Standard recipe for the preparation/fabrication of 9-cell SRF cavity

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KEK

Hot topics session
SRF2011
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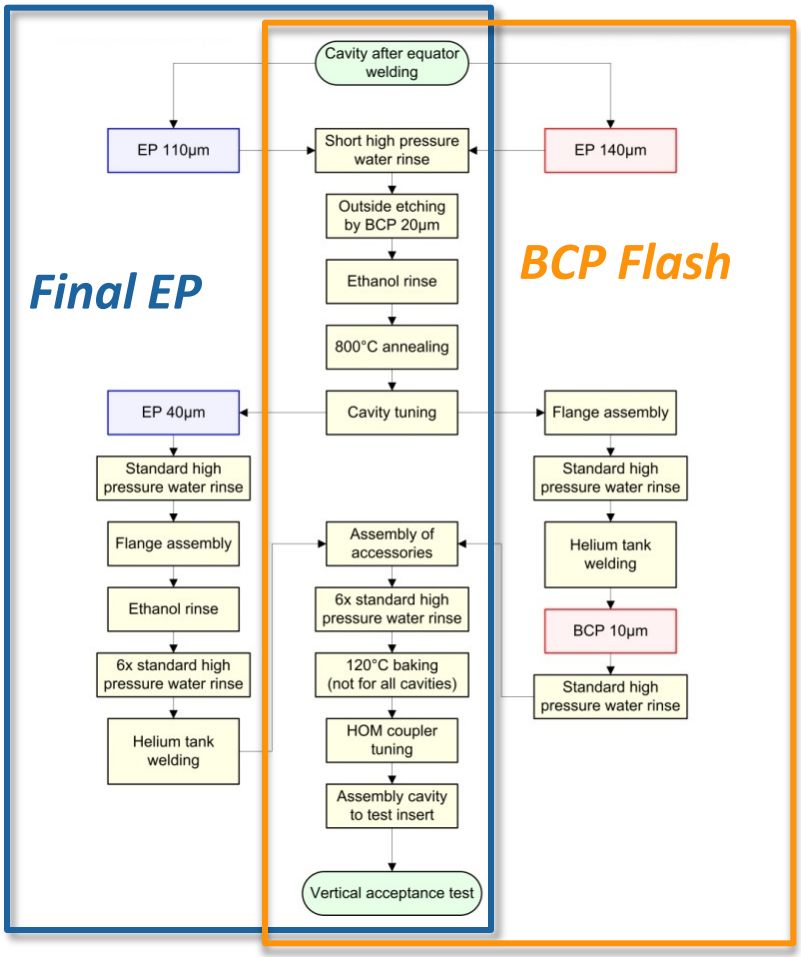
Cavity Surface Treatment – Based on DESY Experience

Two schemes for the final surface treatment (***Final EP*** and ***BCP Flash***) were studied with **cavities from two different vendors**.
The **preparation strategy** to go for a final treatment with the cavity already welded into the He-vessel was investigated.



Results are:
- yield curves for the different schemes
- yield curves for the different vendors
- a preparation strategy allowing two different final treatments

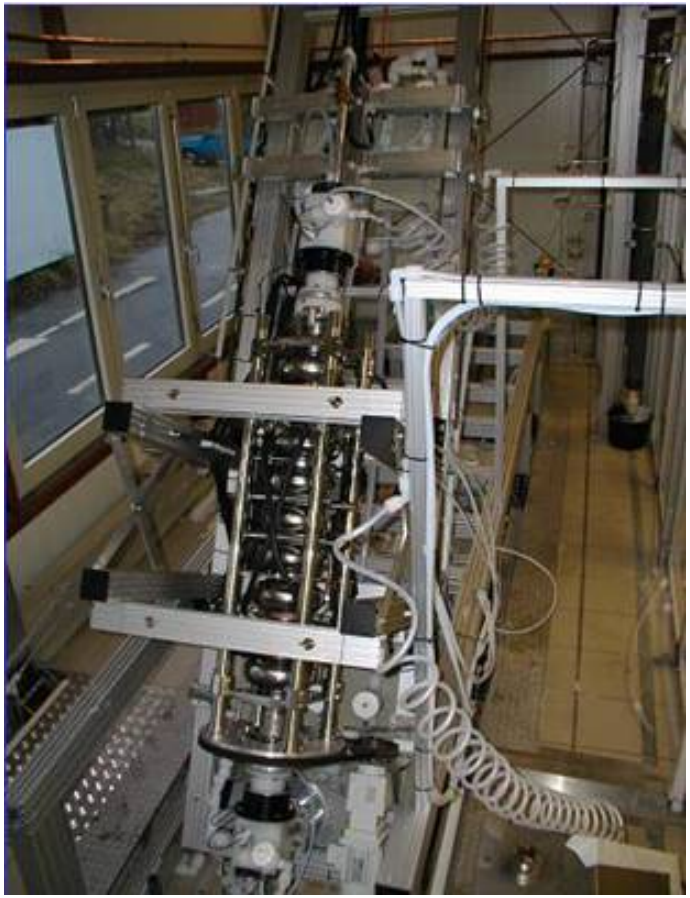
Some **tooling** will come from DESY
DESY procedures and experience described very much in detail in the CFT
Specification are now available to the SRF community since end of 1/2011. (please contact DESY)

Slide from the presentation by Hans Weise (DESY) in TTC meeting at Milano (Feb. 2011)

Standard recipe for the preparation of cavity
Strategy for the discussions

- Main part of surface preparation of cavity is Electro-Polishing (EP) / Buffered Chemical Polishing (BCP) in most of laboratories.
- Most of people might agree that EP has a potential to reach higher gradient even if still it has scattering of performance. So we will concentrate on EP.
- In the EP process, there are many parameters. Given the limited discussion time, I propose we focus on only voltage/current density/temperature.
- Perform comparison of standard V/I/T parameters among laboratories of EU/US/Asia.
- A. Matheisen (DESY) will talk about the standard recipe of EP at DESY.
- T. Saeki (KEK) will talk about the standard recipe of EP at KEK.
- Tom Reid (ANL) will talk about the standard recipe of EP in FNAL/ANL.
- R. Geng / T. Reilly / C. Reece (Jlab) will talk about the standard recipe of EP at Jlab.

Main parameters of the EP process in the DESY EP facility.

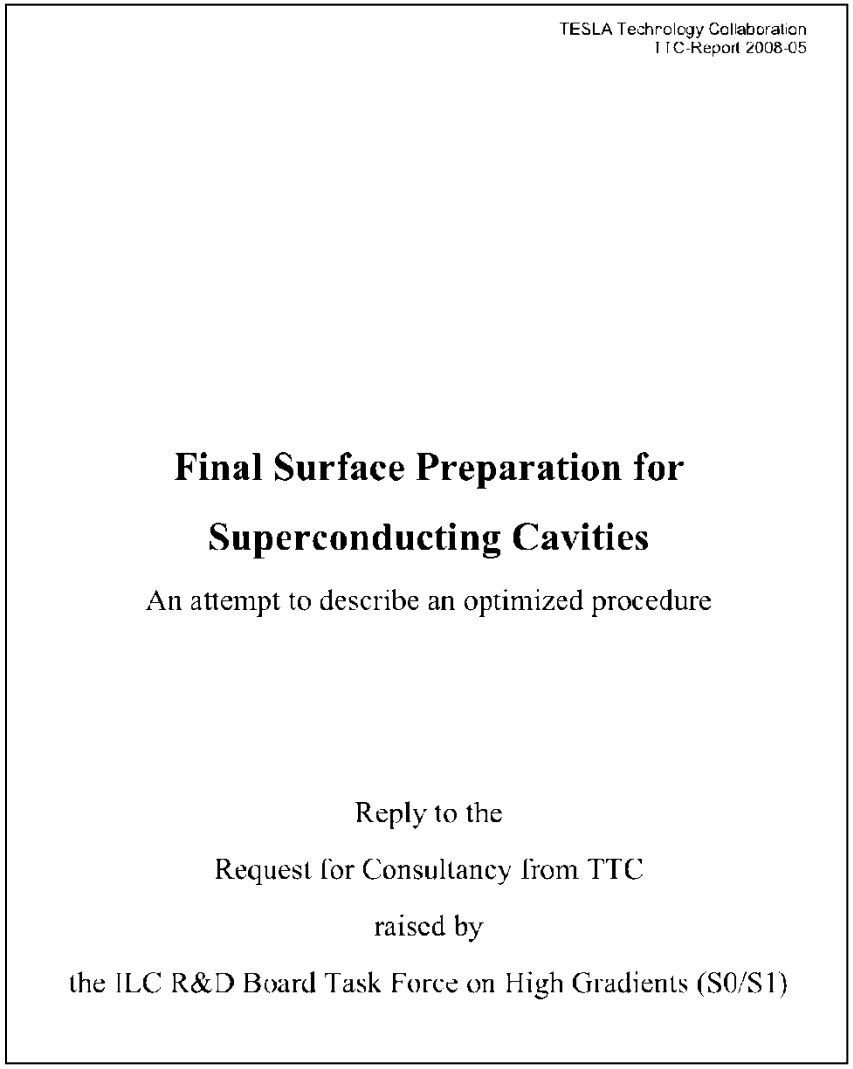


Slide provided by A. Matheisen and D. Reschke

	Fresh acid	Used acid	Unit
Life time	0	600	minutes
Nb content	0	10 – 12	gr/l
HF content	2,78	~1,9	Mol/l
Acid volume	150	140	L
Voltage	17 +-0,1	17 +- 0,1	V
Average Current	320	210	A
Current density	58,1	49	mA/cm^2
Average current oscillation	+44 -66	+43 -73	A
Removal rate	0,445	0,36	µm/min
injection speed per cell	5,3 – 5,6	5,9 – 6,5	m/sec
Acid circulation	9-9,5	10-11	l/min
Nitrogen overlay	30	30	l/min
Max Acid temperature	35	35	C

DESY recipe :
Constant voltage method (~17 V).
Current density = 49 – 58 mA/cm2, Temperature < 35 ^{0}C
Also constant current method is successfully used in industry in EU.

Preparation of recipes among laboratories (2008 - 2010)


TESLA Technology Collaboration
TTC-Report 2008-05

Final Surface Preparation for

Superconducting Cavities

An attempt to describe an optimized procedure

Reply to the

Request for Consultancy from TTC

raised by

the ILC R&D Board Task Force on High Gradients (S0/S1)

TTC-Report 2008-05 :
Detailed comparison of surface processes among laboratories. But this is going to be obsolete in some part. For example, STF/KEK facility was constructed, ANL/FNAL EP facility started the commissioning, many other upgrades in laboratories.

Natural question:
Should we update the comparison table step by step?

KEK researchers visited Jlab to compare the EP parameters between two laboratories in Nobember 2009.
C. Ginsburg(FNAL) proposed KEK to visit ANL/FNAL after TTC meeting @ FNAL (April 2010) to compare the EP parameters among KEK, Jlab and ANL/FNAL. KEK/JLab agreed with this proposal. FNAL/KEK researchers visited ANL/FNAL for the comparison on 22nd April 2010.

Difference between Jlab and KEK November 2009

	JLab	KEK
EP Acid Tank	270L (Tank Capacity) 230L (EP acid volume)	2000L (Tank capacity) 1000L (EP acid volume)
EP Acid Flow Rate	5 ~ 10L/min. Over flow pipes 15mmϕ	10 ~ 20L/min. Over flow pipes 25mmϕ
EP and Water Rinsing Atmosphere	Nitrogen During EP: 12L/min. During Rinsing: 13 ~ 20L/min.	Air
EP Acid Temp.	16 ~ 26 ^{0}C EP acid (Return pipe) 21 ~ 34 ^{0}C Outside cavity	17 ~ 32^{0}C EP acid (Center of Cell) 28 ~ 50 ^{0}C Outside cavity
EP Voltage and Current	14 – 17 V Current density = 20 – 30 mA/cm2	19 ~ 21V Current density = 50 mA/cm2

Related to nice results of JLab? => Now, EP current density (Final EP) = 30 – 40 mA/cm2 at KEK
Yield rate for ILC threshold of VT (35 MV/m): 50% for recent 6 MHI cavities (1 bad cavity with only 1st VT).

EP parameters : voltage, current density, temperature

- As the time for discussion is limited, we will focus on only three parameters of EP, voltage, current density, temperature.
- Still, we have a wide variation of V/I/T parameters among laboratories in EU/Asia/US.
- Constant voltage, constant current, etc…. How you control the V/I/T in each EP.
- Some history and current situation:

  -- KEK recipe from TRISTAN by Kenji SAITO: i density ~ 50 mA/cm2, T<35 ^{0}C.

  -- DESY recipe: Constant V, current density = 49 – 58 mA/cm2, T < 35 ^{0}C.

  -- Jlab recipe by J. Mammosser, R.L. Geng, C. Reece: “low V/I/T parameter set”.

  -- KEK visited Jlab in 2009 and KEK/STF started low V/I/T recipe:

  current density = 30 ~ 40 mA/cm2, T < 30 ^{0}C.

  -- FNAL/ANL recipe: current density = 16 - 21 mA/cm2, V ~ 18 V.

  -- Jlab reached the yield rate of 90% for ILC specification.

  -- Saclay is interested in and studying “very low voltage EP”:

  V ~ 5 V. Low production rate of sulfur.

Standard recipe for the fabrication of cavity
Strategy for the discussions

I would like to have very practical discussions. I also try to include industry/vendor people in the discussions even if we have a barrier of “intellectual properties”.

XFEL recipes are defined in XFEL Specification

Specification is released. Contact person: waldemar.singer@desy.de.

XFEL Specification:

- SERIES MECHANICAL FABRICATION: (XFEL/001- XFEL/018)
- SERIES SURFACE AND ACCEPTANCE TEST PREPARATION (XFEL/A - D)
- HARDWARE AND PROCESSES USED AT DESY (XFEL/Appendix I - IV)
- ILC-HI GRADE CAVITIES AS A TOOL OF QUALITY CONTROL (XFEL/HiGrade)
- SETS OF DRAWINGS

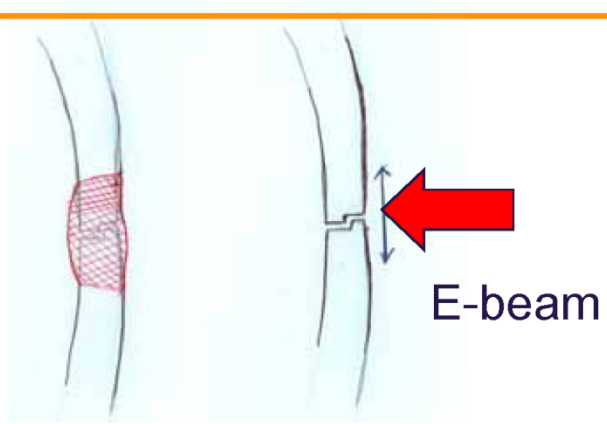
Two main aims have been pursued:

- Spec. has to contain all detailed recipes for the cavity mechanical fabrication, treatment and assembly for RF test
- DESY experienced has to be included.

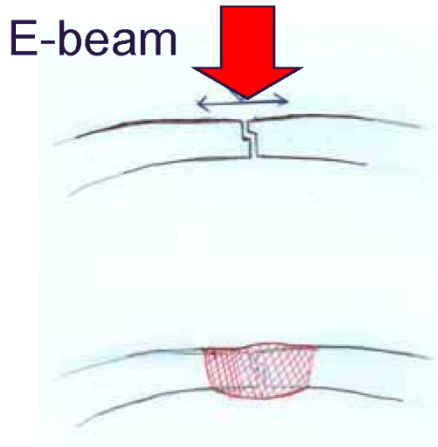
The work was done by DESY experts and the assistance of the experienced external advisers from the industry.

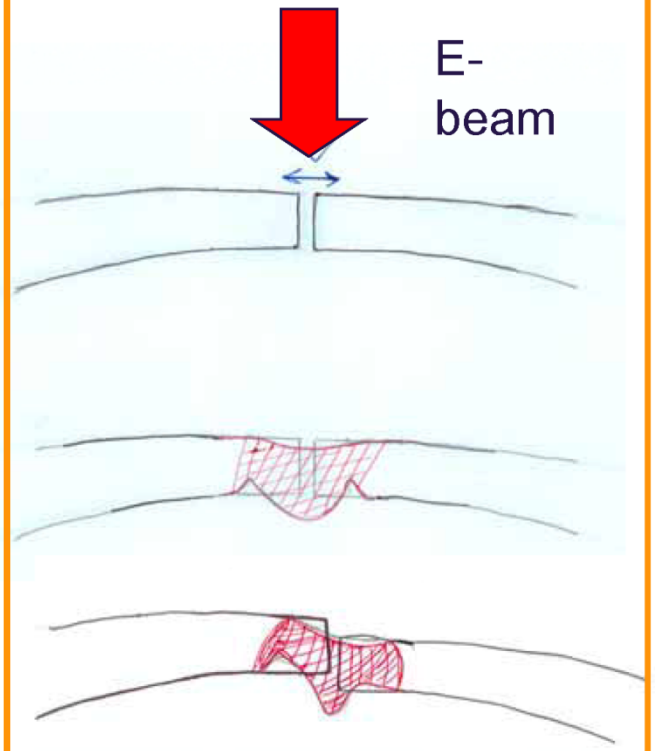
Cavity (CV) horizontal or vertical position? Lap (recess) or butt joint?

CV Vert. Pos. EBW: lap joint (recess) e.g. RI, CERCA,



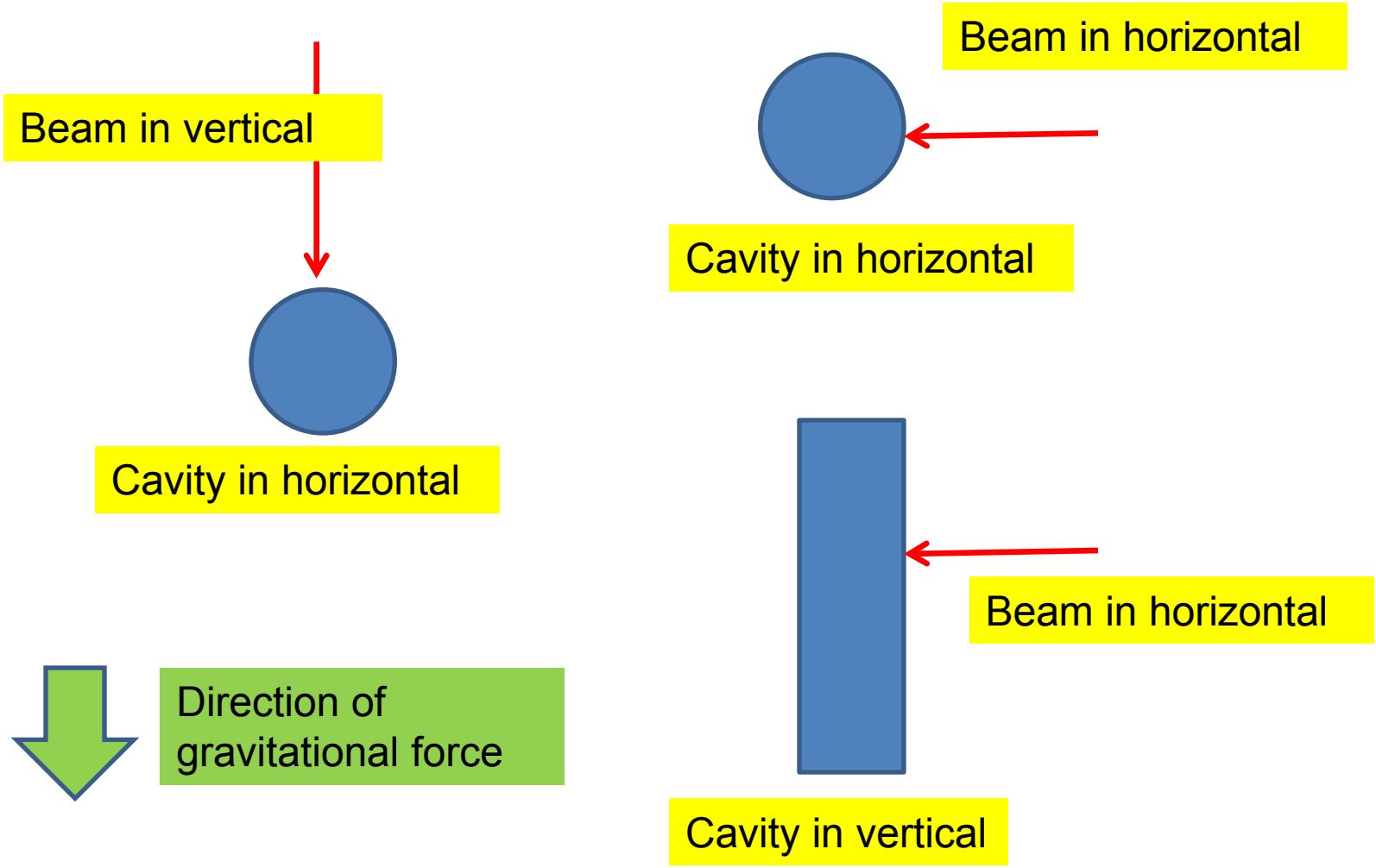
CV Horiz. Pos. EBW: lap joint (recess) DESY, E.Zanon



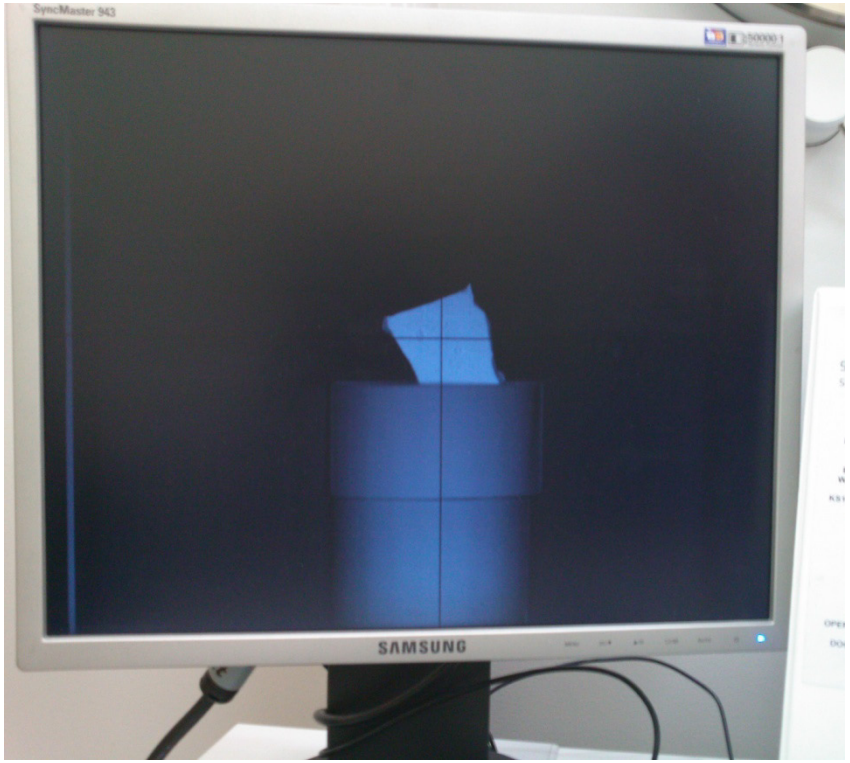


CV Horiz. Position. EBW: butt joint (E. ZANON,)

EBW of equator / combination of beam direction and cavity orientation

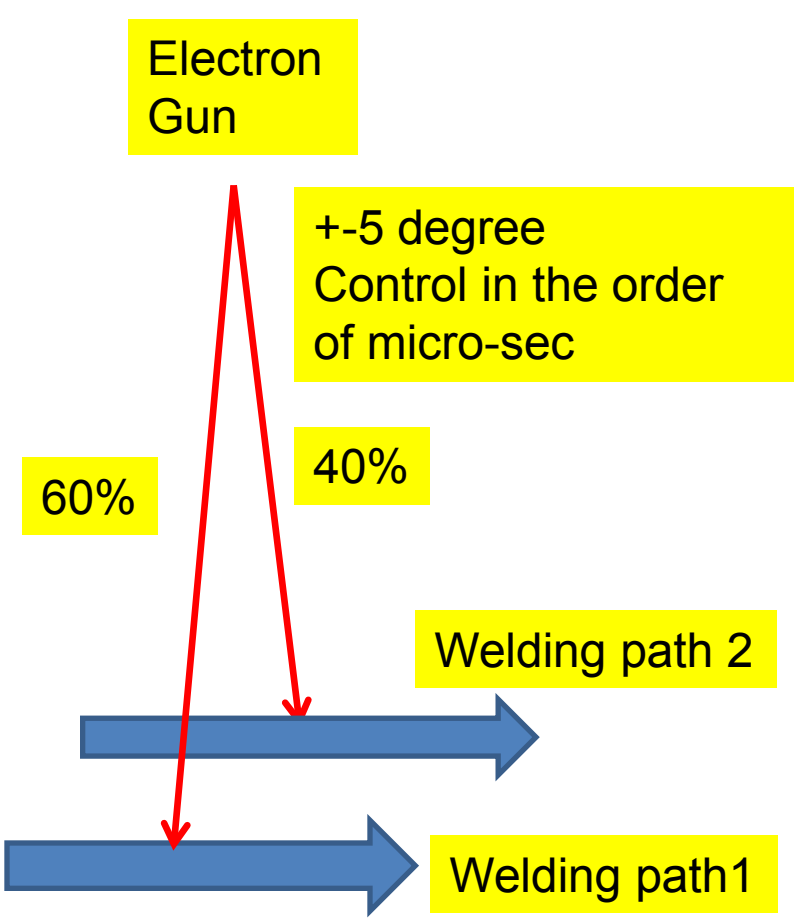


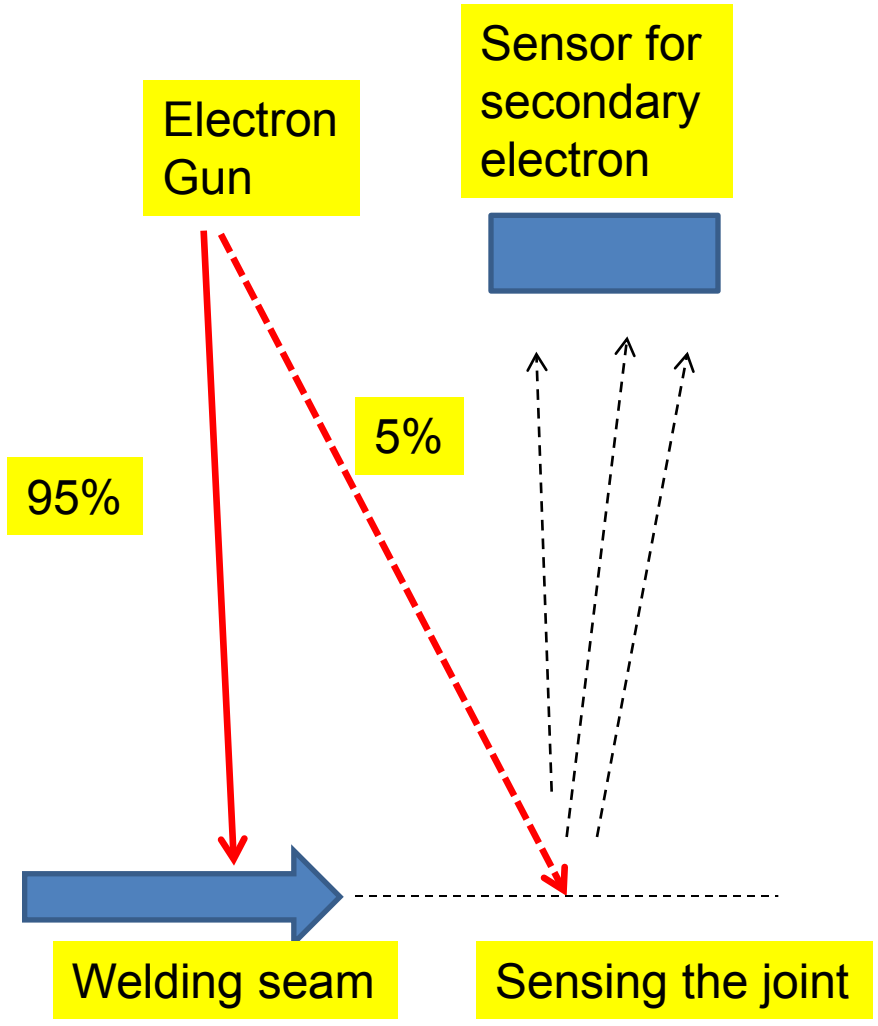
Modern technologies of recent EBW machines



Modern EBW machines can visualize the a work piece inside the machine chamber by utilizing the sensor to the back-scattering secondary electrons. It is useful because when the welding joint is difficult to see and distinguish you can use this function to find the joint.

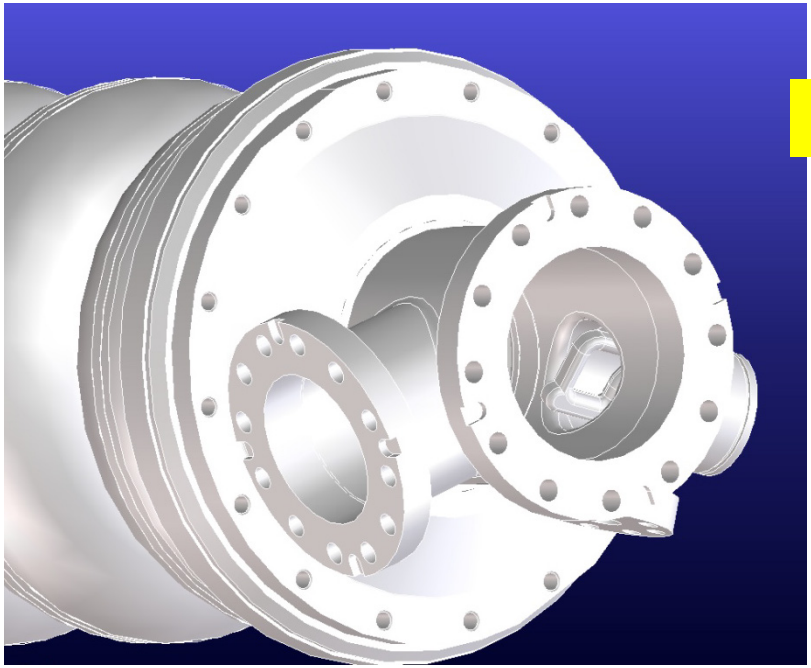
Modern technologies of recent EBW machines



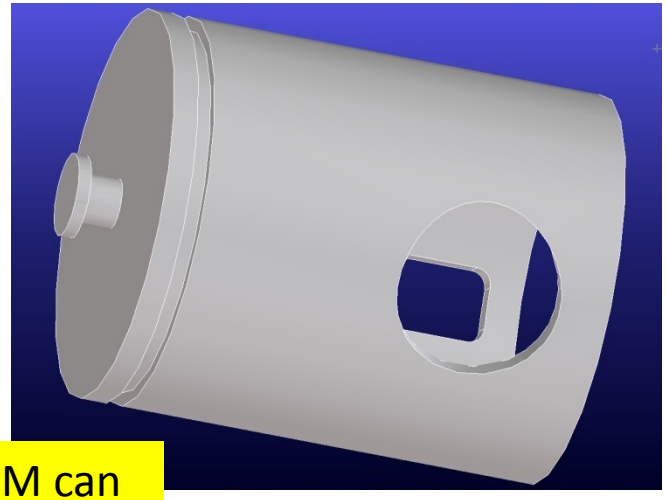


Combination of these modern technologies
=> Useful for automatic welding in mass-production? => talk by PAVAC

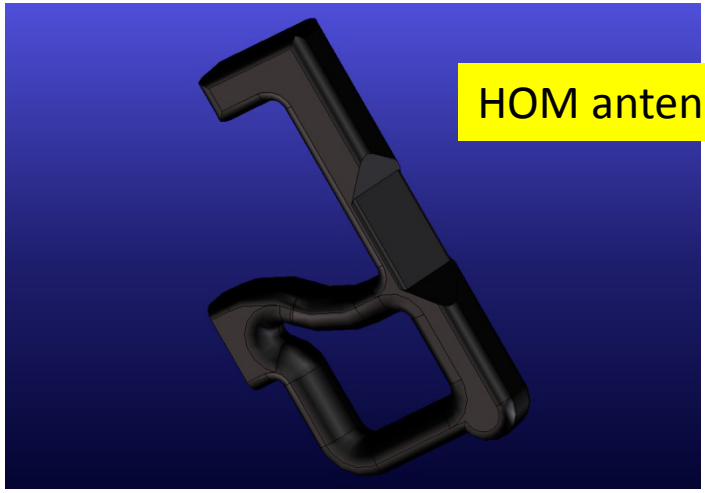
The fabrication of end-group



HOM coupler



HOM can



HOM antenna

The fabrication of end-group

- In terms of mass-production of 9-cell cavity, the fabrication method of end-group is another issue. What is the best fabrication method of end-group?
- What is the best fabrication method of beam-pipe, HOM-can, HOM-antenna.

  -- Beam-pipe, HOM-can : Sheet forming + EBW, deep-drawing, extrusion, spinning etc….

  -- HOM antenna: Machining , press-forming, etc….
- The fabrication of Nb pipe by back-extrusion method by Heraeus.
- The fabrication of Nb pipe and HOM antenna by press-forming by KEK.

Innovative deep-drawing research work in collaboration with Shinohara Press Service Co. Ltd.

Nb (thickness of 1.5 mm)

Deep-drawing by single press-forming process

Punch diameter = 40 mm

Lower ear height

Upper ear height

Inside of deep-drawn cup

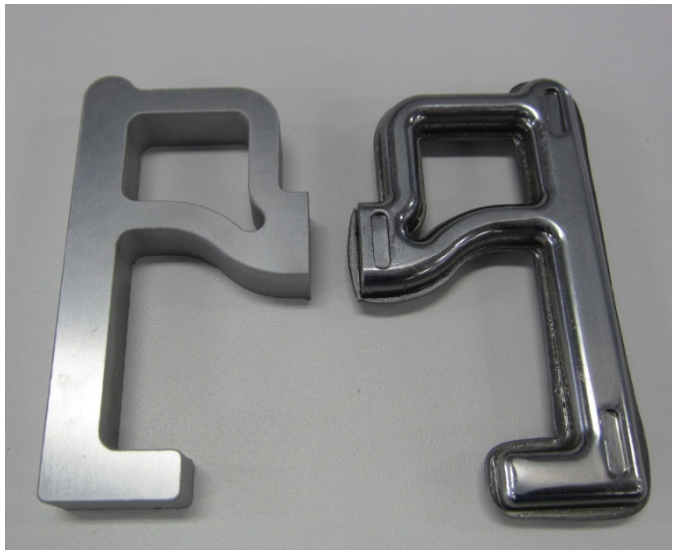
This collaboration started in September 2010. 1.5 mm thick Nb material sheet is used to investigate the advanced deep-drawing technology for the mass production of HOM-can. The required drawing ratio (blank diameter / punch diameter) and drawing height are tentatively attained with above Nb sheet.

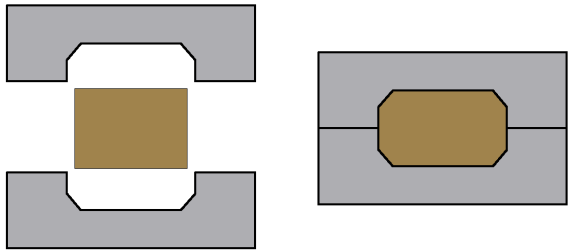
Subject： Plane anisotropy is unexpectedly enormous which causes the large difference of lower and upper ear heights . This might be improved in the future, otherwise it might cause a problem in yield rate of valued Nb material in deep-drawing as well.

Production of HOM-antenna by press forming

Water-jet cutter in a job shop

SHINOHARA





Press-forming

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- W. Singer (DESY) will talk about the standard recipe of cavity fabrication at DESY.
- The parameters of EBW at equator will be discussed: trimming shape (butt or step), EBW beam direction (vertical or horizontal), cavity orientation (vertical / horizontal), EBW parameters (high or low voltage, de-focusing, oscillation, etc…)
- Modern technologies of EBW machine will be discussed. Talk by PAVAC.
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