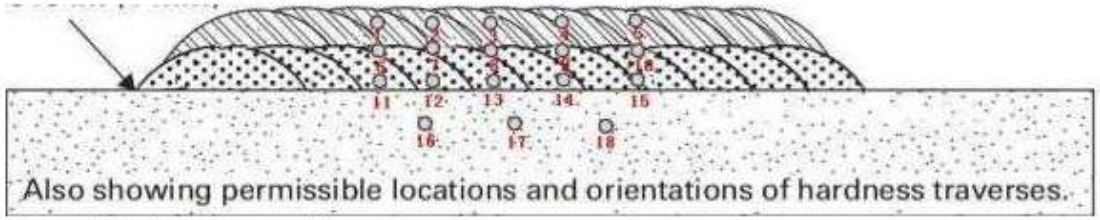


Figure 3 Indentation position

Area		HV10	Area		HV10	Area		HV10	Area		HV10
1	Close to surface	756	6	At the centre	834	11	Close to base	620	16	Base	367
2		883	7		740	12		501	17		368
3		906	8		923	13		518	18		377
4		912	9		807	14		533	•		-
5		871	10		818	15		605	-		•

Table 2 Sample hardness results

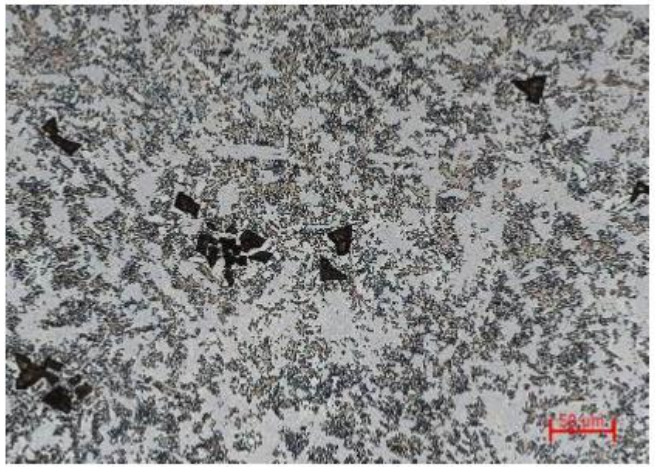
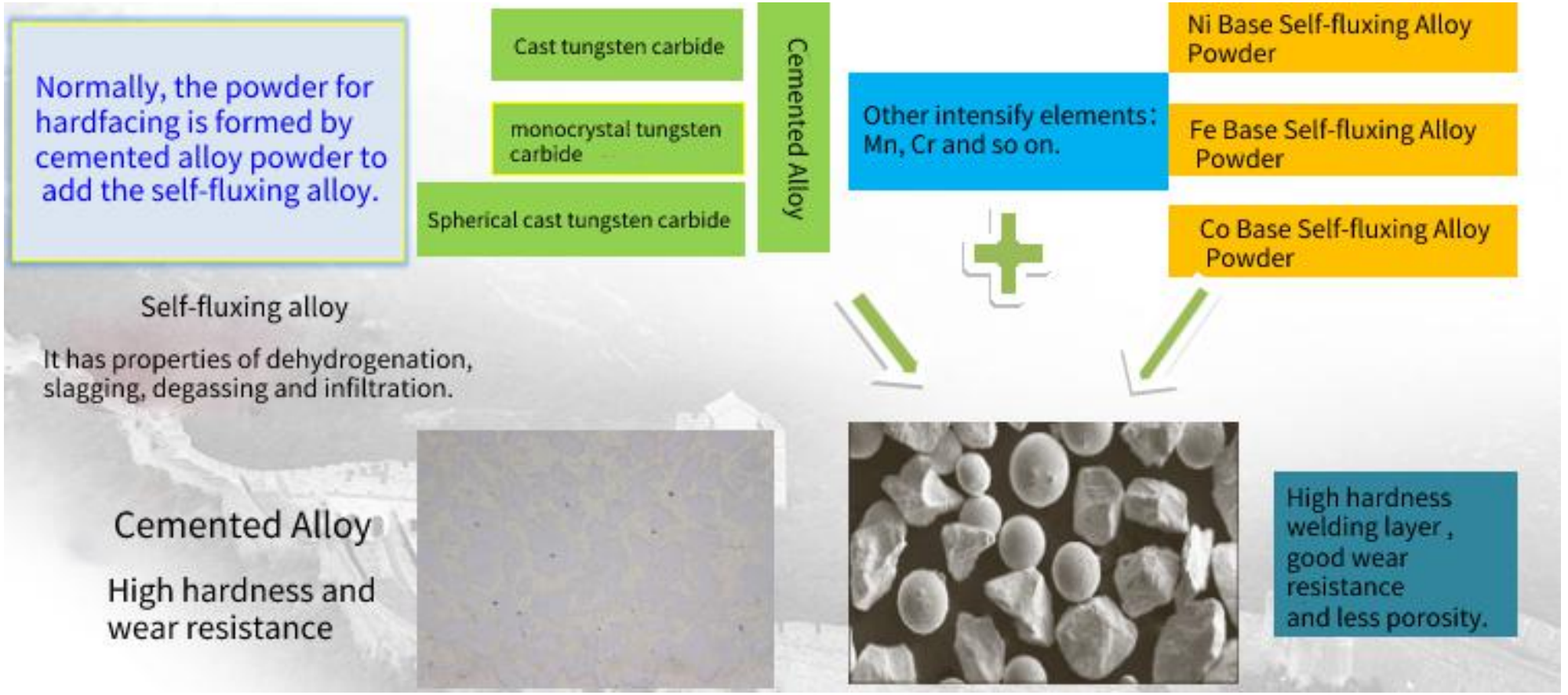


Figure 4 Microstructure of sample weld

3.2 The design of the hardfacing powder

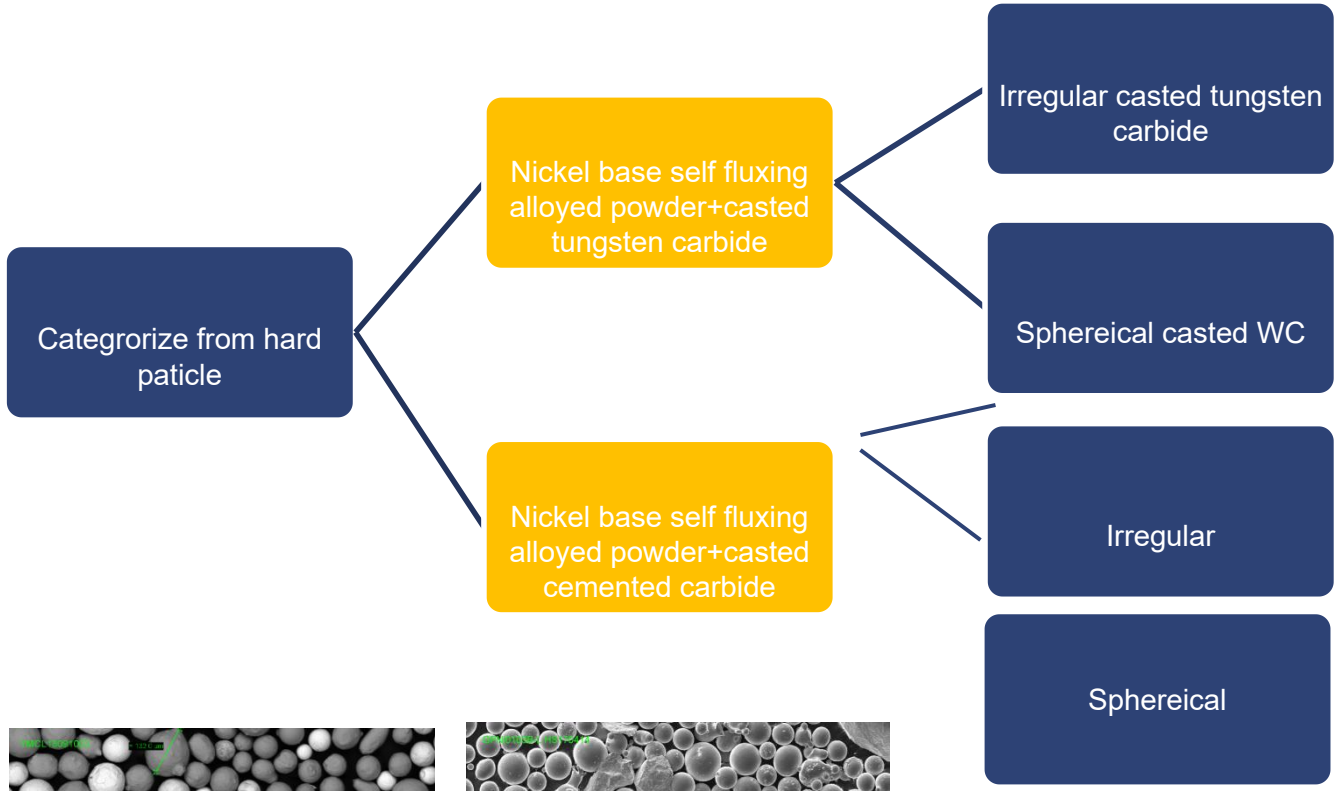


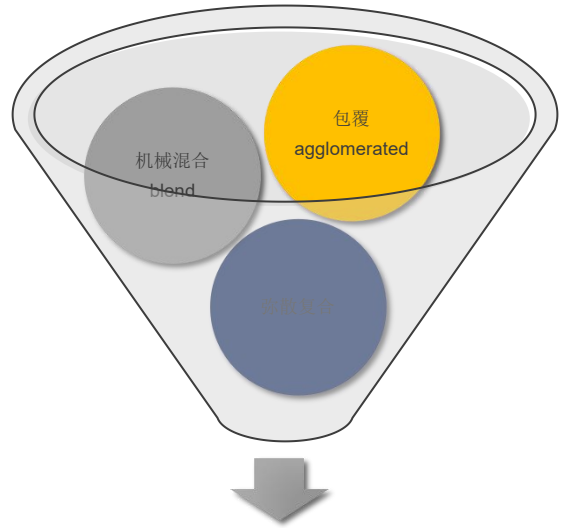
3.2 Nickel Base Powder

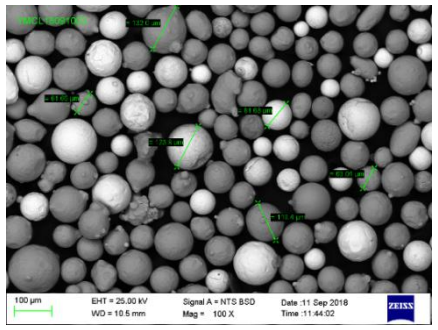
Powder	Hardness	Component										Others	Granularity	Application
		C	Cr	Si	W	Fe	Mo	Ni	Co	Mn	B			
Nil5AA	15	0.03	0.46	2.3		0.46		Remainder		0.09	0.9	Cu:20.0	180/500	WC series spray the bottom layer
NI20M	20	0.03	4.5	2				Remainder			0.7		180/500	Mould
NI22AA	22	0.2	0.1	2.85		0.5		Remainder		0.5	1.45		180/500、100/270	Mould
NI22M1	26	0.03	0.5	3		0.5		Remainder		0.5	1		180/500	Mould
Ni25	25	0.2		3.5		8		Remainder			1.5		180/500, 150/300	Punch,valves,plunger
NiSOAA	50	0.45	11	4		2.7	1	Remainder			22		150/300	Cam,mould,plunger,vent valves
Ni55	53	0.4	15	4.3		5.0Max	2.5	-			3.1		150/300、53/20 μm	Valves,mould,screw
Ni65AA	56	1.0	18	5.3		5.0Max		Remainder			1.9		100/270	Valves,pump blades,shafts, plunger
Ni60AA	60	0.78	15.9	4.55		5.0Max	/	Remainder	/		/		150/300、53/20 μm	Valves,pump blades,shafts, plunger
NI60A	60	0.7	15	4.0		8.0Max					3.2		150/300	Valves,pump blades,shafts, plunger

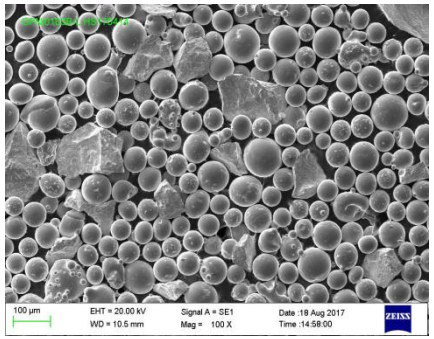
3.2 Nickel Base Powder/Blending Cemented Carbide

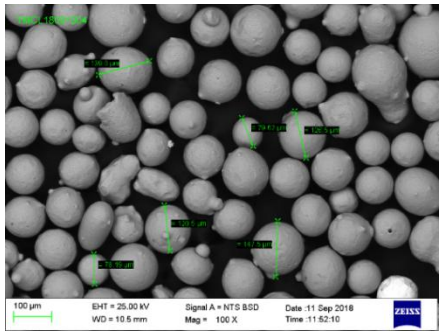
Although nickel powder has a comprehensive propoty , but in some tough working envirment, using life is not as good as expected. to harden its wear resistant , add some pertantage of hard particle

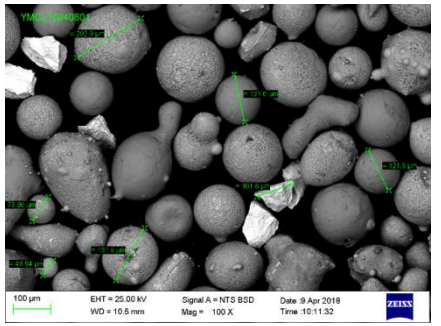












3.4 Cobalt Base Powder

Co-base self fusion powder is developed from stellite alloy . it is a known fact that stellite is a kind of excellent high temperature alloy , has good hear resistance, hot corrosion ,toughness, cold or hot fatigure performance .it is majorly consist of Co,Cr,W , so called Co-Cr-W alloy meanwhile. and add some B Si then can form Co-base self fusion powder. It is normally can working in above 600 degree with excellent heat resistance ability.

Co-base self fusion powder can apply in precious product as high temperature corrosion for instance high temperature and high pressure valve, sealing plate of exhausting valve in motor, and enginer components of aircraft cause from hot corrosion.

3.4 Co Base Powder

Powder	Hardness	Component										Granularity	Application
		C	Cr	Si	W	Fe	Mo	Ni	Co	Mn	P		
CoOl	48-54	2.4	30	1	12	*.00	1.00	*.00	Remainder	W1.00		100/270	Seat, bearing, knife or rotary seal ring ttggringringring, etc
Co03	48-54	23	30	1	12	*.00	/	^3.00	Remainder	/		100/270	Needle seat, guide roll, valve seat.
C0O6	38-44	1.2	30	1	4.5	W3.00		moo	Remainder	1.00		100/270,300/500	turbine blade.
Col56	40-45	1.6	28	1.1	4.0				Remainder			100/270	Auto parts, military products.
C0O6H	43-48	1.3	30	1.5	5.5	3.00Max	0.8	3.00Max	Remainder	l.OMax		100/270	Engine valve, High pressure valve, vortexTurbine blade, etc.
Col2	42-48	1.4	29	1.4	8.5	*.00	1.00	^3.00	Remainder	W1.00		100/270	High temperature and high pressure valves, serrated

3.5 Cu Base Powder

Copper powder, consisted of alloy of Sn, Ma that is with B and Si, is less application than the one of nickel, cobalt and iron. In addition to this, the advantage of Phossy of reducing the melting point and wetting the base easily that the copper contained a certain amount of would be self-fluxing well.

The surfacing layer with copper has the excellent properties of toughness, electrical and thermal conductivity.
The Copper powder was adopt in the technology of plasma cladding that greatly saves the manufacturing cost and has a extensive use, especially in valve industry.

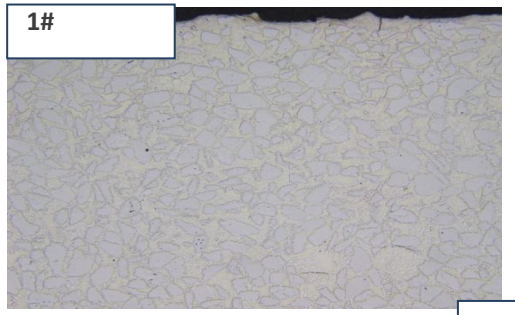
Powder	Component (Weight %)									
	C	Si	B	Cr	Fe	Ni	Mn	P	Sn	Cu
TCu1			2			5		0.5	7-10	Remainder
TCu2		2	1.8			18	1.2			Remainder
TCu3			1			6		0.5	7-10	Remainder
TCu4		AL10				2				Remainder

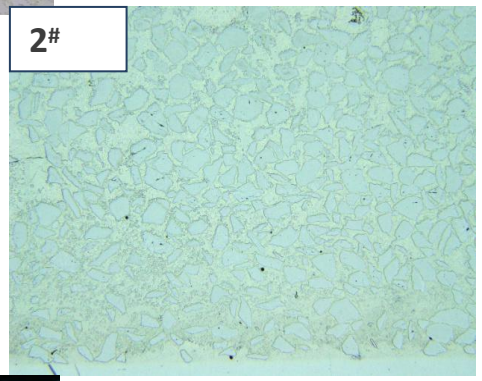
4.1 Comparing PTA with conventional hardfacing

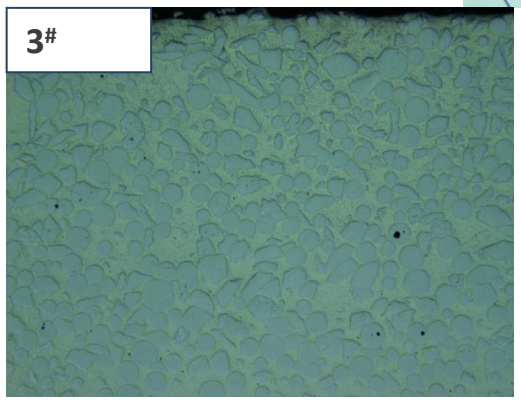
Welding	Dilution (%)	Powder feeding (Kg/h)	Claded thickness one layer（mm）	Consumables
PTA	5	12	0.25	Powder
TIG	15	2.5	2.5	rod
FSW	1	1.8	1.2	Powder rod
SAW	20	10-20	4.0	wire
GTAW	20-30	6-10	3-4	wire

4.2 Compairing PTA with conventional welding

Unmber	1#	2#	3#
Powder	YZ+Ni50	YJ+Ni60	YZD+Ni50
Parent Paterial	45#	45#	45#
current	140A	140A	140A
Feeding speed	65g/min	65g/min	65g/min
Welded sample thickness	3.5mm	3.5mm	3.6mm
Hardness	55.6HRC	62.3HRC	60.8HRC
Volume loss	17.32mm^3	23.95mm^3	14.54mm^3







4.3 PTA /FS/HVOF

Process	PTA	FS	HVOF
Powder	Alloy(or as base)	Alloy(or as base)	Unlimited
Pretreatment	Oil and Rust removal	Oil and Rust removal	Sand blasting, oil and rust removal
Pre-heat	No	No	No
Remelting	No	Need	No
Shape	Rule	Unlimited	Rule
Automatic	Manual or Auto	Manual or Auto	Auto
Porosity	< 1%	< 10%	< 0.5%
Bonding Strength	> 350MPa	100-350MPa	≤80MPa
Maximum deposition rate	95%	70%	55%

4.4 Powder preheating procedure

The powder is not preheated， the thickness of surfacing 1.5 mm with through-wall crack.

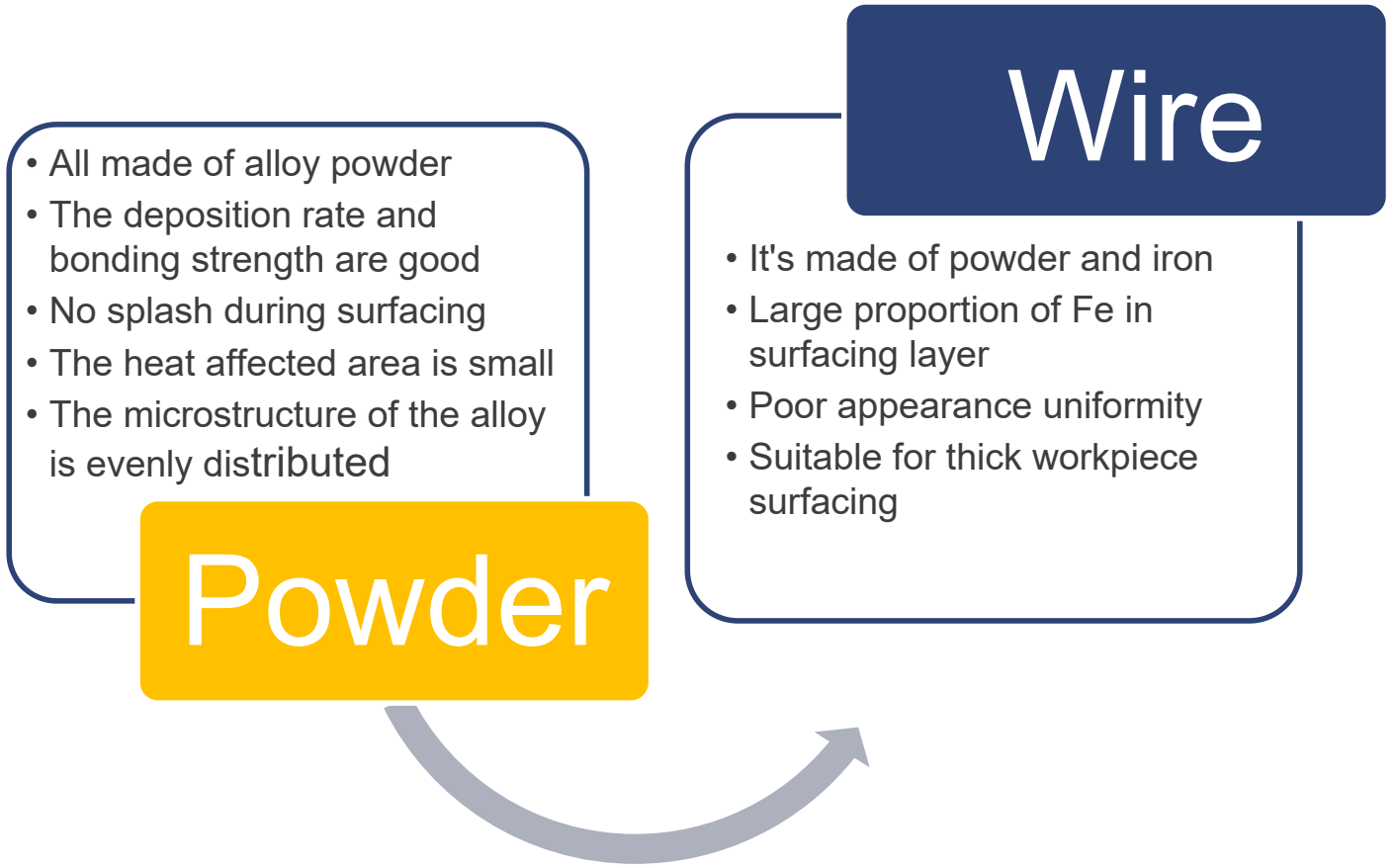
After preheating treatment, the thickness of surfacing 1.5 mm without any crack.

4.4 Powder preheating

The workpiece was preheated to 350 degrees above and then start surfacing welding, testing10 times.

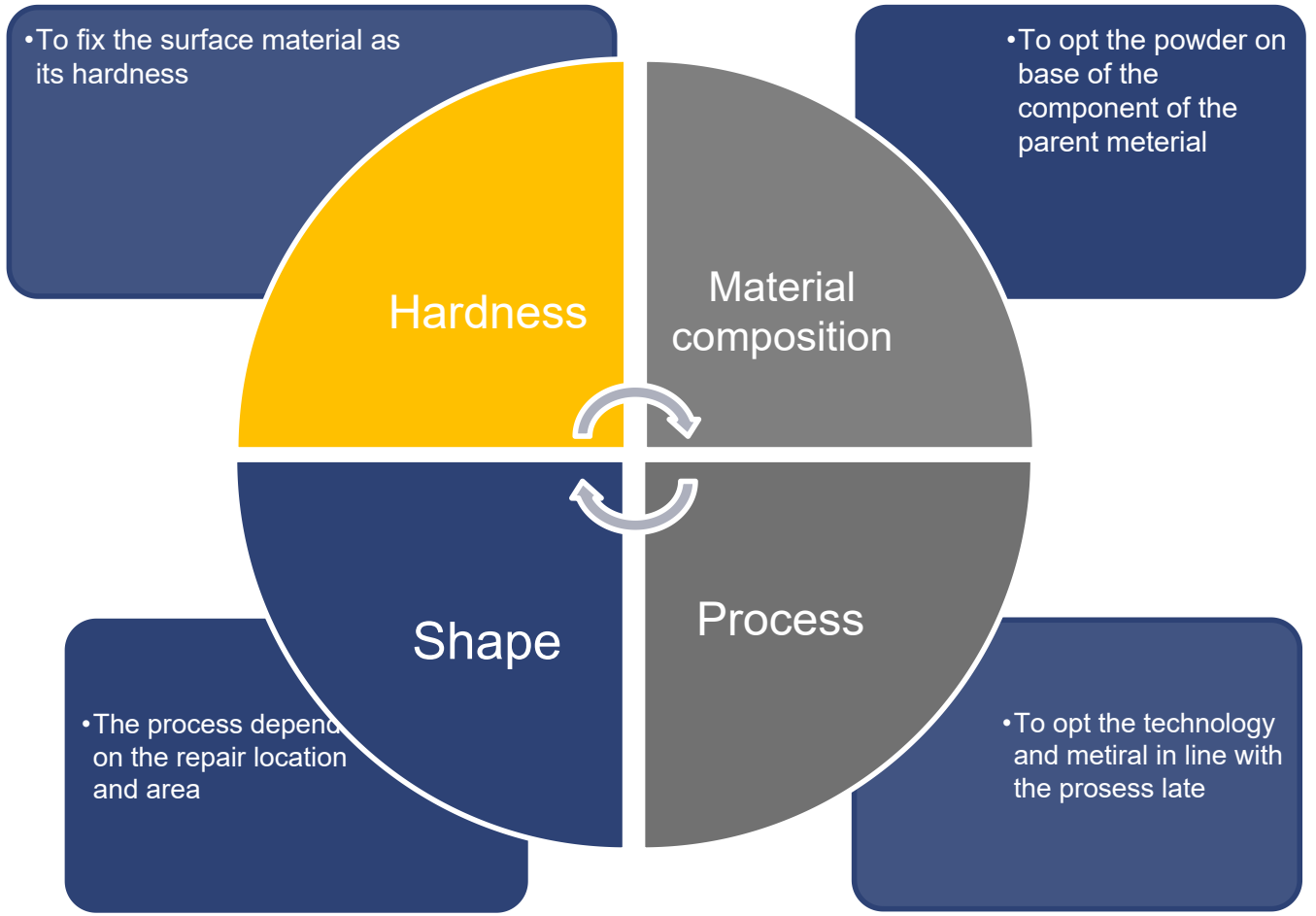
After preheating treatment, no cracks appeared in surfacing welding layer 1.5mm.

4.5 The differences between wire and powder



4.6 PTA Equipment

5.1 PTA Powder Selection



5.2 PTA Powder Selection

Temperature

- To select as the heat on account of the the material working in the different temperature

Medium

- Judge the working conditions of resistance of wear corrosion impact as the medium.

Working

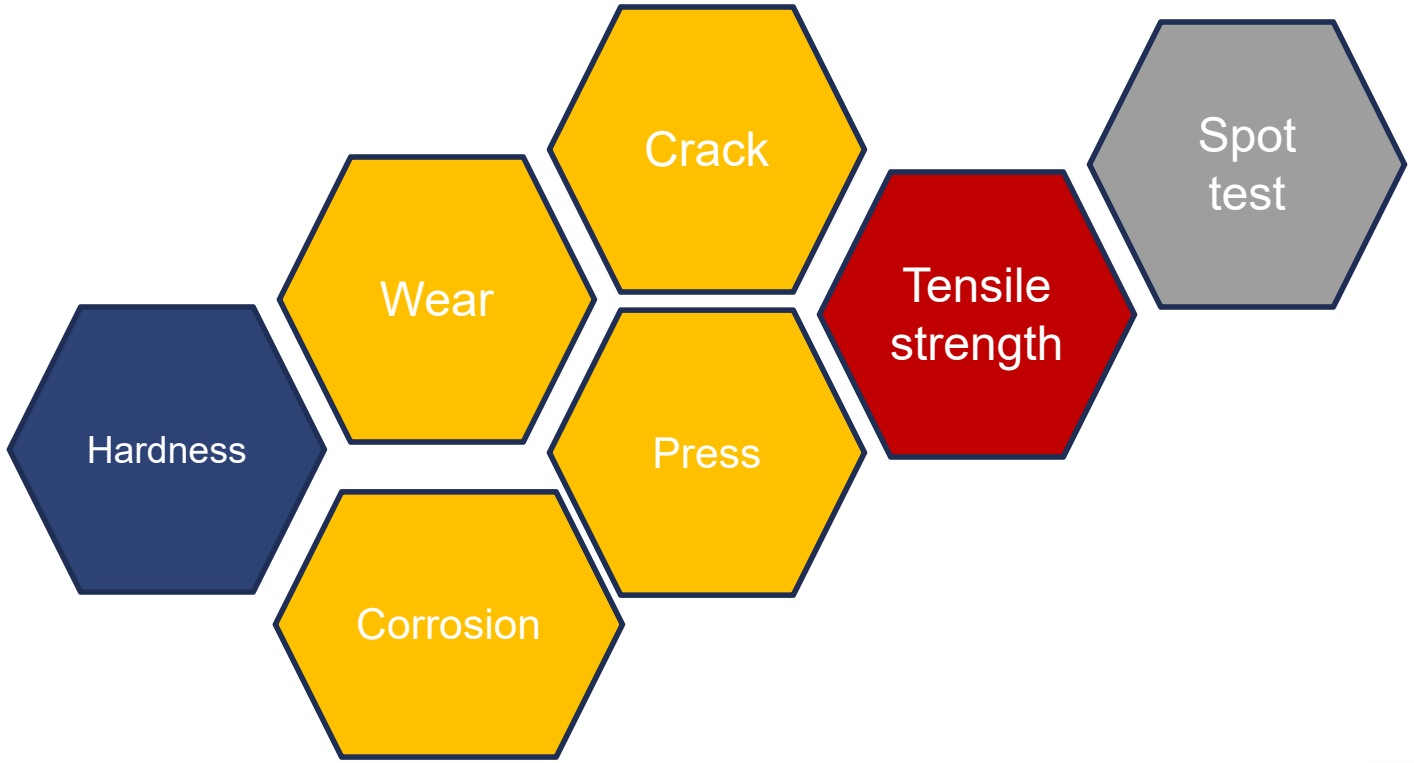
- According to the way of work (The firction of the slide, rolling and strike.

Life cycle

- depending on customer’s expectation of service life to the hardfacing.

Machining method

- On the basis of the process in the late.



5.3 PTA Powder Selection

5.4 PTA Hardfacing FAQ

Type	Shape	Location
Pore	One or more round holes	At the bottom of the arc welding layer, the number is small. Irregular in the weld pass, the number is more
Cracks	Single pass crack, perpendicular to the pass direction, length equal to the pass width, depth equal to the pass thickness. Occuring in the central of weld pass and being indentical with the derection of it.	Close to the arc of Strike and Extinguish. Random distribution
Non Fusion	As a result of not fusion fully between of the weld layer and parent mel, falling off happened on bonding suface.	Anywhere in the weld pass
Puff	Existed the fine holes in the interior of the weld layer and the development of the fine spots, clusters and linear defects as PT .	At the place of the extinguish.
Shrinkge	The irregular holes and collapse.	Anywhere in the weld pass
Fall off	Occurring between of the weld layers.	Anywhere in the Multi-layer welding

5.5 PTA Application

Oil&Chemistry

Oli exploitation PDC driller Drilling rig Drill pipe Centering Guide TC Bearing

Oil Refining and Chemicals Valve Plunger

Mining tools

Mining teeth

Rotary teeth

Driller

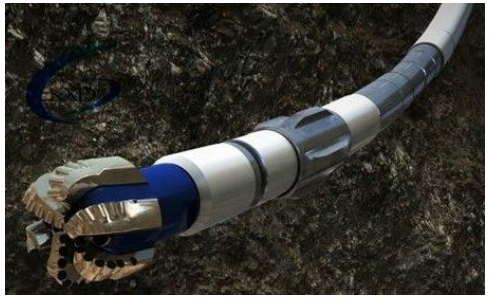
General machinery

Plastic machiney screw Plunger

Glass mold

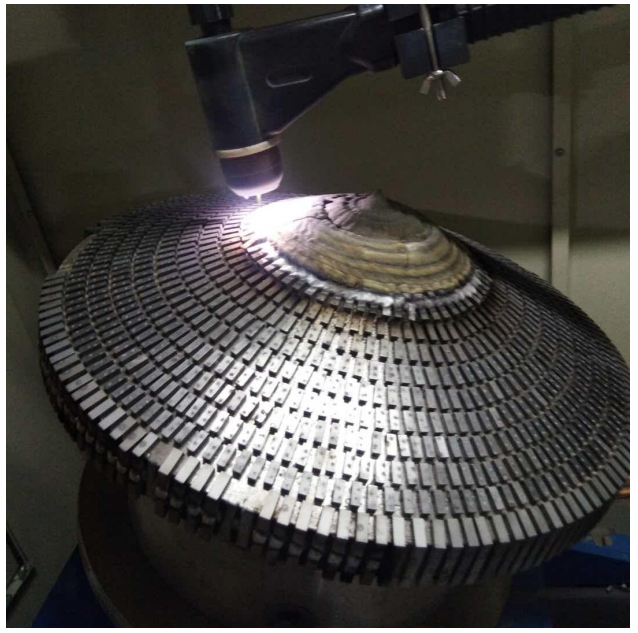
Manchanic blade Rotary tillage Blade cutter

PDC drill
Applied parts: Gauge Parts
Applied materiral: Ni+WC
Effect: the degree of automation is greatly improved, and the wear resistance is excellent.



PDM drill
Applied parts：Centering guide and Elbow Casing Pump
Applied material：Ni+WC
Effect: Ensure the wear resistant as well as impact resistant.

TC bearing
Applied parts：the gap of TC and body
Applied material：Ni+WC








5.6 PTA Industry Application

5.7 Spot

5.7 Spot

5.8 Enterprise qualification

TÜV AUSTRIA CERT GMBH
Certification Body

TÜV AUSTRIA

CERTIFICATE OF CONFORMITY

Certificate.- No.: TA 385213785

Product:	Plasma Welding Machine	Applicant:	Shanghai Duomu Industry Co., Ltd. No.2, Alley 615 Fengdeng Road, Shanghai, China
		Manufacturer:	Shanghai Duomu Industry Co., Ltd. No.2, Alley 615 Fengdeng Road, Shanghai, China
Type / Models / Trademark:	DML-V02BD; DML-V03AD; DML-V03BD; DML-V03CD		
Description / Technical Specification:	Details as described in the test report.		
EU Directive:	2014/30/EU 2014/35/EU		
Standard(s) / Product - Certification Basis:	EN IEC 60974-1:2018/A1:2019 EN 60974-10:2014/A1:2015		
Test Report:	TCF-210221		
Comments:	N/A		

According to the above stated test report(s) the specified product complies with the applicable requirements of the mentioned standard(s). The applicant may use the test report and this Certificate of Conformity in connection with his declaration of conformity referring the respective EU Directive(s) and Annex.

This Certificate of Conformity has been granted to the applicant based on the results of testing performed by the applicant/manufacturer or an approved laboratory and the consequent review of the test report by TÜV AUSTRIA CERT GMBH. Therefore, it does not imply any assessment of the instruction manual, product or the production process of this product by TÜV AUSTRIA. Revisions to the referenced certification basis or any change of the design, materials, components or processing may require the repetition of all or some of the qualification tests in order for the test report and therefore this associated certificate to remain valid. Furthermore the General Conditions for a Certificate of Conformity on a national or international Standard concerning a specified product are valid.

2021-09-08
Date of Issue

Ivan Huang, Certification representative

CE Mark may only be affixed to this product after fulfillment of all applicable EU directives for this product and the preparation of the necessary technical documentation as well as the conformity declaration by the manufacturer.

The validity of this certificate (Max. 5 years from the date of issue) can be checked on the TÜV AUSTRIA's Homepage. Any alteration or duplication of this document in parts is subject to approval by TÜV AUSTRIA CERT GMBH. The holder of this document is advised that it does not reflect a Notified Body's opinion but that the information contained heron reflects the certification body's findings on the date of issue and within the limits of the applicant's instructions, if any.

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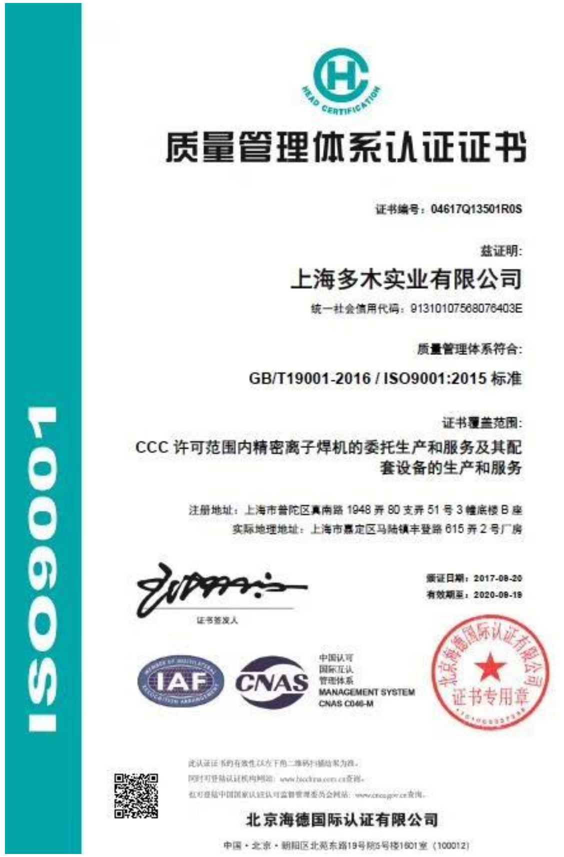

ISO9001

质量管理体系认证证书

证书编号：04617Q13501R0S

兹证明：

上海多木实业有限公司

统一社会信用代码：91310107568076403E

质量管理体系符合：

GB/T19001-2016 / ISO9001:2015 标准

证书覆盖范围：

CCC 许可范围内精密离子焊机的委托生产和服务及其配套设备的生产和服务

注册地址：上海市普陀区真南路 1948 弄 80 支弄 51 号 3 幢底楼 B 座
实际地理地址：上海市嘉定区马陆镇丰登路 615 弄 2 号厂房

证书签发人

颁证日期：2017-09-20
有效期至：2020-09-19

北京海德国际认证有限公司

中国国家强制性产品认证证书

证书编号：2013010608650885

委托人名称、地址
上海多木实业有限公司
上海市普陀区真南路 1948 弄 80 支弄 51 号 3 幢底楼 B 座

生产者（制造商）名称、地址
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经济开发区世纪大街与闫行路交汇处天晟工业园一号楼 5 层

生产企业名称、地址
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吉林省长春市经济开发世纪大街与闫行路交汇处天晟工业园一号楼 5 层

产品名称和系列、规格、型号
精密离子焊机
DML-V01(1～220V,50A,X=35%)、DML-V02(1～220V,100A,X=35%)、DML-V03 (1～220V,125A,X=35%)

产品标准和技术要求
GB/T15579.1-2013;GB/T8118-2010 中 6.15 和 6.16

上述产品符合强制性产品认证实施规则 CNCA-C06-01:2014 的要求，特发此证。

发证日期：2017 年 12 月 21 日　有效期至：2022 年 12 月 20 日

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本证书为变更证书，证书首次颁发日期：2013 年 10 月 30 日
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主 任：

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5.9 Cooperation Partner