CAPACITOR DISCHARGE WELDING

CD-welding: Function, Features and Advantages

- Technology ➔ classification and functionality
- Applications ➔ from small to large
- Welding parts ➔ good and less
- Parameters ➔ finding and monitoring
- Welding quality ➔ get and save
- Welding jigs ➔ supporting the quality

Longitudinal beam with nuts M12
KAPKON GmbH

- Founded in 1980 → as Obermark Schweißtechnik Vertriebs GmbH
- 2011 renamed to KAPKON GmbH
- Manufacturer of resistance welding machines
- Specialized to CD- welding technology
- Focused on fusion of resistance welding technology and reliable monitoring
- Welding lab and process workshop for start-up and commissioning of machines, jigs and technologies
- Offering complete solution including machine, jig, automation and process monitoring

KAPKON plant #1: engineering and machinery building

KAPKON plant #2: welding lab and job-shop
CD-WELDING OF HOT STAMPING PARTS → INTRODUCTION

- Projection welding and especially CD-welding has been published poorly
- Because of the lack access to users knowledge we want to share our experiences
- A couple of companies started in hot-stamping business recently, to support these we choose the theme of this lecture
- CD-welding became the usual technology to weld every kind of fasteners to hot stamping parts
- We want to assist all users to start up this business and avoid frequently made failures

Video of typical CD-welding
CD-welding counts to the resistance welding technologies

Resistance welding has been used since a long time

Regarding the metallurgy resistance welding works comparable to the forge welding used since the Bronze Age

Melted metal will be pressed by force and while cooling the materials join

While setting of the melted material CD-welding produces fine-grained structure because of the fast cooling speed

The metallic bond takes care for a metallic continuity

Forge-welding at a blacksmith shop

source: www.damastschniede-engl-de
Resistance welding is a sub-technology of pressure welding and will be classified to:

- Spot welding
- Projection welding
- Seam welding
- Butt welding

CD-welding has been used for projection welding mostly

Exceptions proves the rule!
CD- WELDING ➔ HOW AND WHY

- Energy is been switched from a charged rack of capacitors by a thyristor two one or two transformers

- The charging time of capacitors is up to 1,5 seconds

- Welding times are between 2 and 10ms

- High charging voltages = high rates of transformer = high welding currents

- Because of the instant discharging of the capacitors welding current and temperature at welding joint slope up very fast

- Caused by high resistance the fast up-slope heated only the welding joint to and the projected sheet area to the melting point
CD- welding \textbf{How and Why}

- Because of the thermal inertia the joint has been welded before the material around warms by convective heat
- Noticeable heat will be caused only by tall and small cross-sections of the fasteners
- The speed of current up-slope is the main feature of CD-welding
- This dynamical heating of the projection explains all advantages of CD-technology as a quite “cold” welding
- Focusing energy to the welding joint means less energy losses and a high power efficiency

CD-welded of a threaded bush
CD- welding main advantages machine

- Big welding range from small nut M5 to M16
- Welding current up to 200 kA
- High secondary voltage of 45V for cracking isolations
- Low power supply → max. 63 A main fuse
- No water cooling water, no water consumption
- Easy setup, flexible use at different workplaces
- Fast and easy commissioning
- Reliable monitoring, current control and deflection detection included
- Automated calibrate after electrode change or dressing
- PLC controlled and connectable by Ethernet
- Servo-driven welding head
- Fast welding cycle <2.5 s
CD- WELDING→ MAIN ADVANTAGES PARTS

- Different steels:
  - Mild and stainless steel
  - Hardened and tempered steel
  - Hot formed steel (22MnB5)
  - DP and TRIP steel
  - Casting and sintered metal

- Nonferrous metals:
  - Aluminum and Copper
  - Brass and other alloys

- Coatings:
  - Zinc and tin
  - AlSi coating for hot-forming parts

- Heat-sensitive joint:
  - Close to plastic parts
  - Beside electronic equipment
  - Colored surfaces

Welding and clamping a rubber-sealing

Rubber seal

Welding joint

Clamping Ring
APPLICATION ➔ WELDING OF HOT-STAMPED PARTS

- Pushed by the requirements of lightweight construction, hot-stamping parts got a frequent application.

- It means sheet parts of 22MnB5 (traded as USIBOR, BORON, ULTRAFORM, BTR, MBW a.s.o.)

- A blank will be heated up to 950°C in an oven and in the next step formed and quenched at a press-die.

- 22MnB5 is an austenitic steel which has a good workability, while quenching martensite arises, which causes the hardness and strength of the part.

Source: Arcelor-Mittal

Structural parts of 22MnB5 in a car body
While transporting the red-hot blank will be protected by a coating of AlSi against scaling of the steel.

The AlSi coating has a low conductivity, which will be affected by iron-atoms diffusing into the coating during the oven-process.

Because of the quite long welding times, spot-welding works without major problems.

Beside the joining by spot-welding, the parts are needing a lot of fasteners like spacers, screws, nuts, thread-bushes and so on.

Because of the short welding time with projection welding and depending on the conductibility of the AlSi coating, the welding quality of these parts is not stable.

B- pillar of 22MnB5
Finding parameters → An easy job to do

- Which parameters are valid:
  - Charging voltage → determine the energy and is the basic parameter for it
  - Capacity → is the second parameter of energy, will be fixed by the number and size of the capacitors
  - Energy: calculated by the formula $W = C \times U^2/2$
  - Electrode-force → second parameter which influenced a CD-welding
  - Welding time → has been fixed by the size of transformer and the design of the secondary circuit

Operator panel of a CD-welding machine
Finding parameters → An easy job to do

- Step #1 → finding an appropriate electrode force:
- Feeding sheet and part in position
- Pressing the welding head with a little force
- Open the cylinder check the projection for any remarkable deforming
- Increasing the force in steps as long as the projection or the sheet has been signs of deforming → the maximum force has been achieved
- For the sample M6 → about 11 kN

Sample: nut M6 to sheet of 22mnB5, 2.3 mm thick
FINDING PARAMETERS  AN EASY JOB TO DO

- Step #2  choosing energy:

- First weld with a small energy

- Checking the weld by cracking the nut off, welding joint is okay, if the nut pulls out some sheet or crack in itself

- If the weld is not okay, increasing the energy step by step and verifying this by pull out test

- The maximum energy for this part will be achieved, if it shows remarkable splatters while welding

- Does the strength not fit to the demanded value a second trial could be done by a higher welding force

CD-welding curves of resistant and current
Keep the quality high → tough job

- When will a welding be okay?

- That’s easy: If the requirements of the drawing or specification are fulfilled?

- Unfortunately not..

- Often the drawing asks for a torque test only, which doesn’t give be a reliable information of the welding joints strength.

- For production test a check by pull-out force has been strictly recommended → just this will stress the welding in accordance to the function

- For tests by quality department → a frequent macro-section is necessary as a basic prove

- Practical hint for hot stamped parts: a good weld could be came up only, if on the opposite side of the sheet clear current marks are visible
Keep the quality high ➔ tough job

- What shows a cracked nut regarding the welding quality?

- Zone #1: crystalline fracture ➔ perfect welded

- Zone #2: transition section ➔ joined partly, fractional area could be sensed clearly

- Zone #3: not welded, lackluster but fair surface

- Zone #4: overheated by a lack of pressure, the shiny surface indicates a split welding joint between nut and sheet

Cracking zone on the sheet after welding and testing a zinc-coated welding nut with 15 mm ring-projection
How could projection welding quality be monitored?

How works the standard-procedure?

Step #1: setup with parameters, like current, energy and welding time, which will be checked

Step #2: welding, taking samples, cracking and rating the quality level

Step #3: if the samples are okay, declare the measured parameters of this to the reference and adjust the limits

Pull-off device for checking a welding joint in that sample 80 kN are required
Keep the quality high → tough job

- Alternative procedure → smarter and cheaper?
- Inline-process-monitoring by PQS-weld

- Step #1:
  recording and analyzing of all interesting parameters which are: voltage, current, resistance, force and deflection

- Step #2:
  welding of samples, continuous cracking and testing of parts

- Step #3:
  declare all parts of the production, which was proved by tests to a reference → the software will calculate the average of it and take it for 100% quality, the range of all curves will be set as the limit for okay or not okay

Sensor-box and monitoring module Quadrigo
Advantages of an inline- monitoring and quality assessment

References and limits are not determined by random results

Reference will be always an average of all tested parts and will be proved continuously while further production

The quality limit will be not a fixed by any percentage of reference, the limit will be also refer to all curves of proved parts

Adapting the whole process by sorting equal curves to separate groups, which will map all changes which influence the production (wearing, different material..)

Finally a quality assurance without testing real parts could be achieved, which promise benefits regarding quality costs

Analyzing screen of PQS-weld
At projection welding the jig and the parts are a genuine part of the secondary circuit

Every conducting component and every connecting between them has been a resistance

Additionally CD-welding is affected by inductivity

The welding joint is the biggest resistor and takes the highest resistive voltage drop; therefore it takes also the most of the electrical energy to alter it to heat

Because the energy will be constant for every weld; a raising of resistance, for example between electrode and part will cause a lack of energy for heating up the parts in the worst case the welding gets too cold and fail.
KEEPTHEQUALITYHIGH⇒AGOODJIGWILLHELP

- Besidethiseffect,anincreasingresistance
coulddelaytheupslopeofweldingcurrent

- Does the temperature achieve the melting
  point not in a certain time, the projection will
  be pressed down only, but not welded

- Maybetheweldinglooksasusualbycolor
  andform, but annealing colors aren’t a
  reliable sign of a good welding

- With mid-frequency and AC single-phase in
  that case an extension of welding time will be
  possible and often used.

- But this could be considered as the wrong
  way, because it stresses the whole jig and
  electrode and causes an fast wearing of it
**KEEP THE QUALITY HIGH ➔ A GOOD JIG WILL HELP**

- Simple hints for Design and maintenance of welding electrodes:
  - Appropriate contact area ➔ contact area should be 15x larger than the contact area between the parts before welding
  - Material: CuCoBe has been recommended ➔ because of the hardness of 22MnB5 the material CuCrZr fits less to this applications
  - With softer material the dust of the burned AlSi surface will we pressed into the electrode surface easily
  - Smooth electrode surfaces reduces the grade of picking up dirt from the sheet
  - Cleaning electrodes only by metal-polishing fibers (for example Scotch-Brite)

Difficult jig ➔ easy to care for
Pictures CD-welding machines for hot-forming applications
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