Utilization of Industrial Electron Beam Processing in Order to Optimize Fabrication of SRF Cavities in Larger Quantities



The 2nd Workshop on SCRF Cavity Technology and Industrialization for the ILC

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Agenda

- Introduction
- Prototyping versus Production
- Cavity structures and methods
- EB Production Systems
- Process and weld performance
- Machine requirements and solutions
- Summary

Introduction



PAVAC Industries Inc. 12371 Horseshoe Way, Unit 105 Richmond, BC V7A 4X6, Canada Phone 1 (604) 231 0014 Fax 1 (604) 326 9078

PAVAC produces Electron Beam Machines (EBW, EB-PVD...) and fabricates SRF cavities.



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Electron Beam





SRF-Cavities



Production Definitions

 In hardware design, a prototype is a "hand-built" model that represents a manufactured product to visualize and test the design.



 Mass production (or serial production) is the production of large amounts of standardized products.

Cavity Structures





Total EB Welds in a 9 cell cavity: 65

Cavity Elements









<u>3 x SMARTBELL</u>

DUMBELL

COUPLER TUBE

TUNER TUBE

- Simplifying assembly methods and procedure steps
- Optimization of fixtures for faster assembly and minimizing alignment errors
- Improvement of quality and reduction of cost
- Elimination of unnecessary production steps (if possible)

EB - Production Systems







Small – Medium Chamber 70% of 1.3GHz cavity welds Fast pump down (30sec) Easy part loading Short setup times Operation entry user level Large Chamber 100% of 1.3GHz cavity welds Long pump down (30 – 60 min) Complex part loading Complex setup Operation advanced user level

High Speed Production

70% of 1.3GHz cavity welds No pump down (5-10 sec) Automatic part loading Complex setup Operation advanced user level

EBW-Large Chamber



- Target: Prototype production "fits all needs"
- Not designed for fast cycles and short production runs
- Operation complex due to flexibility of machine

EBW-Medium Chamber



- Pump down to weld pressure 30 seconds
- Single (simple) task tooling and process controls
- Changing setup is easy
- Operation entry user level

Process Optimization

	LARGE CHAMBER		MEDIUM CHAMBER
	COMPLEX PROCESS	SIMPLIFIED PROCESS	SIMPLIFIED PROCESS SPECIAL EBW
LOADING/ASSEMBLY TIME	120	20	5
PRE-WELD TEST	25	5	2
VACUUM TIME	60	60	2
LAST CHECK	10	15	2
EBW	12	4	4
COOLING	45	10	5
AIR	10	10	1
UNLOADING	30	5	2
MINUTES	312	129	23
HOURS	5.20	2.15	0.38

For producing cavity elements, a dedicated medium size chamber EBW is more economical in operating costs and capital investment. Therefore, costs for parts are lower and production yield can be increased due to shorter production time.

Note:

Cavity welds impact each other in complex setups. Thus, more QC checks are required.

Weld Performance



- Weld performance is related to the quality of tools and machines used during production. Some features to consider:
 - Machine accuracy and repeatability
 - Weld joint detection tracking

Accuracy and Repeatability



PAVAC uses AC linear motors combined with linear scales. Linear motors have no contact and, therefore, lubrication is not required.

Linear scales have a resolution of 0.001mm and allow a repeatability of less than 0.005mm.

The increased machine accuracy allows a better positioning of the beam for welding.

In order to form a consistent under bead in cavity areas, the beam requires a positioning accuracy of plus/ minus 0.025mm. Therefore the machine requires for control purposes a 10 times higher process resolution, which is 0.0025mm.

Weld Gap Detection

<u>CCD Camera + Machine</u> <u>Vision</u>



Machine Vision System takes real time CCD images and processes data and displays key information for user.



Reflective Electrons



Seam tracker (electron trap) mounted isolated in chamber



Software analysis the returned electrons and finds the gap.

Under Development X-Ray Detection



X-Rays from electron beam show structural changes on X- ray chip below weld parts. X- ray image (array) transferred to Machine Vision software for processing.

Vacuum Inside Cavity



- Smart fixtures for better alignment and faster weld assembly
- Vacuum pressure inside the cavity during weld procedures requires optimal tool design

Summary

- Prototyping and production strategies differ from each other and require to change machine and process requirements
- Single-simple jobs are preferable to complex setups
- Production concepts will allow to lower costs for cavity components and increase production yields
- PAVAC continues to use its own EBW systems for cavity production and to improve machine functionality