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Original Research Article

Selected aspects related to the calculations and design of a cryogenic transfer line

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ABSTRACT

This paper presents the results of calculations of a planned helium transfer line operating at cryogenic temperatures as low as 4.5 K. A strength analysis was conducted for the cryogenic transfer line designed to transport supercritical and gaseous helium. The strength analysis of a transfer line operating at extremely low temperatures was conducted using the Finite Element Method (FEM) for complex boundary conditions. The results of numerical calculations served as the basis for the design documentation of the XATL1 cryogenic line to be installed at DESY site.

1. Introduction

System design of large-scale cryogenic requires the account of a large thermal contraction throughout the thermo-mechanical system. A convenient tool that allows numerical solution of this problem is the Finite Element Method [7–9] widely used in cryogenics [1–3].

A four channel cryogenic transfer line was designed to transport supercritical and gaseous helium. The cryogenic transfer line is aimed to transport supercritical helium from the AMTF hall to the HERA West facility about 160 m away. The layout of the transfer line called XATL1 is presented in Fig. 1 [12].

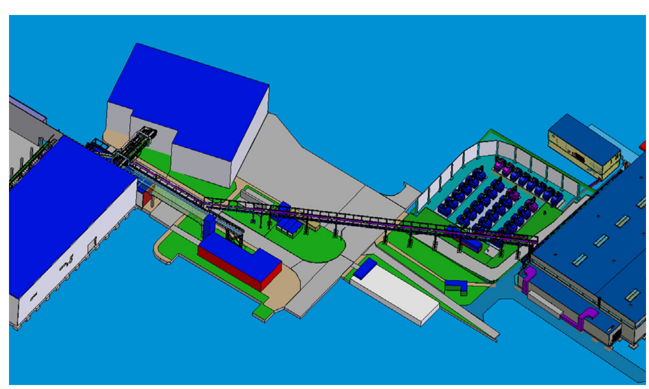

Fig. 1 – Cryogenic line XATL1 (courtesy DESY).

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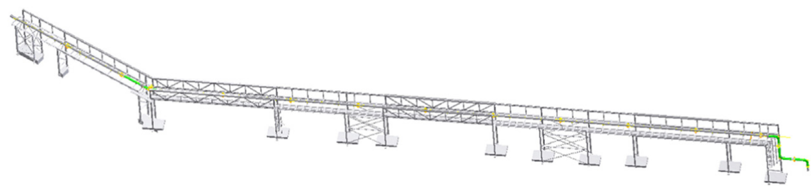

Fig. 2 – View of the bridge with the planned pipeline (courtesy DESY).

In the first stage the design requirements and boundary conditions were established for the line XATL1. One of the basic requirements of the cryogenic line design was to use the existing bridge to support the planned transfer line. The structure of the bridge and the line is shown in Fig. 2. In order to draw up the design documentation of the cryogenic line XATL1, the following steps were taken: building a 3D geometrical model of the pipeline, conducting a strength analysis regarding thermal shrinkage, choosing the appropriate number of compensators, which ensures proper and failure-free operation of the cryogenic line [4–6]. The basis for the 3D model was the functional design described in [11–13].

2. Creating the geometric model of the pipeline

The length of XATL1 transfer line is of about 167 m. The pipeline is composed of 11 linear modules, elbow 150°, elbow

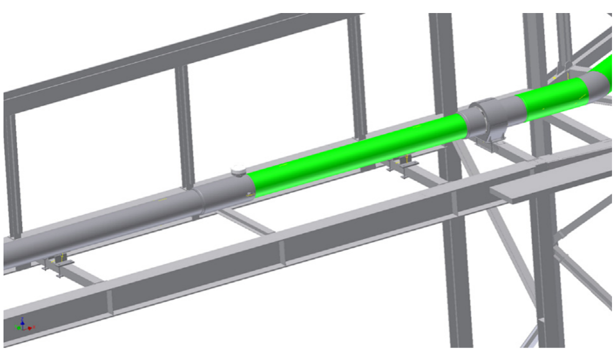

Fig. 3 – Section of the pipeline with sliding and fixed supports.

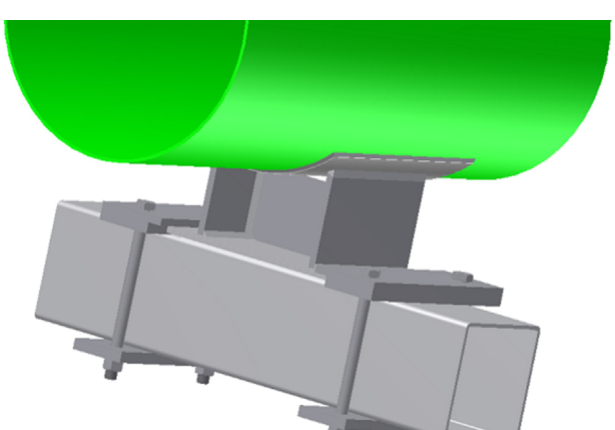

Fig. 4 – View of the sliding support attached to the bridge.

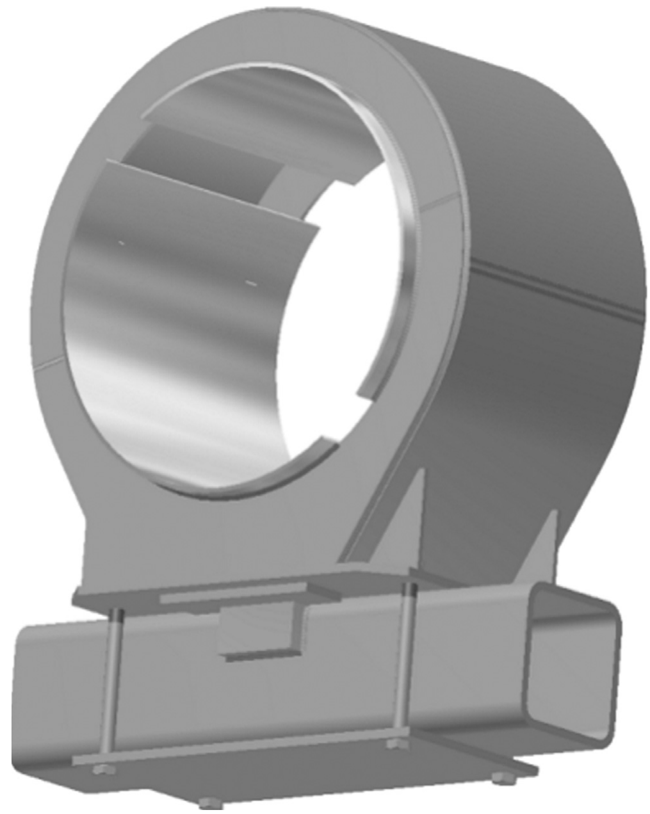

Fig. 5 – View of the first fixed support attached to the bridge.

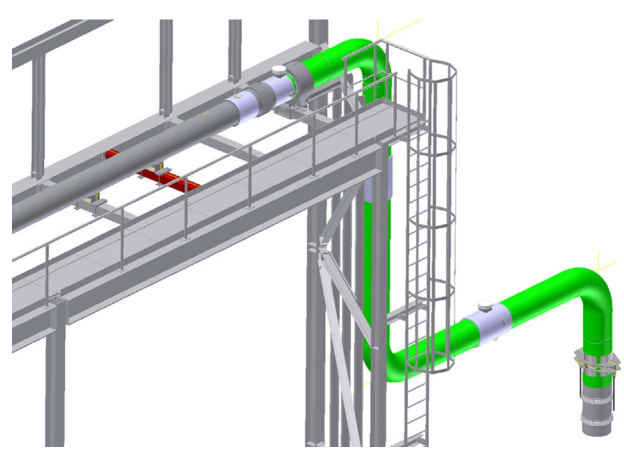

Fig. 6 – Section of the pipeline with subsequent supports highlighted.