Theory of submerged arc welding 埋弧焊原理

The electric arc welding process in an electrically conductive flux is mainly used with automatic welding machines.
The workpieces are joined together by melting one or more electrode wires to provide filler metal.
这种焊接工艺使用的焊剂可以传导电流，主要用来实现全自动焊接.可以建立一个或多个电弧来熔化填充焊丝,使被焊的工件连接在一起。

Submerged arc is a welding and hard surfacing process which gives:
埋弧焊接主要用于焊接和表面硬化,

- productivity, 生产效率高
- quality 质量好
- operator comfort.操作舒适方便

Main characteristics 主要特点

Submerged arc welding has many intrinsic advantages. They include:
埋弧焊接有许多内在的优点,他们包括:

- **a very varied range of applications:** thin plate welding,
  应用领域广泛,可进行薄板的焊接
  thick plate welding, welding of mild, alloy or stainless steel, hard surfacing and maintenance work,
  也可进行厚板的焊接,如焊接低碳钢、合金钢、不锈钢、表面堆焊及维修工作等;

- **high speed of execution** due to the use of high currents in one or more electrode wires.
  焊接效率高,因为可使用一个或多个电极,它们都有很高的电流.
- **high penetrating power** significantly reducing or even eliminating the need for bevelling, 高的穿透力,有时不用开坡口,就可以完成焊接.
- **low cost welding bead**, the quantity of filler metal being often much lower than with other welding processes.
  低成本的焊道, 与其他焊接过程相比,填充金属的数量相对比较少.
- **little distortion, 很小的变形**
- **very good weld appearance, 非常好的表面成形;**
- **excellent compactness of welds,焊道的组织比较致密.**

Can be used for welding and hard surfacing workpieces made from alloy or low-alloy carbon steel, stainless steel or refractory steel.
主要用来焊接或进行表面堆焊,主要用来焊接合金或低合金钢、碳钢、不锈钢、耐热钢等;

- **welds have excellent mechanical characteristics,**
  焊缝有优良的机械性能
- **concealed arc** enabling the operator to work without a mask and without disturbing others nearby,
  由于电弧被埋在下面，操作员可以安全地进行操作,无须面具,也不能影响他人的工作.
- **no fumes are given off**,无烟尘放出
  giving better operator comfort and a saving in the costs of devices for extracting and treating welding fumes.
  使操作者更加方便,节约成本,可以吸收和处理烟尘。

Limitations of the process 焊接过程的局限性

- submerged arc welding can be used only on alloy or non-alloy carbon steel, stainless and refractory steel,
  埋弧焊只能用来焊接合金和非合金钢,不锈钢和耐热钢.

- the use of powder flux means that welds must be executed horizontally unless special measures are taken,
  由于焊剂呈粉末状，一般情况下,主要是水平焊接,如使用特殊的装置,可以进行立焊和横焊.
- the process cannot weld plate less than 1.8 mm thick (due to its high penetration)
  这种焊接方法不能焊接小于1.8 mm厚的板材.(这主要由于它高的穿透力)
- it is not possible to butt joint workpieces more than 16 mm thick. without special preparation (edge bevelling).
  对于对接接头,板的厚度超过16 mm,如不开坡口,将不能焊透16 mm厚的板材.

The energy required is produced by passing an electric current between the electrodes and the workpieces through a medium which is protected from air. This medium is a slag produced by melting a powder flux which covers the end of the electrode wire, the arc and the weld pool.
所需要的能量是通过电极和工件之间的电流来传导，同时也会防止空气的侵入。焊剂熔化后产生的熔渣,保护电极的末端、电弧、焊接熔池。

This process combines productivity, quality and operator comfort with:
焊接过程效率高、质量好、操作容易。

- excellent weld compactness, 优秀的焊缝质量
- good mechanical characteristics, 良好的机械性能
- high penetration, 较高的穿透力
- fast execution speeds, 快的焊接速度
- good weld appearance, 好的焊缝成型
- absence of spatter and smoke, 飞溅和烟尘少
- high duty cycle. 高的负载持续率

A wide range of applications 应用范围广

Assembly of reconstituted welded beams with constant or variable section using two electrodes (twin-arc).
通过安装在横梁上的装置,使用双电极来实现双丝焊接.

Hard surfacing rolling-mill cylinders (using strip cladding) or rolling stock wheels (using wire).
使用焊带,可以对轧棍的表面进行堆焊,使用焊丝,可以对圆形的车轮进行堆焊.

Single wire welding of various mecano-welded structures.
可以使用多种结构的单丝焊接;

Submerged arc welding can be used for a multiple of widely-varying applications as shown below: all types of boiler work, naval construction, mechanized welding, steel beam fabrication, off-shore engineering.
埋弧焊接应用十分广泛,例如:各种锅炉、舰艇建造、机械工程、钢结构安装、海洋石油平台等.

Single-wire multipass welding of vessels (thickness ε 20 mm).
压力容器单丝多道焊接(厚度超过20 mm)

Single-wire or twin-arc welding for shipbuilding (carriage-mounted equipment).
单丝或双丝焊接为造船使用,(整套设备安装在小车上)

Tandem welding on panel line.一前一后的双丝焊接系统（Tandem）

With many years of experience in welding and submerged arc welding in particular, SAF offers you two automated arc welding and hard surfacing installations: the SUBARC 2 and SUBARC 5.

根据多年的焊接和埋弧焊经验,特别是, SAF能提供两套焊接和表面堆焊控制装置: the SUBARC 2和SUBARC 5

Automatic submerged arc welding and hard surfacing installations 全自动埋弧焊接和表面堆焊设备

A complete range of high-performance equipment using microprocessor technology to combine performance, flexibility of use and guaranteed high reliability in welding cycle management. These installations cater for all possible modes of operation:

设备使用了微处理器技术,性能超群,适用范围广,灵活性强,在焊接循环管理器中,能保证高的可靠性,这些设备能够满足所有操作的模式:

- direct current (DC), 直流
- alternating current (AC), 交流
- direct current + alternating current (tandem arc). 直流 + 交流

Criteria for choosing installations and standard offers numbers

	Single-wire	Twin-arc	Tandem
SUBARC 2	LA 01 090		
DC			
SUBARC 5	LA 01 120 LA 01 130	LA 01 160	LA 01 140 LA 01 145
DC AC			

Positioning equipment 变位器

SAF offers a large range of positioning equipment for use with submerged arc welding.
SAF可以为埋弧焊提供范围很广的变位器

Standard equipment:标准设备

- seamers, 纵缝机床
- column & booms, 十字操作机
- rotators, 滚轮架
- positioners and 变位器
- self-propelled carriages. 自推动小车

Equipment which can be customized to your requirements: 也可以根据客户的需要专门定制的焊接设备

- turntable, 旋转架
- locating positioners, 变位器
- large dimension column & booms, 大尺寸的十字操作机器
- special welding benches. 特制的焊接车床

The SUBARC 2 installation is designed to allow quick and economic integration of direct current MIG or submerged arc

welding depending on the horizontal power source characteristics.

SUBARC 2设备是一非常方便经济的设备,可以与直流MIG或埋弧焊接相匹配，主要依靠水平电源的外特性.

SUBARC 2 consists of: SUBARC 2包括以下部件:

_ Control unit box　控制盒

• Rugged and compact, its size enables it to be located as near as possible to the welding point.

坚固耐用、因为尺寸较小、可以将它放置在焊接区域的附近.

• Parameter read-out on digital displays.

焊接参数可以显示在数字屏幕上;

• Automatic control of flux feed.

也可以自动控制焊剂的送给;

• Installation available with manual or automatic flux valve.

可以使用手动或自动焊剂阀门;

The DEVIMATIC (D5/3) wire feed unit motor/gearbox

(D5/3)送丝机;可用电动或齿轮控制

• Compact 4-roller drive mechanism.精小的4轮机械驱动

• Rugged and powerful motor.　坚固有力的马达;

STARMATIC 650 DC generator　STARMATIC 650 DC 发电机

• Multi-process source: submerged arc, MAG or gouging.多用途电源，可以埋弧、 MAG、碳弧气刨使用;

• Rugged and compact.坚固精巧

• Very precise regulation of the process.可以非常精确地调节焊接过程;

SUBARC 5

For the most demanding applications, SUBARC 5 is a compact welding and hard surfacing installation.
SUBARC 5 allows accurate pre-setting and pre-selection of the actual welding current and voltage parameters for excellent arc striking every time.

SUBARC 5可以完成更多的应用,是一个精巧的焊接和表面堆焊装置;

SUBARC 5可以进行精确的预置参数,也可以提前选择实际的焊接电流和电压焊接参数，还可以进行优秀的起弧功能.

Installation complete with the MECACYCLE M movement + cycle drive module for moving the welding head assembly in a predefined cycle.

这个设备能够完成机械运动,循环驱动模块可以驱使焊头按照预设的循环进行组合运动.

Control unit box　控制盒

• Rugged, simple and user-friendly controls.坚固耐用、使用界面友好、简单实用;

• Digital read-out of three parameters: current, voltage and wire speed.

可以数字显示焊接工艺参数:电流、电压、焊丝速度

• Pre-setting of voltage and welding current.

可以预设焊接电流和电压

• Storage and read-out on digital displays of current and voltage when

welding has finished.
当焊接结束后,可以储存或数字显示焊接电流和电压。

- Wire/workpiece short-circuit detection and display in manual wire feeding mode minimizes mechanical stresses on wire feed head supports.
  焊丝和工件之间可以实现短路过渡,在手动送丝模块中能减少焊丝头支撑座的机械压力。

SUBARC 5 carries out: SUBARC 5主要完成

- submerged arc welding:埋弧焊
  direct current: flat or drooping power source characteristics.
  直流:平或下降的电源外特性
  alternating current: drooping power source characteristic.
  交流:下降电源特性
- MIG/MAG (spray-arc transfer).
  MIG/MAG (喷射电弧过渡)

Power unit box　　电源控制箱

- All the controls for configuring the installation are accessible on the front panel of the power module.
  对于所有的控制都可以通过电源前面板显示出来。
- Full control of all welding cycle time-delays.
  可以进行焊接循环延迟控制。
- Welding process selector (submerged arc or MIG/MAG).
  焊接工艺转换开关(埋弧焊或MIG/MAG焊)
- Fixes to the top of the power source away from "sensitive" areas of the installation (near the arc).
  电源的顶部远离"明感区"

The DEVIMATIC (DX 7) wire feed unit motor/gearbox
(DX 7)送丝机,(电动/齿轮传动)

- A tachogenerator driven by the wire feed motor guarantees very accurate welding control.
  送丝马达驱动一个测速发电机,能够保证非常精确的焊接控制;
- A simple and rugged mechanical assembly that is easy to configure to suit your application.
  简单结实机械装置，很容易满足你的应用要求;
- Fine adjustments for all degrees of freedom in rotation allow easy adjustment of the point at which the wire impinges on the workpiece.
  可以自由的旋转,进行很好的调节,以使焊丝与工件紧密接触.

Software for analysis and recording of welding parameters (option) (cat n° 9109-5532).

分析和记录焊接参数的软件(可选)

The installation can be completed by software for the analysis and recording of the welding parameters (current, voltage).
这台设备可以通过分析软件记录焊接参数(电流和电压) **(定货号 9109-5532)**
This software is compatible with all PCs equipped with a minimum of WINDOWS 3.1. A screen display shows the upper and lower limits of the parameters together with the operating conditions (wire and flux types, wire and welding speeds etc.)

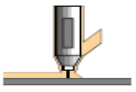
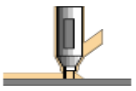
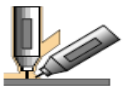
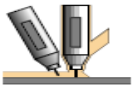
这个软件可以适合WINDOWS 3.1系统,屏幕上会显示出与焊接条件相匹配的的上限和下限的焊接参数,如焊丝的类型、焊丝直径和焊接速度)

Two parameter display screens are available; the first provides the trace of both current and voltage, the second provides a display of the welding data: current, voltage and energy for each measurement point. After welding, it is possible to print these recorded parameters (manufacturing traceability).焊接参数可以在屏幕上显示出来,可显示出焊接电流和电压的变化轨迹,其次还可显示出焊接的数据:如电流、电压和所测的能量。在焊接后,还可以打印出那些焊接规范。

SUBARC 5 : an overall package

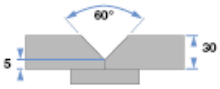
SUBARC 5 takes you into the forefront of high performance submerged arc welding. From single-wire to TWIN-TWIN tandem arc welding, our team are there to help you obtain the performance you want.

SUBARC 5是为埋弧焊接提供高性能控制装置,从单丝到双丝的埋弧焊接, 我们会提供焊接工艺达到您所需要的性能。

	Number of current sources	Number of electrodes	SUBARC 5 process
Single wire process*			
• Direct current (DC) - standard offer LA 01 120	1	1	
• Alternating current (AC) - standard offer LA 01 130	1	1	
Twin-arc process*			
• TWIN - standard offer LA 01 160	1	2	
Additional filler metal			
• Cold wire - standard offer LC 03 040	1	2	
• Hot wire	2	2	
Tandem arc process			
• TANDEM - standard offer LA 01 140	2	2	
• TWIN-TWIN - standard offer LA 01 145	2	4	

** available in solid wire or specific flux-cored wire versions*

Example



3,4 kg of metal deposited per meter

Comparison of performances of submerged arc welding processes

Process	SINGLE	TWIN	HOT WIRE		TANDEM		TWIN /TWIN	
Electrode diameter mm	1 x 4.0	2 x 1.6	Head 1 x 4.0	Hot wire 1 x 1.6	Head 1 1 x 4.0	Head 2 1 x 4.0	Head 1 2 x 2.0	Head 2 2 x 2.0
Current A	650	800	650	-	750	600	900	750
Voltage V	31	34	31	-	30	36	32	36
Fwd movement cm/min	60	90	60		130		160	
Energy kJ/cm	20.2	18.1	20.2		20.5		21.0	
Deposit rate kg/h	7.5	14	17.5		22		32	

Difference between the processes

Deposite rate kg/h	7.5	+ 87 %	+ 133 %	+ 193 %	+ 326 %
Fwd movement cm/min	60	+ 50 %	+ 0 %	+ 117 %	+ 167 %
Optimum duration of weld in min. 100 m weld	2 720	1 457	1 166	927	638
Time saved	-	46 %	57 %	66 %	77 %

Using consumables from our submerged arc range guarantees that you will obtain the best performance throughout the lifetime of your installation. A wide range of services are also available to help you optimise your production processes.
埋弧焊选用合理的焊材，可以保证焊缝得到很好的机械性能,也可以优化焊接工艺.

Services服务

SAF offer a full range of services to enable you to optimize your production processes and to keep your future automatic welding equipment in step with your manufacturing requirements.
SAF提供全方位服务，保证全自动焊接设备满足制造生产的需要。

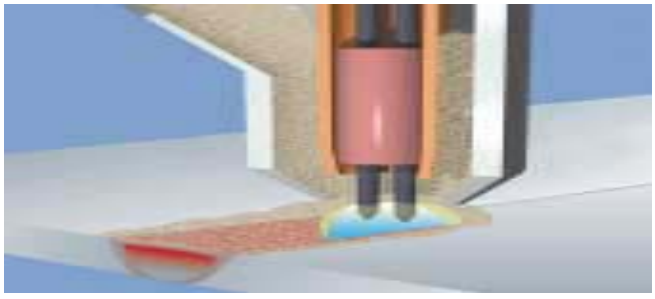
For example, SAF service solutions:
例如: SAF 服务结果

- accompany you throughout the commissioning phase of your equipment,
  在整个试运车阶段,一直陪伴和指导客户;
- qualify and provide draft specifications for your welding procedures (Welding procedure specification, Welding procedure qualification test record, welding parameters, mechanical characteristics),
  根据客户的产品,可以为客户提供好的焊接程序、焊接程序试验记录、焊接参数、机械性能;
- optimise your productivity (increase welding speed, improve quality),
  增加焊接生产效率, 提高焊接速度和焊接质量;
- train your welders, operators and maintenance technicians in the use of the equipment,
  可以在使用焊接设备时, 为你培训焊工和操作者和技术人员,
- out-source maintenance tasks.电源维护任务.

Consumables消耗品

The mechanical quality of the weld beads depends directly on the wire/flux association. SAF has selected for you **the best combinations for an optimum result.**
焊缝的机械性能主要决定于焊丝和焊剂的综合性能,为了得到更好的焊接结果, SAF为您提供了最好的选择;

TOPTWIN: submerged arc weld with flux-cored twin-arc electrode wires and specific fluxes
TOP 双丝焊接:药芯双丝埋弧焊接使用了特殊的药芯焊丝.



Results 结果

- **Angle weld, thickness 6 mm 角焊接 厚度6 mm**

Weld speed 1.8 m/min (63% with respect to the single solid wire submerged arc weld)
与单丝实芯焊丝埋弧焊相比, 焊接速度可达到1.8 m/min, 比单丝实芯焊丝埋弧焊焊接速度快37%;

- **Flat weld, thickness 10 mm 平焊, 厚度10 mm**

Weld speed 1.05 m/min (+100 % with respect to the single solid wire submerged arc weld)
焊接速度1.05 m/min, 与单丝实芯焊丝埋弧焊相当;
• Flat weld, thickness 40 mm 平焊, 厚度40 mm
Weld speed 0.7 m/min
焊接速度为0.7 m/min,

STARMATIC power ources
STARMATIC焊接电源

STARMATIC power sources intended for submerged arc welding applications are:
STARMATIC电源主要用于埋弧焊
• rugged,坚固耐用
• reliable,可靠
• proof against aggressive industrial environments,能够适应各种工业环境
• fan cooled,风冷

Four power ratings available for
可以得到四种额定功率电源
Remote controllable thyristor based power source:
STARMATIC 1003 AC/DC, 1000 A duty cycle à 100 %.
可以远控,晶闸管电源:STARMATIC 1003 AC/DC, 1000 A 负载持续率100 %.

* 230V three-phase power supply at 50 or 60Hz available to order.
230V三相电压,频率50 -60Hz

Technical specifications	Alternating current operation
Description	STARMATIC 1003 AC/DC
Cat n°	9114-0620
Duty cycle at 100 %	1 000 A under 44 V
Primary three-phase power supply	400 V 50 Hz
Consumption at maximum current (400 V)	143 A
Power at 100 % duty cycle	98 kVA
External characteristics - static	
horizontal	■
drooping	■
Protection index	IP 21
Insulation class	H
Weight	540 kg

• fitted with thermal cut outs,有过热保护
• easy to move using crane or forklift,使用起重机移动方便.
• quick connection to the core of the installation by simple and accessible connectors,
快速接头,方便操作,简单使用.
• remote controlled.远控
two distinct types of operation: DC or AC 两种不同的操作模式:直流和交流

Direct current operation产　直流操作

Remote controllable thyristor based power sources:可远控晶闸管电源

- STARMATIC 650 DC, 650 A duty cycle at 100 %.
- STARMATIC 1003 DC, 1000 A duty cycle at 100 %.
- STARMATIC 1303 DC, 1300 A duty cycle at 100 %.

- STARMATIC 650 DC, 650 A 负载持续率 at 100 %.
- STARMATIC 1003 DC, 1000 A负载持续率at 100 %.
- STARMATIC 1303 DC, 1300 A 负载持续率 at 100 %.

Direct current operation		
STARMATIC 650 DC	**STARMATIC 1003 DC***	**STARMATIC 1303 DC***
9114-0768	9114-0630	9114-0640
650 A under 44 V	1 300 A under 44 V	1 000 A under 44 V
230-400-440 V 50-60 Hz	400-440 V 50-60 Hz	400-440 V 50-60 Hz
73 A	95 A	145 A
34.5 kVA	65.8 kVA	99 kVA
■	■	■
■	■	■
IP 21	IP 23	IP 23
H	H	H
247 kg	394 kg	483 kg

A large range of additional equipment is available to adapt SAF installations to each customer's requirements with the aim of optimising performance and increasing productivity.

Saf设备能够满足客户的需要焊接设备，既可以提高生产效率，又可提高产品的性能。

Tools

Wire lead-ins The straight and curved wire lead-ins are fitted with nozzles which have unusually high resistance to wear, giving them a long service life. Their shape and dimensions cover virtually all applications without special adaptations.

弯曲的或直的送丝机构装配有喷嘴,它有很高的抗磨损能力,寿命较长,不需要特殊的制作,他们的形状和尺寸能够满足所有的应用.

_ Flux recovery equipment　焊剂回收设备

A compact unit which reduces significantly manual refilling of the flux feed hopper using a venturi powered by compressed air (5 to 7 bar).

焊剂回收设备是非常轻巧，通过5－7 bar**压缩空气可以自动地将焊剂过滤到漏斗里，减少手工劳动强度；**

Cat. n° : 9109-5145　　定货号：9109-5145

非常精巧的装置,能够减少手工工作,通过压缩空气可以回收焊剂.

Add-ons

6 programs control unit　6程序控制器

Allows 6 different settings to be memorised (current, voltage and welding speed).

Very practical for fabrications requiring multi-pass welds.

Cat. n° : 9109-5375

可以设置6组不同的焊接规范,(如电流、电、焊接速度),对于多层多道焊接,这是非常有实际意义的.

_ Spot laser 激光跟踪
Shows the point of impact of the electrode wire relative to the joint on the workpiece. One spot is used for horizontal alignment. Two spots are used to inspect the vertical alignment. The video unit consists of:
可以显示出焊丝和工件的相对位置，一个激光点用来在高度方向的跟踪，第二个激光点在水平方向跟踪，这套装置包括：
• collar-mounted spot laser, 装夹;
• double-mounting support, 激光点的装备支撑;
• collar-mounted power supply unit, 装夹配件
• 22 m power supply cable 22米电缆线
Cat. n° : 9109-6270 定货号：9109-6270

Strip cladding head 焊带焊头
Feeds strip cladding from 25 to 80 mm in width. This system is used for hard surfacing various workpieces.
Cat. n ° : 9111-0474.
可以送25 - 80 mm宽的焊带,主要用来堆焊不同的工件表面;

Video unit 视频系统
Enables the welded joint to be viewed on a colour screen. The light spot shows up the filmed area. An essential tool for welding inside a tank for example.
The video unit consists of: a control box, a video camera and support, a light spot with power supply and connecting cables.
Cat. n° : 9109-6395.
能够在彩色的屏幕上显示出焊接接头和弧光区域,如果是内部焊接,这是非常必要的，这个视频系统包括下列装置:控制盒, 视频照相机、支撑座,电源和连接电缆.

Pumped flux 用一泵来推动焊剂
Pumps flux over large horizontal or vertical distances.
在水平和竖直方向可以使用一个泵来推动焊剂的移动;
• For an installation with flux recycling - Cat. n ° : 9109-6310 (including flux recovery system).
这套装置包括在焊剂回收系统里; 定货号9109-6310
• For more compact installations- Cat. n ° : 9109-6120, without flux recovery system.
对于更精巧的的装置，焊剂回收系统不包含此套装置，定货号9109-6120
Available as an option: flux low detection, damp reusage limitation.
此套装置可以作为一个选项，当漏斗里只有少量的焊剂时，此装置就会报警。
SENSORTRACK proportional joint follower 跟踪传感器
Allows the welding head to follow a joint trajectory by using a seam-tracing finger which runs on the workpiece.
通过传感器，允许焊头沿着工件上焊缝的轨迹行走;
Its principle of operation is based on slaving the correction speed to the amount of deformation of the sensing finger.
它的工作原理就是通过传感器的触指变形量，来纠正移动速度，从而起到导向的作用;
This technology provides an excellent seam-following function (without disruption of the welding arc) on joints having both large and rapid variation.
这项技术可以提供很好的焊缝跟踪功能，而不用破坏电弧。

Standard offer: PH 07-010.