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An Approach to Best Welding Practice. Part - XXI - Section III - B - III

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"AN APPROACH TO BEST WELDING PRACTICE. Part – XXI-B" is the Twenty First Detail Part of **"AN APPROACH TO BEST WELDING PRACTICE"** which was written as a general and overall approach to the subject matter.

AN APPROACH TO BEST WELDING PRACTICE. Part – XXI., Section III-B - III is particularly focused on the Generation and Computer based Storage of Welding Data on Resistance Welding Processes for Fabrication. It is required as a Working Guideline for Planning Engineers, Welding Co-ordinators and Quality Managers working in an Engineering Fabrication Plant using welding as the main manufacturing process.

In fact, this is a lengthy process to develop and as each and every step is connected with each other for cross references, none can be eliminated.

In every Fabrication concern where Welding is the major manufacturing process preparation, recording and storage of welding processes must be done.

Which Data are needed ?

It is understood and accepted that in Fabrication and manufacturing Industries where Welding is the main process, classification of Data used and needed is very difficult. We can at best identify the following needs

1. Welding processes
2. Welding Power Sources with Ancillary Equipment
3. Consumables – Electrodes, Wires, Flux Cored Wires
4. Shielding Gases
5. Joint design weldment design and surface preparation
6. Weld location Welding position

How to store and retrieve data ?

A large number of computer softwares have been developed to store data, modify and to retrieve as and when required. This system will eliminate human error, can link and compare past performances with the present one instantly, may even point out optimum use of resources for increased efficiency, effectiveness of resources for ultimate gain of productivity and quality improvement.

An integrated system will include:

- ➢ Filler and base metals and their chemical and mechanical properties;
- ➢ Histories of welder qualification and the quality of welds by each welder;
- ➢ Welding-procedure information, including WPSs, PQRs, and pre and post weld heat-treatment information;
- ➢ Design information, including joint design graphics and welding symbol information; Corrosion-resistant and wear-resistant material information, such as ferrite content and prediction for stainless steel welds.

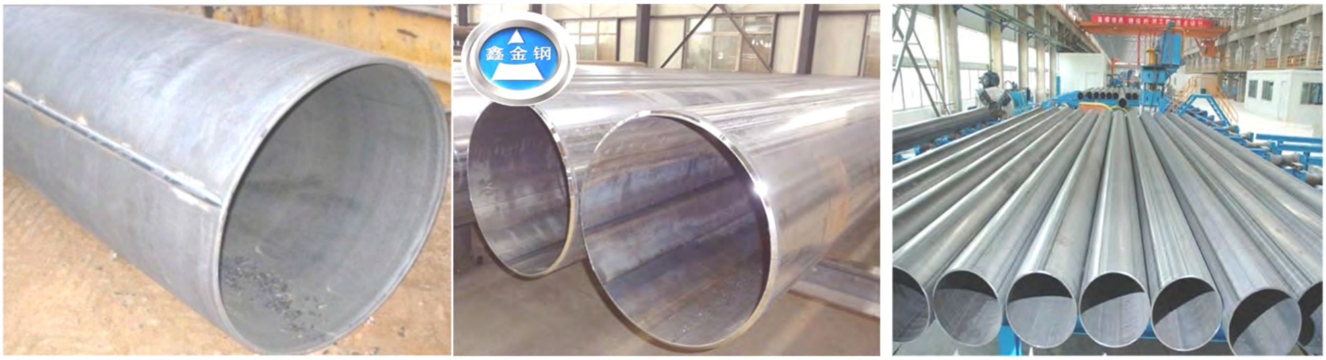
The softwares are all designed to operate in the computing environment of the desktop computer, turning the computer into a welding engineering work station.

Resistance Welding Applications

The applications of resistance welding include the following:

- Wide use in automotive industries.
- Manufacturing bolts, push rods, pull rods
- Seam welding used for manufacture of pipes, tubes, tanks, boilers.
- Flash Butt welding used for welding bars, rods, tubes and pipes.

APPLICATIONS

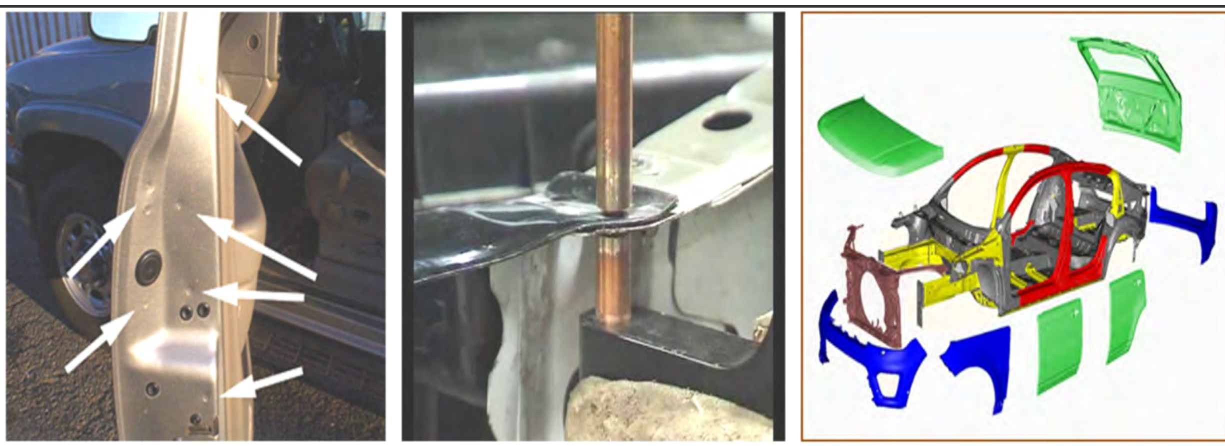


SEAM WELDED PIPES

CONTAINERS

FUEL TANK

FILTER BAGS



AUTOMOBILE PART

Resistance Welding

Introduction

Resistance welding is one of the oldest of the electric welding processes in use by industry today. As shown above the Resistance Weld is made by a combination of heat, pressure, and time. As the name resistance welding implies, it is the resistance of the material to be welded to current flow that causes a localized heating in the part. The pressure exerted by the tongs and electrode tips, through which the current flows, holds the parts to be welded in intimate contact before and during the welding process. Current flow in the joint is determined by material thickness type of material, the crosssectional area of the welding tip contact surfaces. In the diagram shown below a complete secondary resistance spot welding circuit is illustrated. For clarity, the various parts of the resistance spot welding machine are identified.

Basic Concept to Produce a Good Resistance Weld.

To produce a good welded joint by Resistance Welding the following points are to be observed :

- In order to develop higher temperature between the interfaces of the work to be welded rather than at the surface of the work in contact with the electrodes it is necessary to keep the resistance between the electrodes and the surface of the body being welded to minimum.
- In order to obtain a good weld it is necessary to maintain the contact resistance uniform which depends upon the surface condition.
- For welding thin materials the resistance of the current path in the work is kept minimum.
- For welding thick materials of low conductivity, the resistances of the current path should have a high conductivity. To achieve this either reduced pressure or high resistance electrodes having melting point higher than that of metal to be welded, can be used.
- For welding two dissimilar metals having different conductivity, low conductivity electrodes on high conductivity metal side and vice versa are used in order to prevent overheating on the low conductivity metal and to develop sufficient heat to melt high conductivity metal.
- The pressure which is to be applied on the weld is an important factor. At high pressure, low temperature plastic welds can be obtained and where as if the pressure is lowered the resistance to the welding current is to be increased. There is a limit up to which the resistance can be increased and after that there will be surface burning. The pressure necessary to effect the weld varies from 2.5 - 5.5 kgf/mm^2.
- The magnitude of current is controlled by varying either the primary voltage of the welding transformer (by using auto-transformer between supply and the welding transformer) or changing the primary turns of the welding transformer.
- Alternative method of controlling the current to weld is to vary the magnitude and wave of the primary as well as secondary current by using Thyratron or Ignitron tubes in the primary circuit.
- In resistance welding, the time for which current flows is very important. Usually automatic arrangements are devised which switch off the supply after a predetermined time starting from the application of pressure (starting of weld).
- The pressure may be applied manually, by air pressure, by springs or by hydraulic means. Even after switching off the supply, the pressure is continued on the electrodes until the weld cools down. In machines which are operated continuously, the electrodes are cooled by water circulating through hollow electrodes.
- Electrical circuit diagram for resistance welding is shown in **Fig**. below. The machine employed for resistance welding contains a transformer provided with necessary taps, a clamping device for holding the metal pieces, and a mechanical means for forcing the pieces, to be welded, together to complete the weld.

Resistance Welding Advantages and Disadvantages

Advantages

- This method is simple and does not necessary high expert labor.
- The resistance welding metal thickness is 20mm, & thinness is 0.1 mm
- Automated simply
- The rate of production is high
- Both related, & different metals can be weld.
- Welding speed will be high
- It does not need any flux, filler metal & protecting gases.

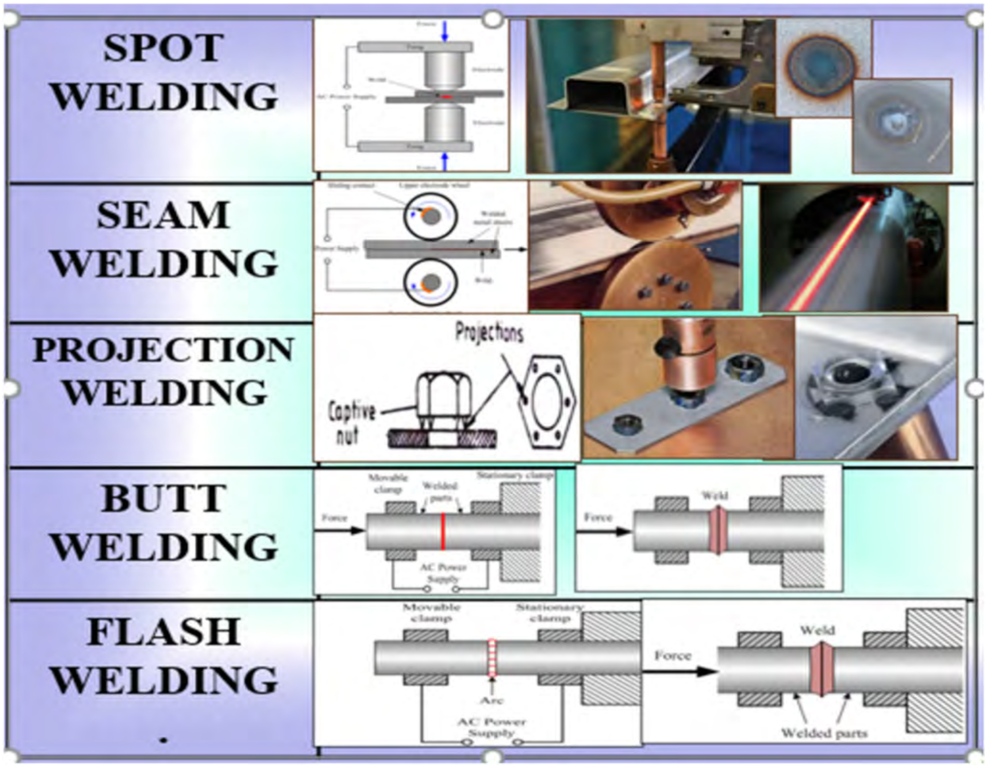
Disadvantages

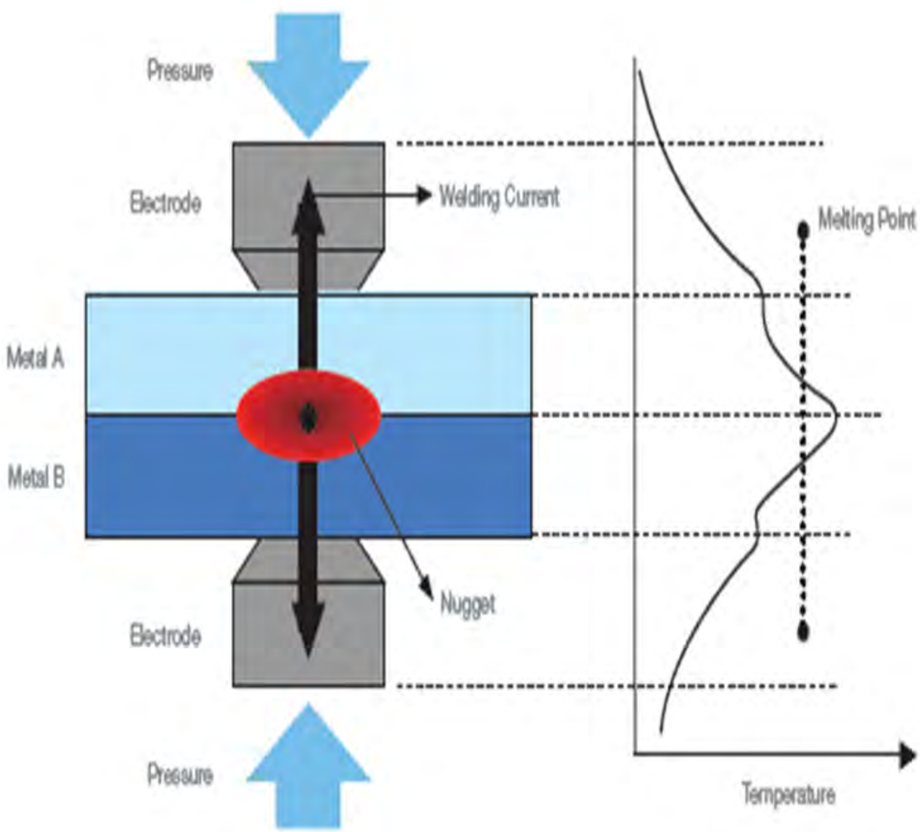
- Tools cost will be high.
- The work section thickness is limited because of the current requirement.
- It is less proficient for high-conductive equipment.
- It consumes high electric-power.
- Weld joints contain small tensile & fatigue power

Spot Welding

Spot welding is the simplest type of welding where the work portions are held jointly below the force of anvil faces. The copper (Cu) electrodes will make contact with the work portion and the current flows through it. The portion of the work material also imposes a resistance to the current flow. The joint resistance produces the heat. The Electrodes exert a pressure and the contact surfaces of the joint melt and forms the weld. The pressure is released on cooling down of the joint. The current supply & the time must be enough for the correct dissolving of edge faces.

TYPES OF RESISTANCE WELDING





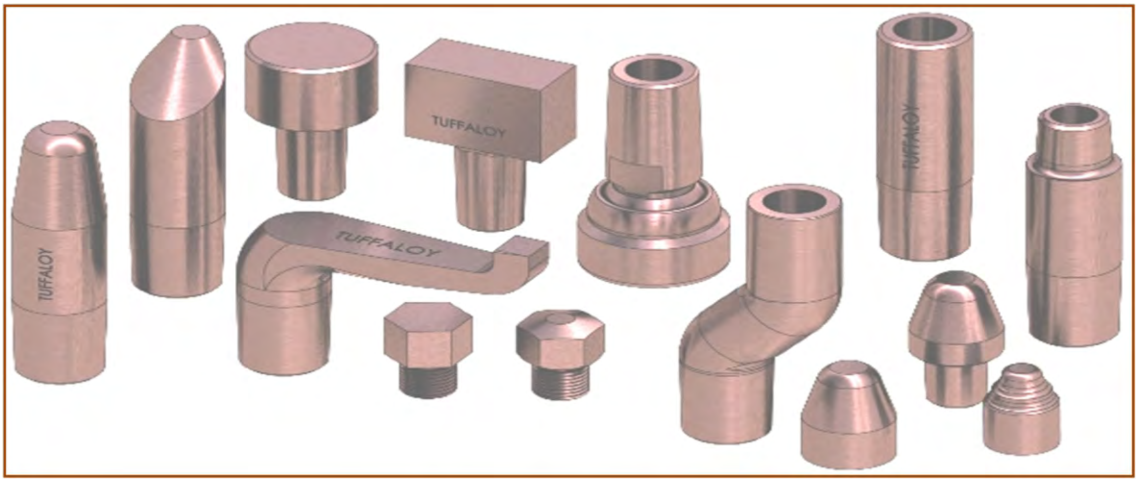


Fig. : Spot Welding Electrode Tips

Electrode Tip Size

As the welding current is permitted to flow into the workpiece through the electrode the size of the electrode tip point controls the size of the resistance spot weld. Actually, the weld nugget diameter is slightly less than the diameter of the electrode tip point.

The formula generally used for low carbon steel is as follows:

Electrode tip diameter = 0.100 in. +

where " t " is the thickness in inches of one thickness 2t of the metal to be welded.

This formula is applicable to the welding of metals of dissimilar thicknesses. The formula is applied to each thickness individually, and the proper electrode tip diameter selected for each size of the joint.

For example, if two pieces of 0.062 in. sheet metal are to be joined, the electrode tip diameter would be the same for both sides of the joint. The calculation would be as follows:

Electrode tip dia. = 0.100 + 2t
= 0.100 + 2 x 0.062 in.
= 0.100 + 0.124 in.
Electrode tip dia. = 0.224 in.

If the two pieces were unequal in thickness, such as one piece 0.062 in. and the other 0.094 in., two calculations would have to be made. Each thickness would be treated as the basis for one electrode tip diameter determination, as follows:

Electrode tip dia. = 0.100 + 2t
= 0.100 + 2 x 0.062 in.
= 0.100 + 0.124 in.
Electrode tip dia. = 0.224 in. (one side only)

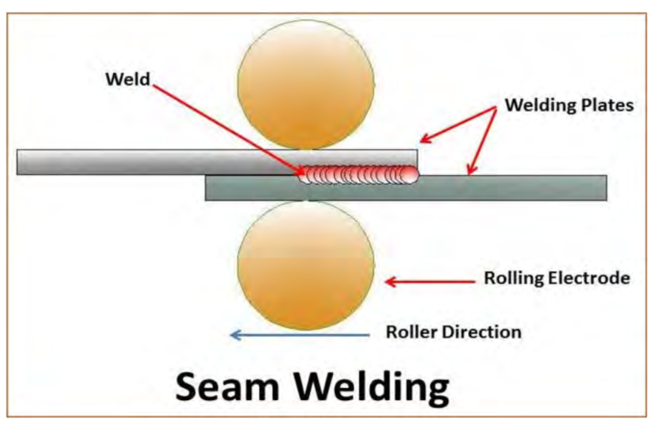
For the other side, the calculation is as follows:

Electrode tip dia. = 0.100 + 2t
= 0.100 + 2 x 0.094 in.
= 0.100 + 0.188 in.
Electrode tip dia. = 0.288 in. (one side only)

This formula is applicable to low carbon steels and may not be correct for other materials.

Seam Welding

This type of welding is also known as continuous spot welding where the electrodes in the form of Rollers supply current through work parts to the joint surfaces. The roller electrodes rotate at a given speed and the materials to be joined as placed between the rotating rollers are melted and get welded at the joint surface under pressure. High current can be supplied through these electrode rollers to melt the edge surfaces & shape a weld joint.



Seam Welding Wheels

The seam welding machine is built with wheels between which the weld is formed. The wheels roll on the surface of the metal to be welded; the metal is passed between the wheels to form the seam weld>/.

The intermittent mode is similar to pulsation with the exception that there is no impulse counter. The weld impulse and the cool time continue from initiation of the control until the initiation circuit is opened. Some machines are built to weld essentially continuously, such as tube mills and some barrel and drum welders

The weld timing & electrode movement can be controlled to ensure that the weld overlap & work parts are not over heated. The speed of the welding can be about 60 in per min within seam welding for an ± electrodes.

Projection Welding

Projection welding is similar to spot welding. The only difference is that at the intended welding spots raised dimples are produced as a preparatory step before placement of the materials together for Resistance welding. The work parts are held in between the electrodes and a calculated level of current is allowed to flow through for a calculated period of time. Pressure is then applied through the electrode on the parts to be joined. The projected raised dimples get melted and produce the joint.

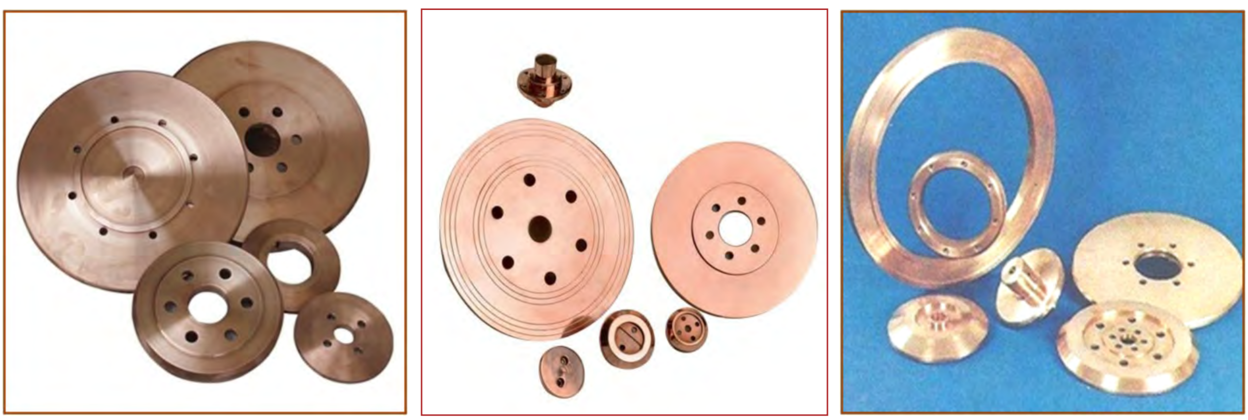


Fig. : Seam Welding Wheels

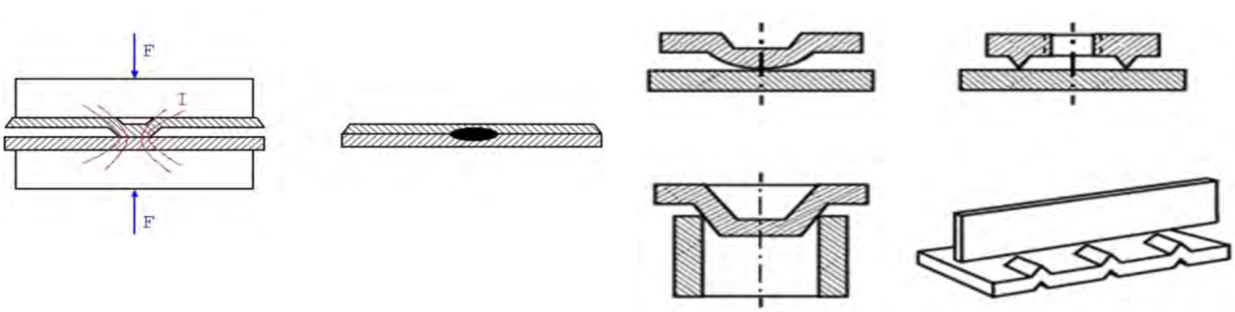


Fig. : Projections in plates for Welding.

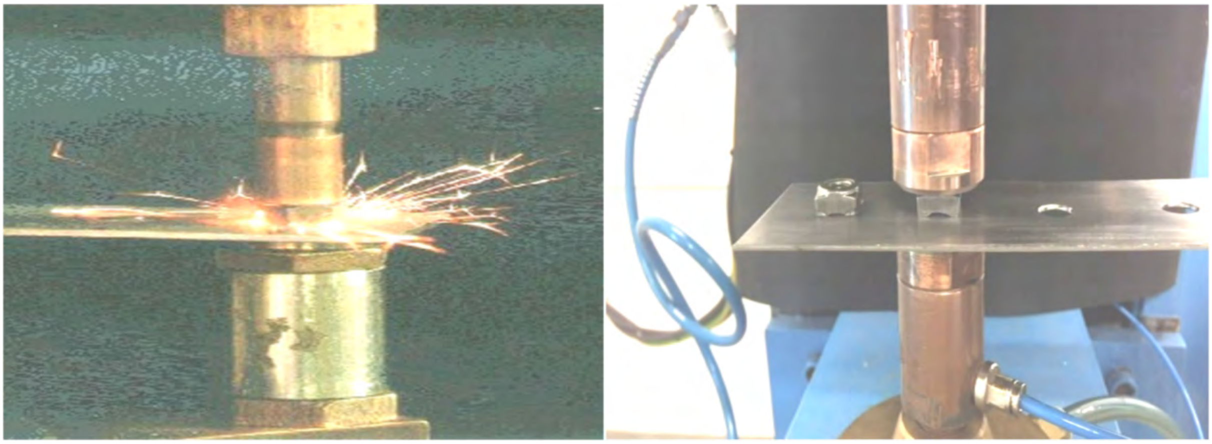


Fig. : Projection Welding. Projection Welding of Nut

Flash Butt Welding

The flash butt welding is a form of resistance welding, used for welding tubes as well as bars, flats and rods mainly for steel industries. In this method, two work parts held separately between two Gripper Electrode Holders slowly brought to each other to create an Arc Flash in between to melt the faces. The parts are then pressed together and held for a time period to get them welded. A high pulsed flow of current within the 1,00,000 ampere range are supplied in this process.

Stud Arc Welding

Stud welding is a complete one-step fastening system, using fasteners called weld studs. Weld studs come in a variety of designs, threaded, unthreaded, tapped, etc., sizes and shapes for a wide range of applications. Stud welding, also known as "drawn arc stud welding", joins a stud and another piece of metal together by heating both parts with an arc. The stud is usually joined to a flat plate by using the stud as one of the electrodes. The polarity used in stud welding depends on the type of metal being used. Welding aluminum, for example, would usually require direct-current electrode positive (DCEP). Welding steel would require direct-current electrode negative (DCEN).

Stud welding uses a type of flux called a ferrule, a ceramic ring which concentrates the heat generated, prevents oxidation and retains the molten metal in the weld zone. The ferrule is broken off of the fastener after the weld is completed. This lack of marring on the side opposite the fastener is what differentiates stud welding from other fastening processes.

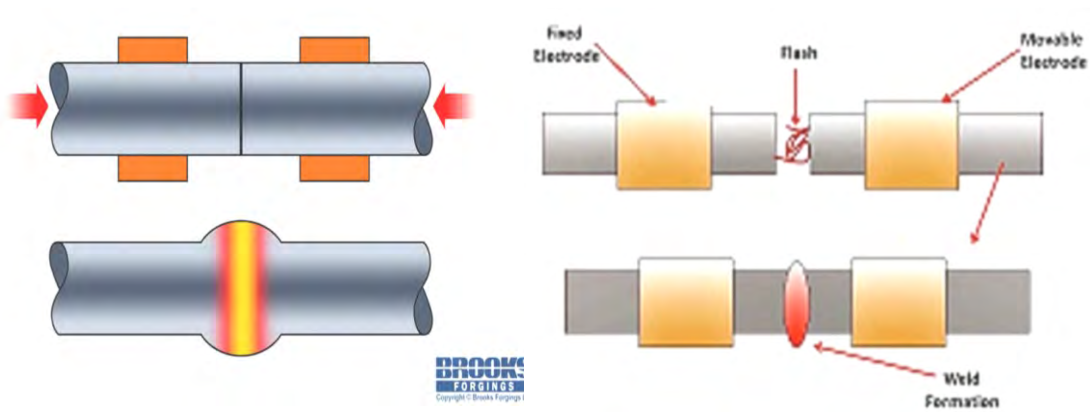
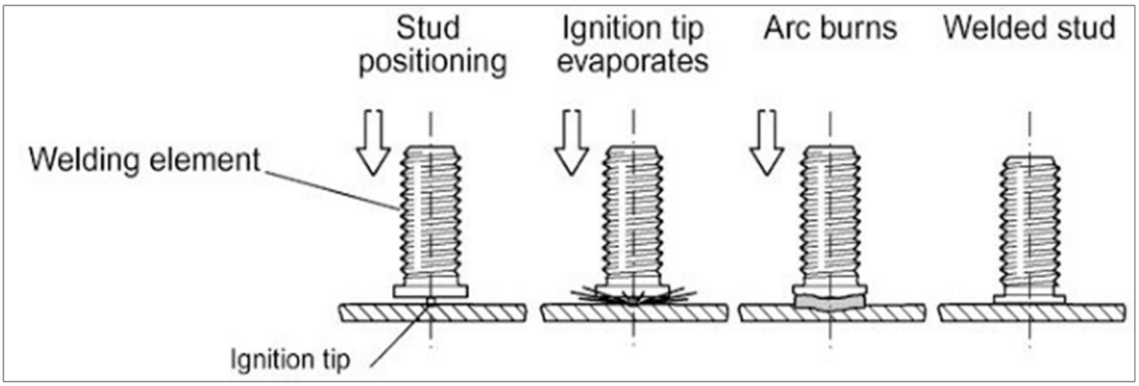


Fig. : Flash Butt Welding – Direction of Pressure and Shape of the Welded Joint



Resistance Welding Working Principle

The working principle of resistance welding is the generation of heat due to the electric resistance of the materials to be welded. Whenever any current flows through an electrical resistance, heat will be generated. The generated heat will depend on material's resistance, applied current, conditions of a surface, and the time period of the current flow.

In resistance welding a heavy current (above 100 A) at a low voltage is passed directly through the work-piece. The electrical voltage required ranges from 4 to 12 volts depending on the composition, area, thickness etc. of the metal pieces to be welded. The amount of power supplied to the weld usually ranges from about 60 watts to 180 watts for each sq. mm of area. Alternating current is found to be most suitable for resistance welding as it can provide many desired combination of current and voltage by means of a suitable transformer.

In order to avoid the surface distortion, the portion of the metal adjacent to the weld or joint should not be allowed to be overheated.

Resistance to the flow of current is made of:

(i) Resistance of the current path in the work

(ii) Resistance between the contact surfaces of the parts being welded and

(iii) Resistance between the electrodes and the surface of the parts being welded.

The different processes of resistance welding such as seam, spot, projection works on the same principle.This method produces weld without application of any flux, filler material, and shielding gases

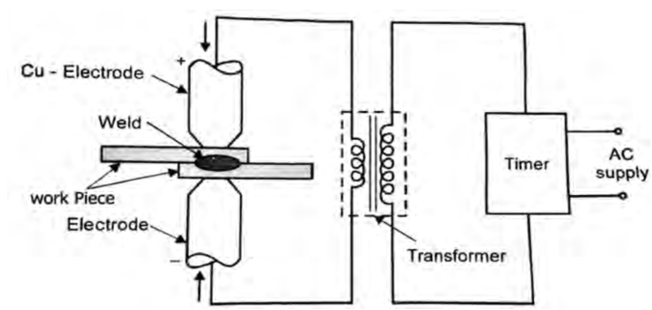


Fig. : Resistance Welding Circuit

This heat generation takes place because of the energy conversion from electric to thermal. The resistance welding formula for heat generation is

$$H = I^2RT$$

Where

- 'H' is a generated Heat, and the unit of heat is a joule
- 'I' is an electric current, and the unit of this is ampere
- 'R' is an electric resistance, and the unit of this is Ohm
- 'T' is the time of current flow, and the unit of this is second

Power Supply for Resistance Welding:

AC supply is used for resistance welding because of the ease and convenience with which the required high current at a low voltage can be obtained by means of a transformer. The kVA required for resistance welding, when actually making a weld, ranges from a few kVA to as much as 1 MVA. The power factor will be about 0.25 or 0.3 lagging. The power factor is low

BASIC WELDING SEQUENCES AND DEFINITIONS

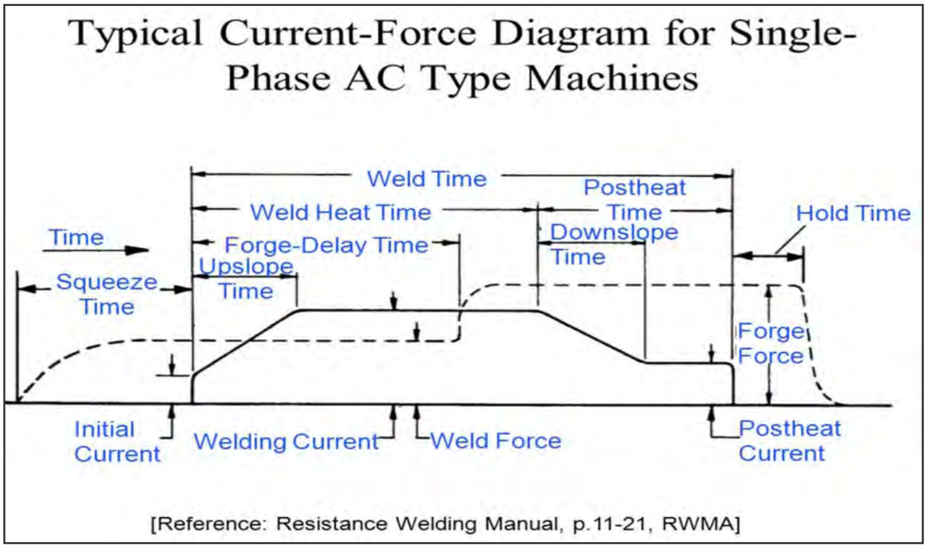


Fig. : Current Force Diagram

mainly due to the high ratio of reactance to resistance of the loop formed by the jaws of the welding machine.

Squeeze Time is the welding process time interval between the initial application of the electrode force on the work and the first application of weld current. This is the process definition. The control of the squeeze time is the time interval between sequence initiation and the beginning of weld current. Weld schedules are available in the RWMA and AWS manuals.

Weld Time is the time during which welding current is applied to the work in making a weld. Weld Time is measured in cycles of line voltage, as are all timing functions. 50Hz is more common in India.

Hold Time is the time during which electrode force is maintained on the work after the last cycle of welding current is stopped. Hold Time is necessary to allow the weld nugget to solidify before releasing the welded parts. This is a forging process.

Off Time is the time during which the electrodes are off the work in a repeat cycle. The term is only applicable where the weld sequence is repetitive (control set to "REPEAT"). Off Time is the time necessary to move the work between weld sequences.

The Three Important Factors in Making a Weld, (P C T) :

- CURRENT
- PRESSURE AND
- TIME

As an example, for commonly used low-carbon steel, 1/16" thick, a typical value of current may be about 10,000 amps; a time of approximately 1/4 second (15 cycles, at 50 Hz); and about 600 pounds of electrode force can be used to make a good weld.

Electrode Force

Electrode force is most commonly provided by pneumatic or hydraulic systems. This force is the result of pressure applied to the piston of a cylinder connected directly to the welding head. The actual amount of electrode force depends on the effective line pressure, weight of the head, and the piston diameter. Most welders have electrode force charts on the side of the machine, tabulating air pressure vs. electrode force. If there is no chart available for the machine, use the following formula to calculate the approximate total weld force:

Electrode Force F = η D2/4 x P or .78 x D2 x P

(.78 is approximately equal to η/4)

D is the Piston Diameter in inches

P is the Line Pressure in pounds per square inch

Electrode Force (F) is in pounds.

To calculate the Line Pressure required to produce a desired electrode force, this formula can be reconfigured as follows:

For example, to attain a 600# total weld force for various cylinder diameters:

- A 3" diameter cylinder would require approximately 85# line pressure.
- A 4" diameter cylinder would require approximately 50# line pressure.

- A 5" diameter cylinder would require approximately 30# line pressure.

These formulas and examples do not allow for dead weights and friction in the cylinder or ram of the machine. When changing electrode force on air operated machines, from one value to a greatly different value, it may be wise to readjust the speed control valve on the welder also.

* Too slow an approach wastes time and may require a longer squeeze time.
* Too fast an approach impacts the electrodes on the workpiece and shortens the electrode life. The impact force may also damage the electrode holders or head and can damage the workpieces as well. When projection welding, high impact may flatten the projection before welding, resulting in poor projection welds, even when all other settings are correct

A solenoid valve is used to actuate the piston in the weld cylinder. The solenoid valve is typically an electrically operated valve in the compressed air or hydraulic line connected to the cylinder on the welding machine. When the welding control applies voltage to the valve, it opens, allowing compressed air or hydraulic fluid to enter the cylinder to develop the electrode force.

Machines for Resistance Welding:

The machine for resistance welding incorporates a transformer, suitable electrodes for supplying current to the weld and arrangement for controlling the mechanical pressure, and finally, means for controlling the duration of weld current flow. The mechanical pressure may be exerted through levers and clutch by an electric motor or by compressed air. The magnitude of pressure required depends upon the type of work and may vary from a few kg for thin sheets or wires up to a tonne or more for heavy work.

Constant time equipment is employed in high speed production where the work has a consistently clean surface. Constant time equipment may be provided with mechanical control or electrical control. In mechanical control providing up to 300 welds per minute, the device employed is a cam- operated switch, connected in the primary circuit of a welding

For a large number of welds per minute the mechanical arrangement becomes unsuitable because it is not capable of providing consistently accurate timing, due to wear of the cam and operating mechanism, arcing and burning of the contacts and irregularities caused by closing of switch at different instants in the cycle.

Defects and Evaluation criteria of resistance spot welding

To determine weld quality a number of parameters can be used as indicators. The following geometrical features are most commonly examined.

I. Weld nugget size
II. Nugget penetration
III. Electrode indentation
IV. Cracks (surface and internal)
V. Porosity / voids
VI. Sheet separation / distortions
VII. Surface appearance
VIII. Location accuracy

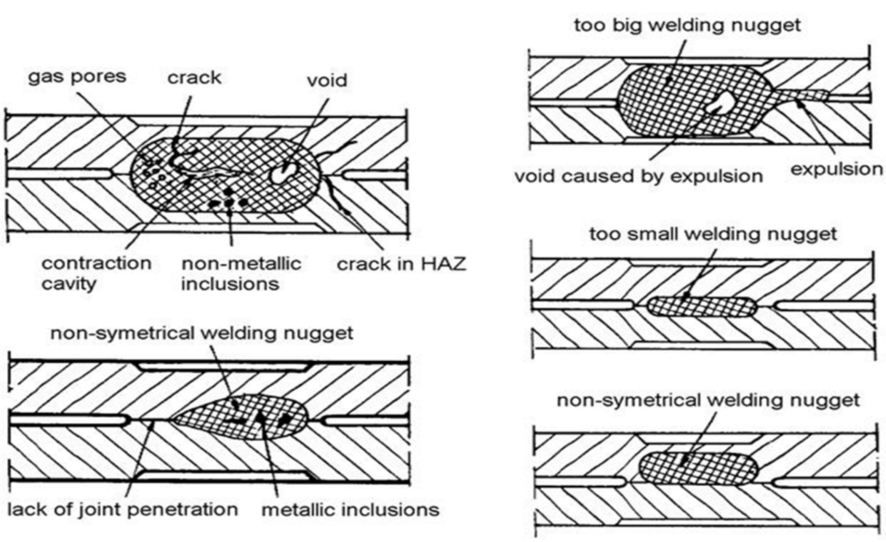
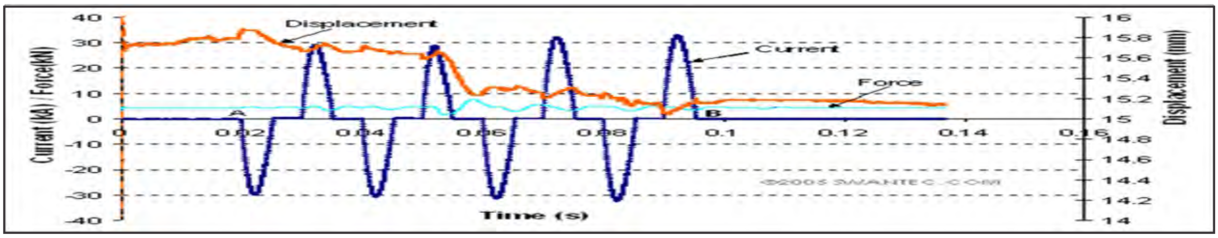
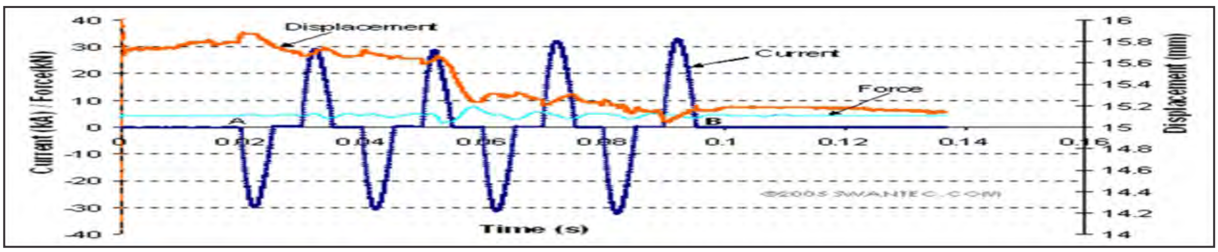


Fig. : Defects in Resistance Welding

RESISTANCE WELDING DATA



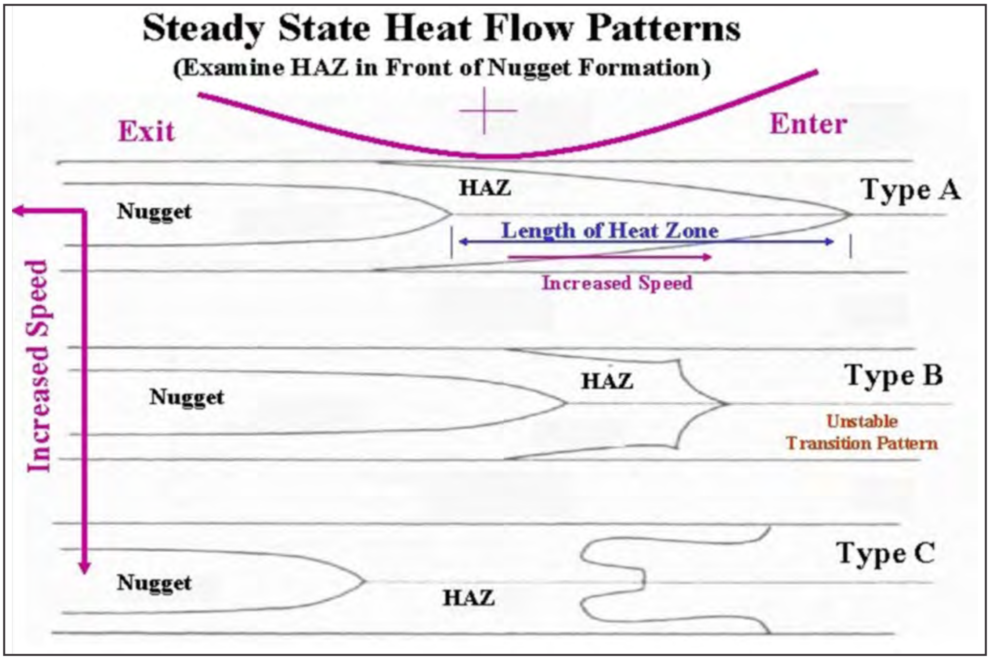
RESISTANCE WELDING OVERVIEW



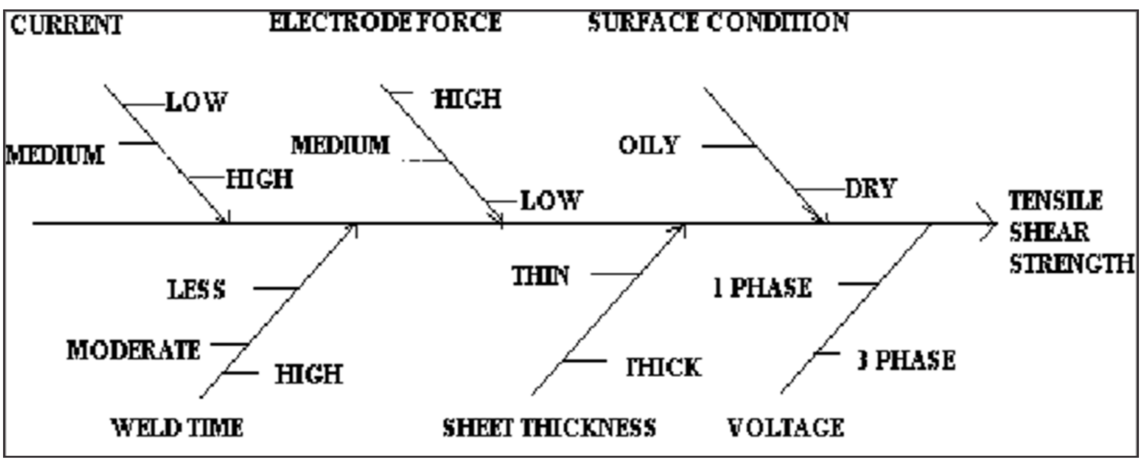
RESISTANCE WELDING OVERVIEW
WELDING PARAMETERS FOR RESISTANCE WELDING

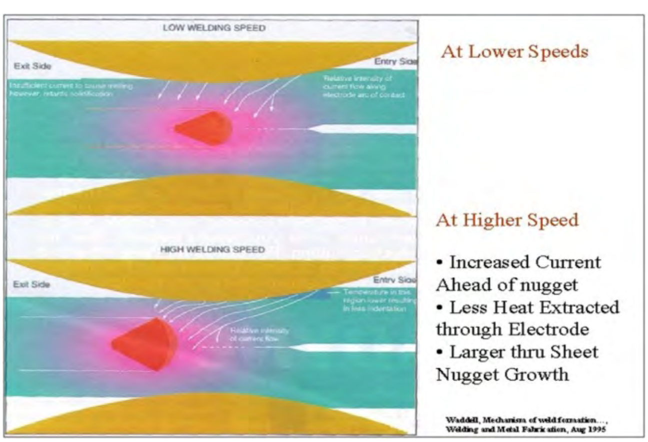
Thread Size	Sheet Thickness mm	Electrode Force kN	Weld Time Cycles	Current KA	Min Torsional Load Test Nm
M4	1.0 - 2.0	2.9 - 3.1	5	7.5 - 8.0	6
M5	1.0 - 2.0	3.6 - 3.8	5	9.0 - 9.5	12
M6	1.0 - 2.0	4.2 - 4.5	6	10.5 - 11.0	20
M8	1.0 - 2.0	4.9 - 5.1	9	17.0 - 18.0	50
M10	2.0	6.0 - 6.5	10	21.0 - 22.0	100
M12	2.0	7.1 - 7.4	12	24.0 - 25.0	180

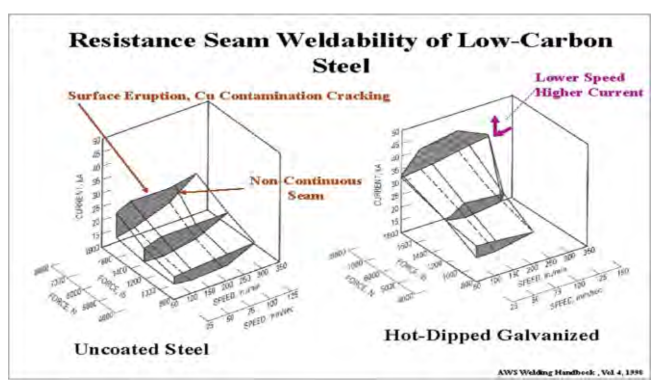
Bolt Size	Sheet Thickness mm	Electrode Force kN	Weld Time Cycles	Current KA	Min Torsional Load Test Nm
M5	1.0 - 2.0	2.7	12	8.0	6
M6	1.5 - 2.5	3.5	14	8.5	10
M8	1.5 - 2.5	3.5	15	9.5	23
M10	2.0 - 3.0	4.5	16	11.0	40



STANDARD WELDING FOR SPECIAL ALLOY MATERIALS





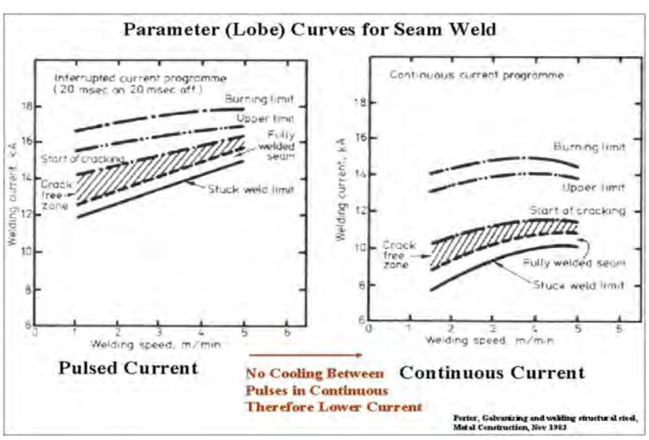


RESISTANCE WELDING PARAMETERS

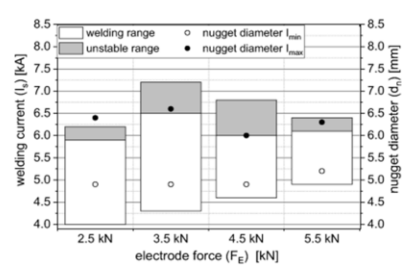
Materials	Applied force/kN	Rod rotational speed/RPM	Weld traverse speed (mm.min^{-1})
AISI 304 (2 mm) to self	8	1600	15
AISI 1012 (1.5 mm) to self	8	1600	15
Inconel HX (2 mm) to self	8	1600	20
Inconel 625 (2 mm) to self	8	1600	20
Inconel 600 (2 mm) to self	8	1600	20
AA6061 (1.5 mm) to self	5	800	20

RESISTANCE WELDING PARAMETERS

Holding Time (s)	Welding Power (KVa)	Force (Kg.)	Electrode Tip Diameter (mm)	Work Sheet Thickness (mm)
10	8	2	5	1
9	8	2	5	1
8	8	2	5	1
7	8	2	5	1
6	8	2	5	1
5	8	2	5	1
4	8	2	5	1
3	8	2	5	1
2	8	2	5	1
1	8	2	5	1

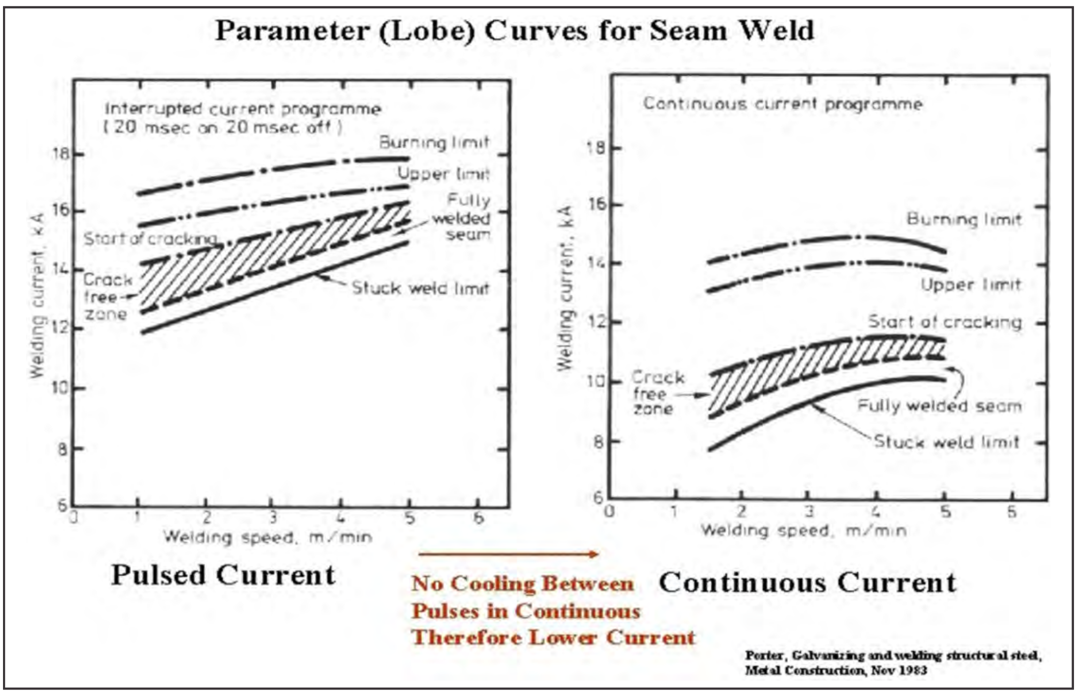


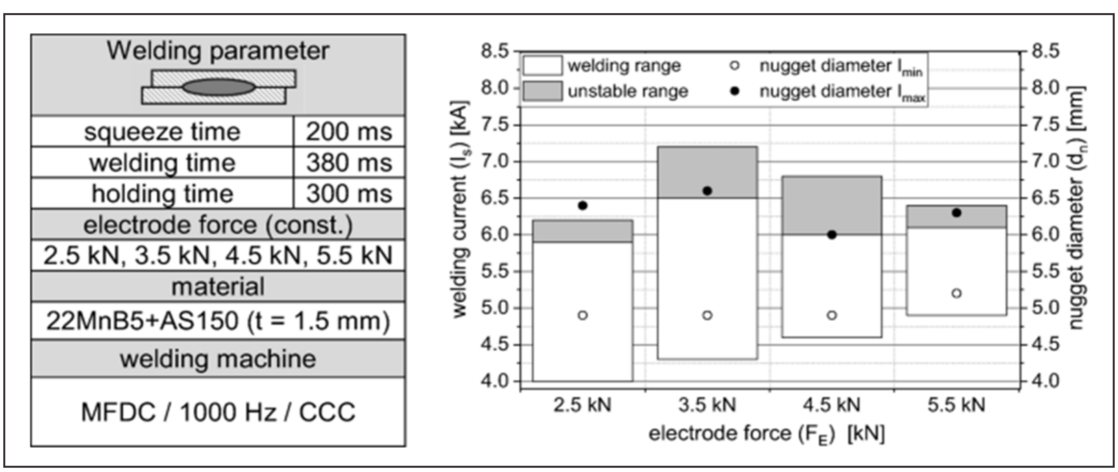
Welding parameter	
squeeze time	200 ms
welding time	380 ms
holding time	300 ms
electrode force (const.)	
2.5 kN, 3.5 kN, 4.5 kN, 5.5 kN	
material	
22MnB5+AS150 (t = 1.5 mm)	
welding machine	
MFDC / 1000 Hz / CCC	



SPOT WELDING SCHEDULE OF SINGLE PHASE DIRECT CURRENT MACHINE

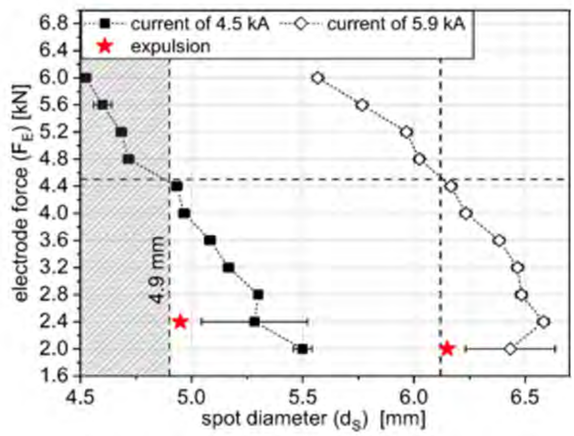
Thick-ness	Electrode Diameter Tip & Radius		Net Electrode Force		Welding Current			Time				Avg. Ten. Shear	Avg. Weld Doa
inch	inch	inch	lb	lb	A	A	A	Cycles	Cycles (60Hz)	Cycles (60Hz)	Cycles	lb	inch
T (1)	D	R (2)	Weld	Forge	Initial	Weld	Post Heat	Up slope	Weld Heat	Weld	Down Slope		(3)
0.0016	7/8	3	500	1200	5500	177000	-	1	-	1	-	167	0.134
0.020	7/8	3	500	1200	8500	19800	11300	1	1	2	1	228	0.143
0.040	7/8	3	700	1600	10800	28300	10600	1	2	5	2	578	0.156
0.064	7/8	6	1180	2750	16850	34500	18700	3	5	11	5	1126	0.281
0.091	7/8	6	1700	4300	17500	46600	33200	4	8	17	5	2039	0.334





RESISTANCE SPOT WELDING WITH VARIABLE ELECTRODE FORCE

Welding parameter (Spotdiameter)	
squeeze time	200 ms
welding time	380 ms
holding time	300 ms
welding current	4.5 kA, 5.9 kA
electrode force	
2,0 kN until 6.0 kN (step 0,4kN)	
material	
22MnB5+AS150 (t = 1.5 mm)	
welding machine	
MFDC / 1000 Hz / CCC	



RESISTANCE SPOT WELDING WITH VARIABLE ELECTRODE FORCE

			SPOT WELDING LOW CARBON STEEL							
Material Thickness of Thinnest Outside Piece	Electrode Face Diameter	Minimum Electrode Size	Net Electrode Force	Weld Current (Approx)	Weld Time	Hold Time Minimum	Weld Nugget Size	Minimum Tension Shear Strength	Minimum Weld Spacing	Minimum Contact Overlap
Inches	Inches		Lb.	Amps	Cycles	Cycles	Inches	Lb.	Inches	Inches
0.031	0.188	4RW	326	8000	8	10	0.161	530	1/2	7/16
0.040	0.250	5RW	412	8800	10	12	0.181	812	3/4	1/2
0.050	0.250	5RW	554	9600	14	16	0.210	1195	7/8	9/16

RESISTANCE WELDING SCHEDULE
SELECTED PROCESS PARAMETERS AND THEIR RANGE

Sl. No.	Process parameters	Range	Unit
1	Current	4 - 5	KA
2	Electrode Force	2 - 3	Kg/cm^2
3	Weld Cycles	6 - 10	Nil
4	Thickness of Ass3 IG Sheet	0.5	mm
5	Electrode Type	Straight	Nil
6	Gap in the Electrodes	22	mm
7	Electrode Tip Diameter	3	mm
8	Shape of Electrode Tip	Circular	Nil

Experiment No.	Nugget Width (mm)	Weld Penetration
1	3.49	Lowest
2	3.69	Low
3	3.76	Low
4	3.89	Medium
5	3.96	Medium
6	4.02	Medium
7	4.26	High
8	4.38	High
9	4.40	Highest

A FEW EXPERIMENTAL RESULTS FOR S/N RATIO

Exp. No.	Welding Current (Amp)	Current Frequency (kHz)	Roll Pressure (kN)	Welding Speed (ft/mn)	Tensile Strength (MPa)	S/N Ratio (dB)
1	150	200	200	100	445	52.97
2	150	300	225	130	416	52.38
3	150	400	250	160	405	52.15
4	200	200	225	160	403	52.11
5	200	300	250	100	432	52.71
6	200	400	200	130	453	53.12
7	250	200	250	130	395	51.93
8	250	300	200	160	400	52.04
9	250	400	225	100	428	52.63

SEAM WELDING MULTIPLE THICK NESS SHEETS

Thickness (inches		Welding Speed (inches/min)	Current (amperes)	Timing Cycles (cycles)		Electrode Force (pounds)
Thin Sheet	Thick Sheet			Heat	Cool	
0.031	0.078	72	16,000	3	2	600
0.031	0.078	142	22,000	2	1	800
0.031	0.050	72	17,000	3	2	800
0.031	0.050	142	20,000	2	1	700
0.050	0.078	60	22,000	4	3	1200
0.050	0.078	120	22,000	3	1	1200

EXPERIMENTAL LAYOUT USING L9 ORTHOGONAL ARRAY EXPERIMENT NO.
WELDING CONDITIONS

Sl.No.	Welding Current (kA)	Electrode Force (Kg/cm^2)	Welding Time (ms)
1	14.0	3.0	10
2	24.0	4.0	20
3	34.0	5.0	30
4	44.5	3.0	20
5	54.5	4.0	30
6	64.5	5.0	10
7	75.0	3.0	30
8	85.0	4.0	10
9	95.0	5.0	20

PROCESS PARAMETERS AND THEIR LEVELS

	PARAMETERS	Level - 1	Level - 2	Level - 3
A	Welding Current	150 A	200 A	250 A
B	Current Frequency	200 KHz	300 KHz	400 KHz
C	Roll Pressure	200 kN	225 kN	225 kN
D	Welding Speed	100 fpm	130 fpm	160 fpm

RESISTANCE WEWLDING MATRIX TABLE FOR SET UP

Single Sheet Thickness mm	Electrode Tip Dia mm	Electrode Force Kgf					Weld Time 50 Hz					Weld Current K Amps					Single Sheet Thickness mm	Min Slug Dia mm
		Uncoated Mild Steel		Coated Mild Steel			Uncoated Mild Steel		Coated Mild Steel			Uncoated Mild Steel		Coated Mild Steel				
		Medium Force Setting	High Force Setting	Hot Dip Zinc	E Z	I Z & Zinc Nickel	Medium Force Setting	High Force Setting	Hot Dip Zinc	E Z	I Z & Zinc Nickel	Medium Force Setting	High Force Setting	Hot Dip Zinc	E Z	I Z & Zinc Nickel		
0.4 - 0.6	4 from	90	133	150	150	140	5	4	6	6	4	4	5	7	6	6		
	to	115	183	204	204	196	7	5	8	8	6	6	8	9	8	8.5		
0.6 - 0.8	4 from	125	175	194	194	183	7	6	8	8	6	5	6	8	7	7	0.6	3.9
	to	133	204	224	224	224	10	8	10	10	8	7	9	10	9	9.5	0.7	4.2
0.8 - 1.0	5 from	140	194	224	224	214	9	7	9	9	7	6	7	9	8	8	0.8	4.5
	to	150	265	296	296	285	12	10	12	12	10	8	10	11	10	10.5	0.9	4.7
1.0 - 1.2	5 from	163	255	285	285	275	11	8	10	10	8	7	8	10	9	9	1.0	5.5
	to	183	326	367	367	347	15	12	13	13	12	9	12	13	13	12	1.1	5.5
1.2 - 1.6	6 from	194	306	347	347	326	14	9	11	11	9	8	10	14	12	11	1.2	5.5
	to	214	408	459	459	438	18	13	15	15	13	11	13	16	15	14	1.4	5.9
1.6 - 2.0	7 from	265	398	449	449	428	18	10	12	12	10	9	12	18	14	13	1.6	6.3
	to	296	527	561	561	540	22	14	16	16	14	13	15	21	17	16.5	1.8	6.7
2.0 - 2.5	8 from	347	510	550	550	530	22	12	14	14	12	10	14	22	17	16	2.0	7.1
	to	377	632	693	693	663	28	16	18	18	16	15	18	26	22	21	2.2	7.4
2.5 - 3.0	9 from	449	612	673	673	652	28	15	17	17	15	12	17	26	19	18	2.5	7.9
	to	479	765	815	815	795	35	20	21	21	20	17	20	30	24	23	3.0	8.6