Utilizing NX CAD extension components to model welded joints

A L Fedorov, S V Mkrtychev, O A Enik

Togliatti State University, 14 Beloruskkaya St., Togliatti, 445020, Russia

E-mail: sm5006@yandex.ru

Abstract. The article deals with utilizing NX CAD extension components to model welded joints. The process of building a 3D model of an I-beam and creating welds in it using the NX Weld Assistant component is described. Based on the developed 3D model using the Finite Element Method (FEM) weld calculation and the beam strain-strength analysis are performed. The results of the analysis showed that 3D models of welds created by means of the NX Weld Assistant allow the design engineers carrying out automated research of the developed metal structure with high accuracy.

1. Introduction
Technological processes to create permanent connections by the methods of welding, soldering, glueing have found wide application in the industry [1]. So, the use of welding for the manufacture of beams can provide high productivity and quality. As the elements of constructions working basically on a transverse bend belong to beams, their most rational cross-section represents an I-beam [2]. Less often, the box-section beams are used.

In the manufacture of the I-beam section, the belt is connected to the wall by a welded joint. The calculation of the welded connection is reduced to determining the value of its cathetus sufficient for the perception without destruction of the actual loads on the beam. Traditional calculations of welded connections for such beams by methods of materials resistance are labour-consuming and, in some cases, do not provide the high accuracy of calculations, which makes the design engineer apply high values of stock factors.

The practice of designing welded products shows that the development of welded joints using traditional tools of 3D modelling is not productive enough as well.

Therefore, in some computer-aided design (CAD) systems, for example, in NX (Siemens PLM Software), specialized components of welded connections designing are added [3].

Utilizing such components in the practice of 3D modelling provides high accuracy of calculations and productivity of the design process [4].

2. Utilizing the NX Weld Assistant component
Let us consider the process of welded joints modelling in a beam with the use of CAD NX.

At the initial stage, it is necessary to create 3D models of the beam parts. These are two belts, a wall, stiffening ribs and thrust bearings that accept the concentrated forces acting on the beam and transmit them to the upper belt.
After creating all the beam parts, we create the assembly file, load the assembly components (previously created parts) into the program environment and impose the coupling components on the assembly components.

Figure 1 shows a 3D model of the beam without welds linking the parts to a monolith. By means of Boolean operations of NX, it is possible to combine all parts. However, the peculiarity of the welded joints is that they differ in their chemical composition, properties and structure from the welded material.

For solving this problem, we use the NX Weld Assistant extension component [5]. After starting the component application, we move to the window for creating corner welded joints models. The design engineer is required to specify the size of the weld cathetuses, reinforcement and the place of weld execution.

Let us take the following sizes of the weld cathetuses:

- cathetus of the weld connecting the belt to the wall - 5 mm;
- cathetus of the weld connecting stiffening ribs to the wall and the upper belt – 4 mm;
- 2 cathetuses of the weld connecting the thrust bearing to the upper belt of 10 mm each.
Figure 2 presents a 3D model of a beam with welds (shown in yellow on the model).

![3D model of a beam with welds](image)

**Figure 2.** 3D model of a beam with welds.

3. **Weld calculation and beam strain-strength analysis**

Let us consider the process of the Finite Element Method (FEM) calculation of a beam based on its 3D model.

For this issue, we use the corresponding NX CAD extension component [6]. The results of this operation are presented in Figure 3.

![Finite element mesh](image)

**Figure 3.** The finite element mesh.

When splitting into finite elements, the program considers the weld as an independent 3D model - the nodes of the finite element mesh on the upper belt of the beam and the welds connecting the belt to the wall do not match. In addition, it is possible to specify a different material for the 3D model of the
weld, other than for the joined parts. When selected, the weld model is highlighted with red lines as an independent three-dimensional object.

For performing correct calculations, it is necessary to ensure the mating of the finite element mesh using the corresponding function of the program.

The next stage of calculations is the application of loads. The forces acting on the beam are applied to the thrust bearings (Figure 4).

![Figure 4. Loads applied to the beam.](image)

After performing the calculations, the design engineer has the opportunity to analyze the stress-strain state of the welded unit [7].

Strains and stress distribution of the beam is shown in Figure 5 and Figure 6, respectively.

![Figure 5. The strain of the beam.](image)
When analyzing the stress in the welded joint connecting the beam belt to the wall, it can be found that it is underloaded (Figure 7).

In this case, it is necessary to reduce the size of the cathetus of the weld to 4 mm. After performing the calculation cycle, we obtain the stress value in the weld close to the yield strength of the beam metal. This saves costly filler material.

The results of the welded joints calculations and the beam strain-strength analysis obtained using FEM allow the design engineer concluding that there are problem areas in the product under study and
to perform its structural correction that provides the compliance with strength and stiffness requirements.

4. Conclusion
The article presents an example of utilizing the NX Weld Assistant component for 3D modelling of welded joints of a beam. Based on the developed 3D model, weld calculations and beam strain-strength analysis are performed using the FEM. The analysis showed that the 3D models of welded joints created by Weld Assistant tools allow the design engineers carrying out automated studies of the developed metal construction with high accuracy.

References
[1] Jarmai K and Farkas J 2008 Design, Fabrication and Economy of Welded Structures: International Conference Proceedings 2008 (Elsevier) p 592
[2] GOST 8239-89 http://docs.cntd.ru/document/1200004409, last accessed 2020/04/04
[3] Siemens PLM Products – NX https://www.plm.automation.siemens.com/global/en/products/nx, last accessed 2020/04/04
[4] Fedorov A L, Mkrtchyan S V and Enik O A 2019 Utilizing the 3D modeling technology to design a welding fixture J. Phys.: Conf. Ser. 1333 082003
[5] NX CAD Extension products https://www.phoenixplm.com.au/products/nx/cad-extension-products/ , last accessed 2020/04/04
[6] NX Advanced FEM https://www.plm.automation.siemens.com/en_cz/Images/nx%20advanced%20fem%20fs%20W%208_tcm841-4364.pdf, last accessed 2020/04/04
[7] Litewka P 2010 Finite Element Analysis of Beam-to-Beam Contact (Springer Science & Business Media) p 175