Investigating of EBW process weldment connections stresses in ILSF 100 MHz cavity by Simufact.welding software

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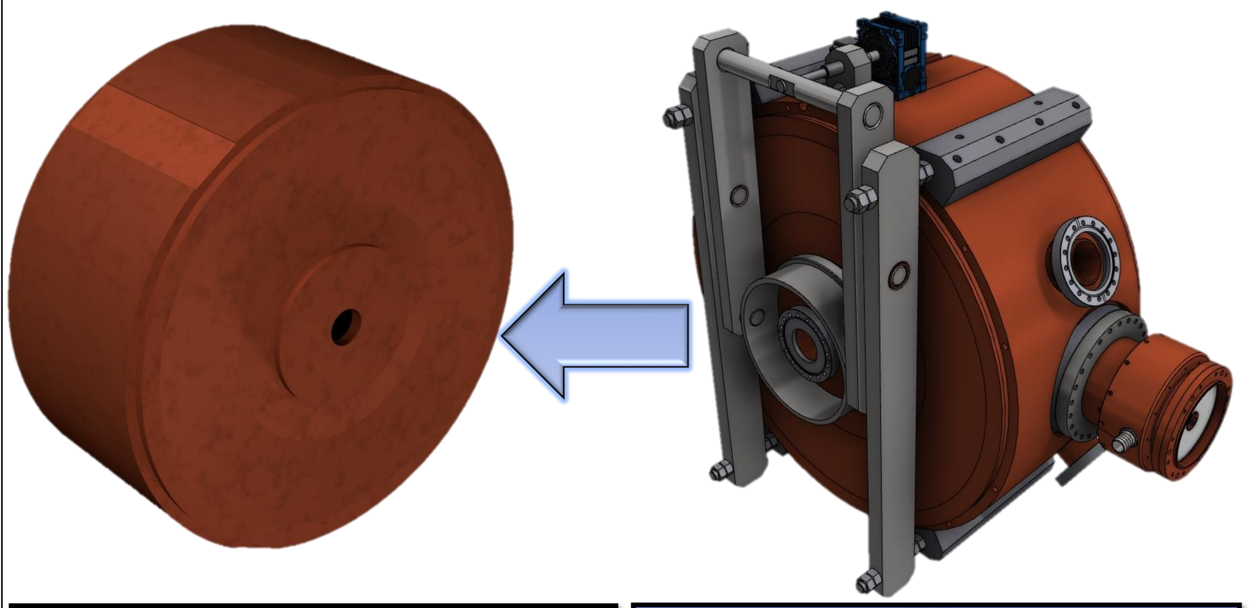
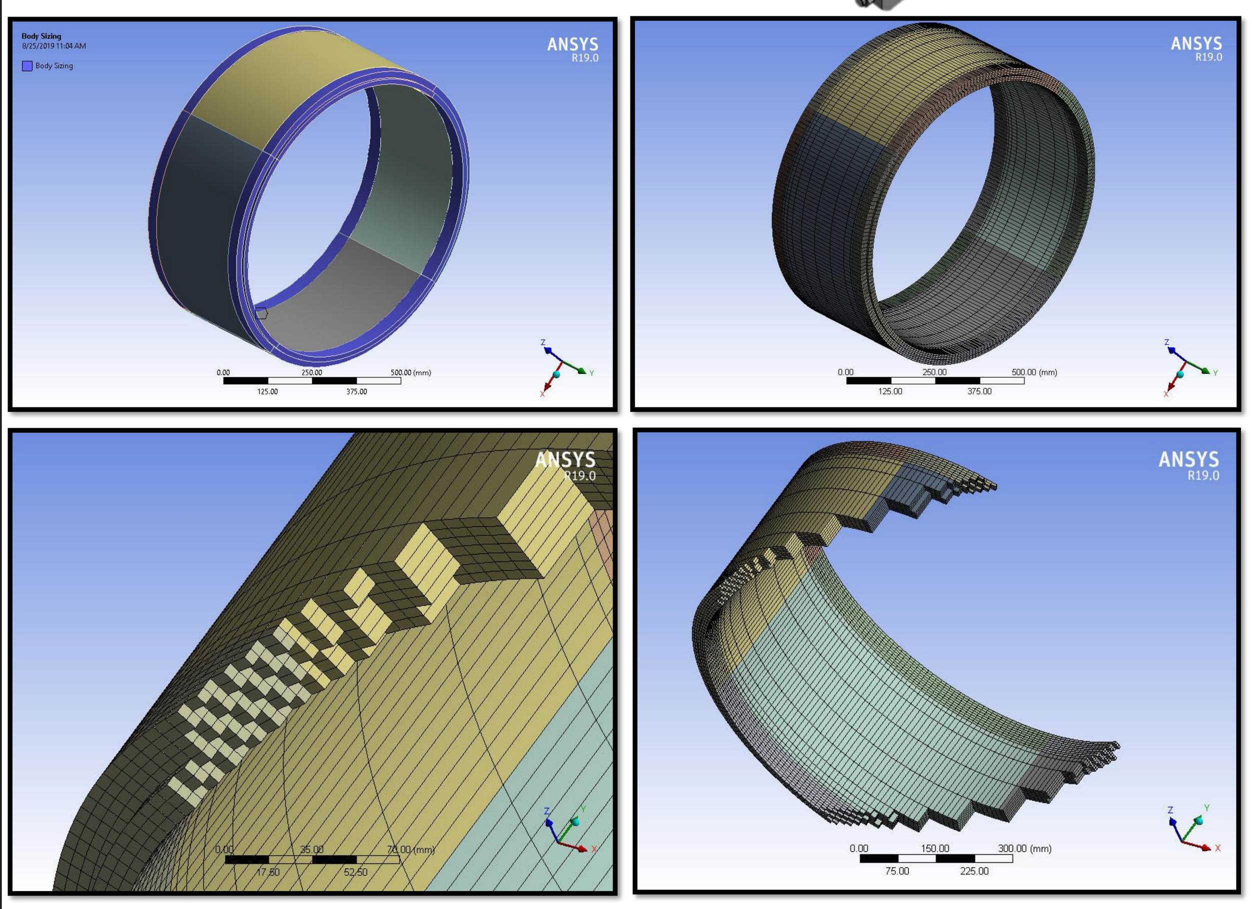
INTRODUCTION

In this article, information about electron beam welding analysis in 100 MHz cavities of ILSF design will be explained. According to studies performed in most accelerators in the world, connections in cavities are made by various methods such as explosive welding, hard soldering, electron beam welding, etc. Many articles on large cavities state that the connection of the side doors must be done by electron beam welding. Therefore, in the present research, the three-dimensional model of the cavity be entered into Simufact.Welding software after simplification and mesh process was done, and then the heat source of electron beam welding and other welding factors such as beam power, Gaussian distribution, etc. are applied in the software. The purpose of this study is the number of residual stresses during the EBW process in the 100 MHz cavity of ILSF.

PREPARATION

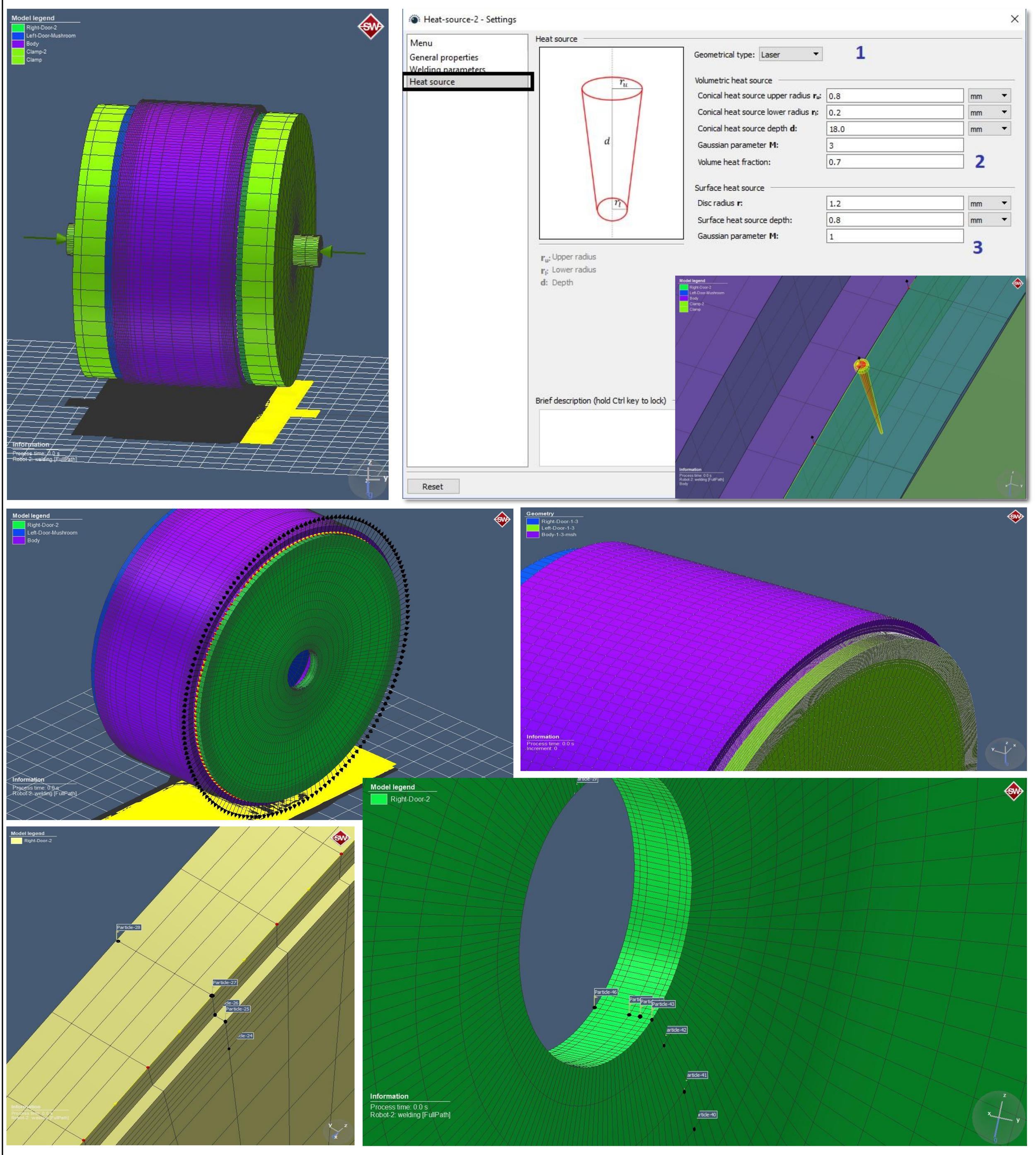
The ILSF 100 MHz cavity was modeled and simplified by Autodesk Inventor software and then meshed by ANSYS software. The simplification is done in such a way that the cavity is transformed into three main parts of the body, the right door and the left door on side which the mushroom-shaped part is also mounted, and the purpose of it is to weld the body part to the doors.





Then enter the 3D cavity model in Simufact.Welding software and the following settings are done in this software:

- Apply thermal boundary conditions
- Apply mechanical boundary conditions
- Definition of material
- Define the robot and the welding path
- Definition of heat source
- Definition tracking points



NUMERICAL MODEL OF HEAT SOURCE

The heat source model in the EBW process is combined in such a way that the thermal effect of the key hole in the penetration depth is modelled with a three-dimensional conical heat source and also the molten metal vapor at the weld surface which has its own local thermodynamic equations of the surface heat source. Used by a Gaussian heat source model to simulate the effect of surface heat.

The formula for the distribution of Gaussian heat source is as follows:

$$q_s(x,y) = \frac{3Q_s}{\pi R^2} \times exp\left|-\frac{3(x^2+y^2)}{R^2}\right|$$

Where(q_s) is the heat flux in the Cartesian coordinates, (Q_s) is the Gaussian heat source power, and (R) is the effective radius of the electron beam.

By moving the welding heat source, the inlet heat flux changes in different positions along the direction of the welding speed. The relationship between moving coordinates and static coordinates is defined as follows:

$$u = y + v(\tau - t)$$

Where (t) is the welding time, (v) the welding speed and (τ) the time delay factor. After converting the static coordinates to the motion coordinates in formula we will have:

$$q_s(x,y) = \frac{3Q_s}{\pi R^2} \times exp\left|-\frac{3(x^2+y+v(\tau-t)^2)}{R^2}\right|$$

If we assuming that (r) is the distance of each point from the heat source to its center, the relation $x^2+y^2=r^2$ holds. Then the distribution of heat flux from the conical heat source in the kinetic coordinates is as follows:

$$q_v(x,y,z) = \frac{9Q_v}{\pi h r_0^2} \times exp\left|-\frac{h^2}{(h-z)^2} \cdot \frac{3(x^2+y+v(\tau-t)^2)}{r_0^2}\right|$$

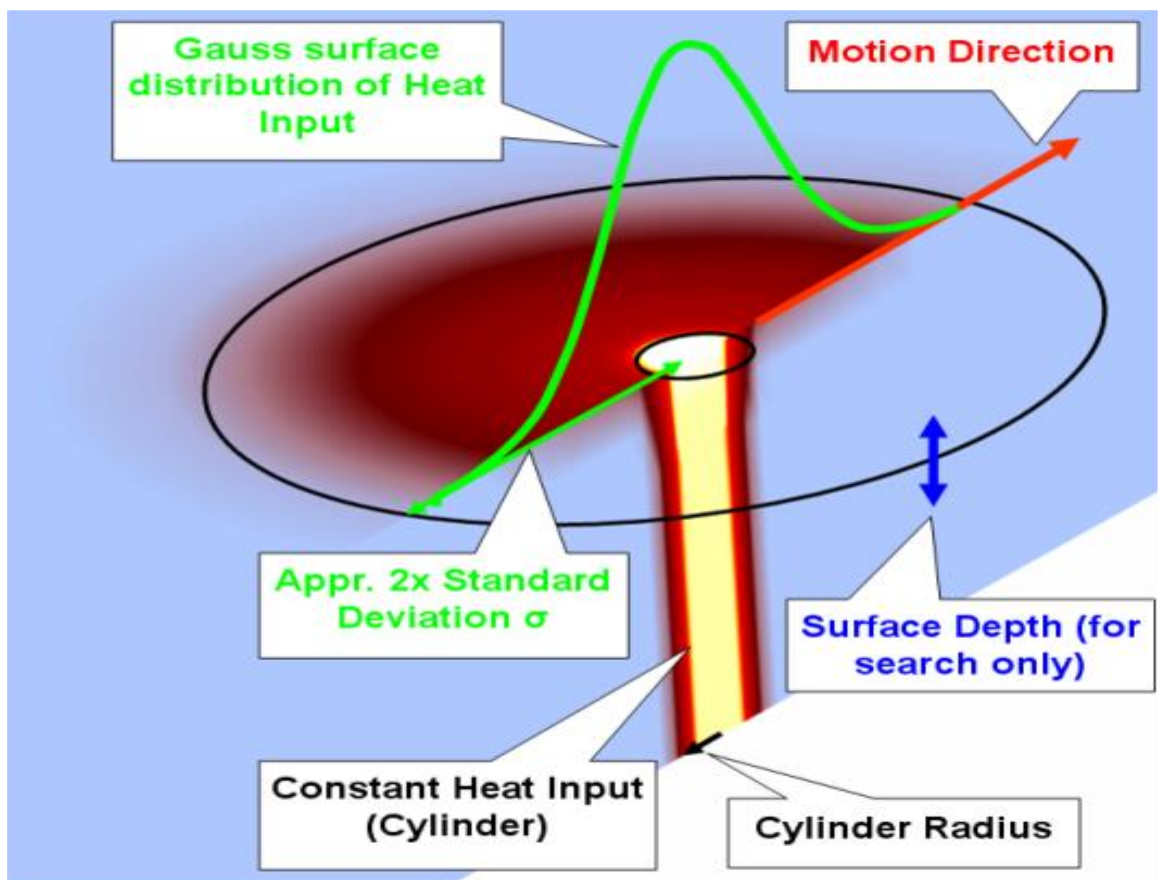
Where $q_v(x,y,z)$ is the heat flux within the welding heat source range effective in Cartesian coordinates. (Q_v)The power of the conical heat source and (h) the depth of the electron beam heat source is effective and (z) vary from "0" to "h". The total power of the two welding heat sources $(q_s)$and (q_v) is equal to the effective input power during the welding process, ie:

$$Q_s + Q_v = Q$$

Where (Q) is the effective input power which can be expressed as:

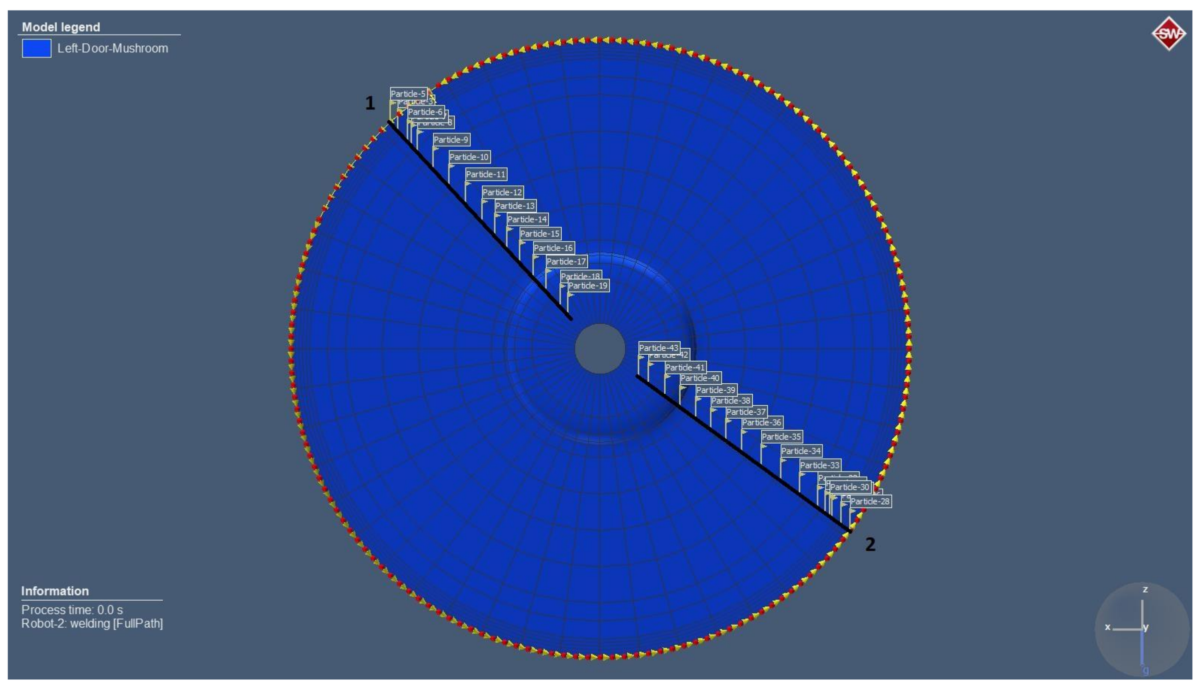
$$Q = CU_aI_b$$

Where (C) is the effective power factor for the electron beam heat source, (U_a) is the accelerator voltage and (I_b) is the beam current.

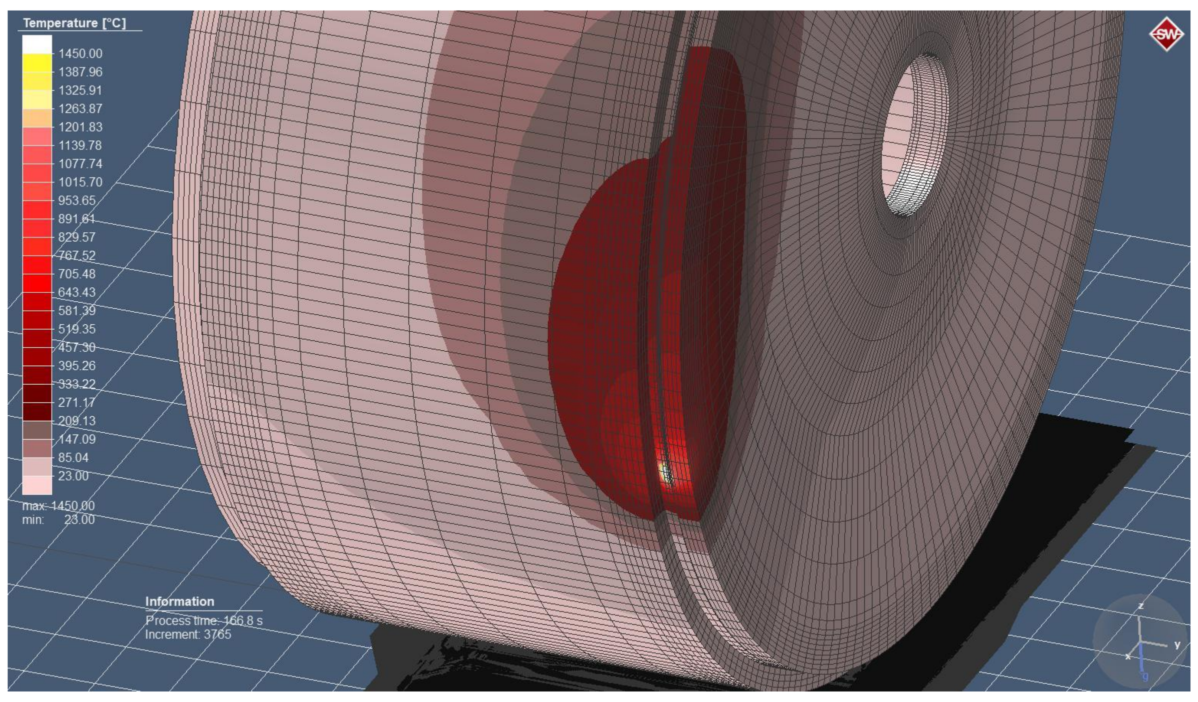


RESULTS

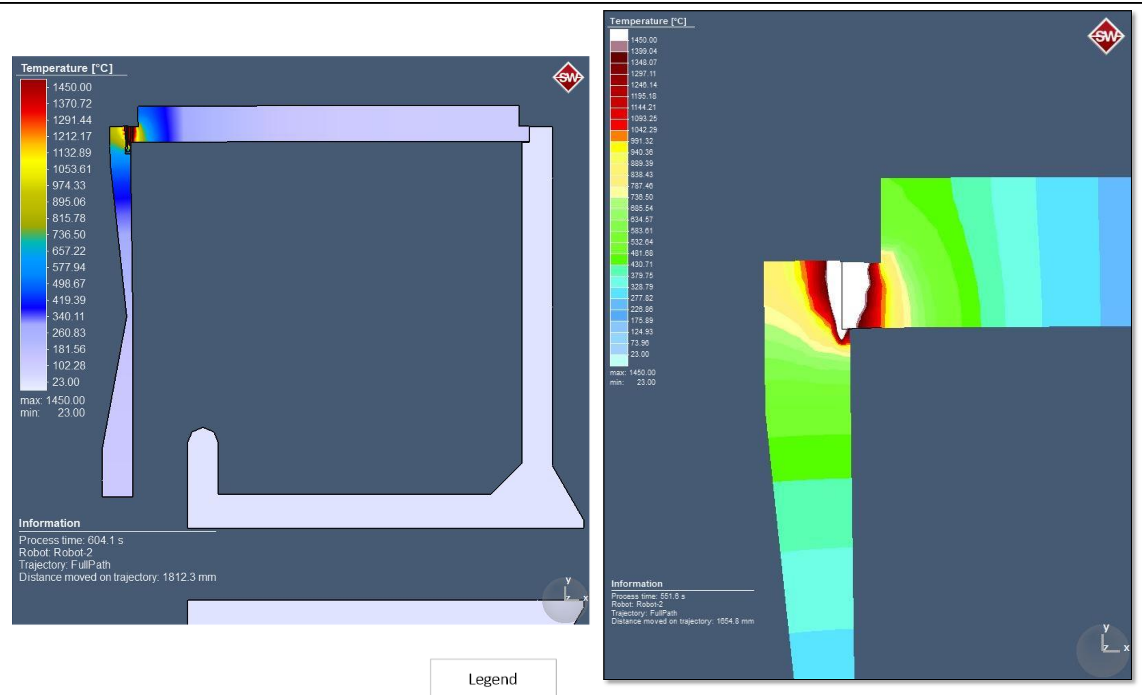
There is the ability to create tracking points in the Simufact.Welding software. The figure below shows these points in two paths, 1 and 2, both on the side door. Path 1 passes where the welding line have overlap, but Path 2 is not.

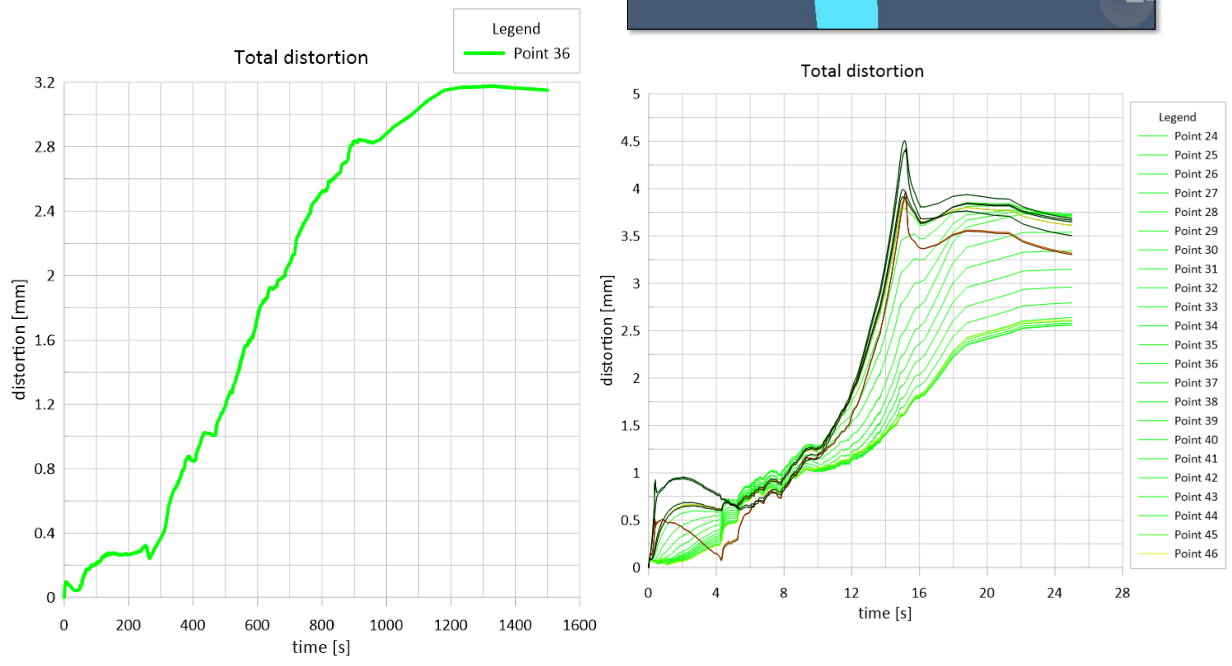


A view of the cavity electron beam welding process is shown in figure below. In this figure, it is possible to see the key hole effect that exists in the heat source sequence.

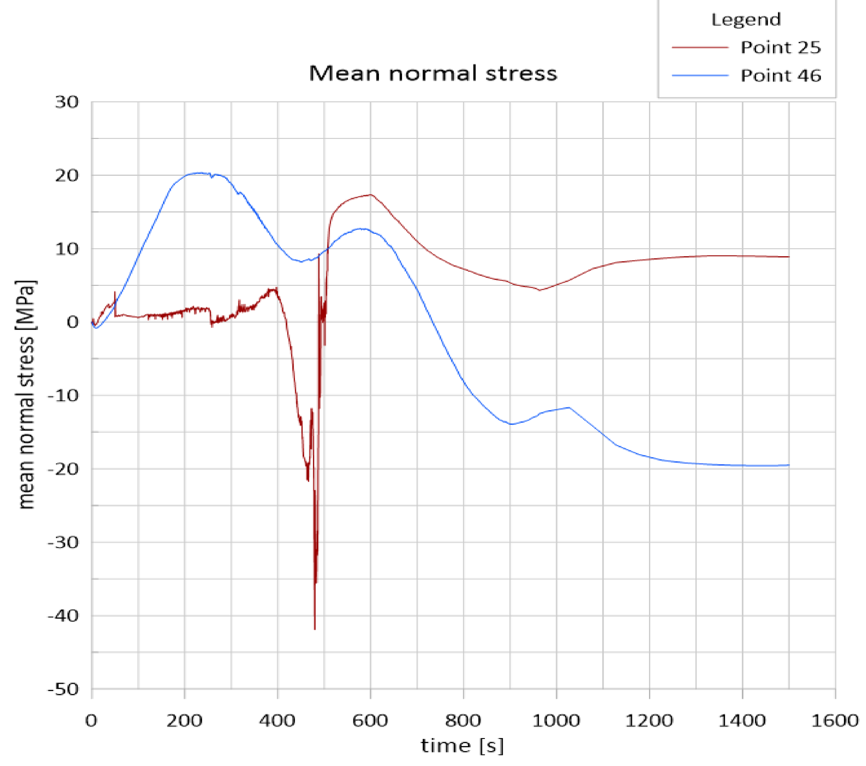


Next figure illustrate the heat distribution in the parts per 604 seconds of the welding process. However, it can be seen that during welding, the areas close to the welding site are heated to about 650 degrees and a little further away to about 400 degrees Celsius. But other parts of the body and side door will be between 100 and 200 degrees Celsius. As well as, the graphs demonstrate the total displacement value at the tracking all points of Route 2. The largest amount of displacement occurred at point 36, as shown in the graph left, which is about 3.2 mm. This is due to the thinning on the side door to perform the cavity tuning process.

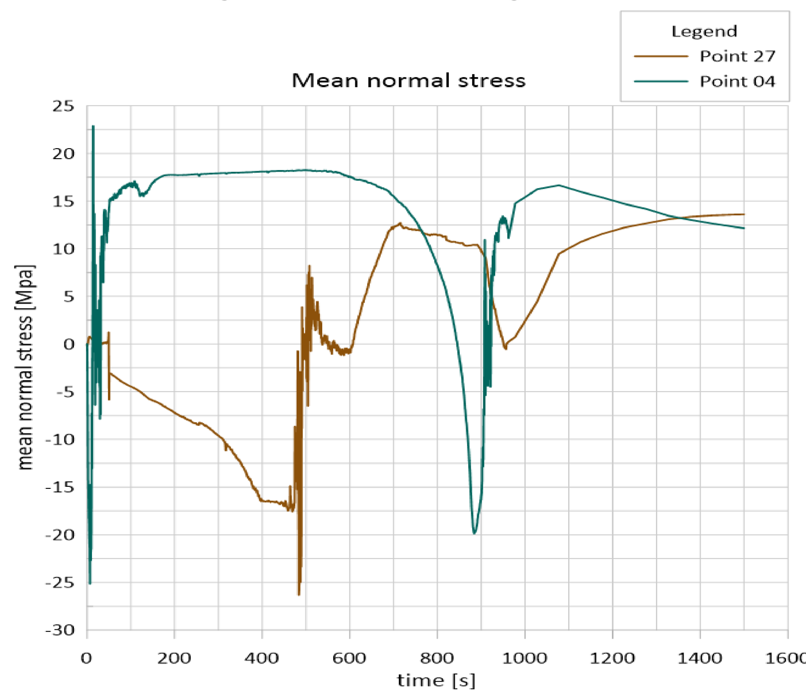




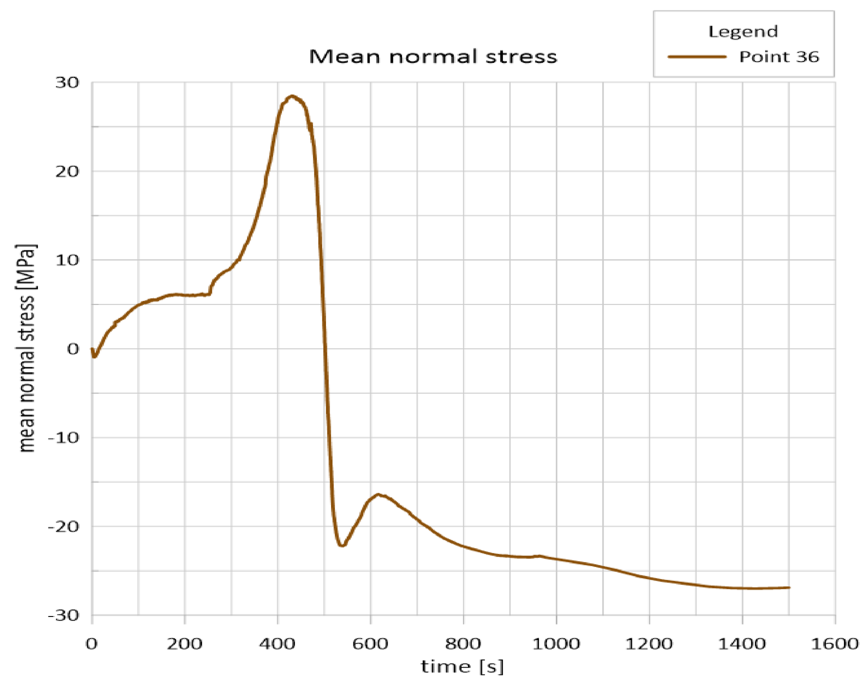
Next graph shown tension changes in the tracking points of the outer edge (25) and inner edge (46) of the side door of the cavity in path 2. it can be seen that in 418th seconds of calculations, the heat source passes through the outer edge (point 25) and at this time the stress at the outer edge is zero. According to this graph in path 2 and at points that are far from the path of the heat source, about 20 MPa of negative stress will remain.



On other hand, we can compare the outer edges of path 1 and path 2. In the next graph difference between the stress of the outer edge of path 1 (point 04) and the outer edge of path 2 (point 27) is shown, and the point is the amount of residual stress of two edges are too close together.



But the most critical point in terms of residual stresses in route 2 is the thinning point on the side door. The amount of residual stress at this point can be found in Next graph, which is equal to 27 MPa.



CONCLUSION

The amount of heat generated in the weld seam is slightly high, so you can increase the speed of the heat source or reduce the inlet power. In the analysis, the amount of residual stress in the parts is not so great that there is a serious need for stress operation after the electron beam welding process in the 100 MHz ILSF cavity. The amount of deformation in the side doors and especially in the thinning part in the analysis of continuous welding path is very high and the side door must be machined to thin part of it, after the welding process.

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