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Minimum cost design of a column-supported oil pipeline strengthened by a tubular truss

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ABSTRACT: A column-supported oil pipeline is considered. When the distance between supports is in anywhere larger than the regular span length, a question arises whether a larger pipe should be used or the original pipe should be strengthened. The aim of this study is to answer this question by comparing the costs of the two possibilities. Therefore a strengthening welded tubular truss is proposed and optimized.

The truss is constructed from a central vertical column and two diagonals. The strengthened pipe and the truss form a statically indeterminate structure in which the member forces depend on their dimensions. Thus, a systematic optimization process is necessary to find the unknown member dimensions, which fulfill the design constraints and minimize the cost.

The unknown force in the vertical column is derived using a deflection equation. The original pipe is designed considering the self-mass, the mass of oil in the pipe and the internal pressure of 64 bars. The strengthening welded tubular truss is optimized taking into account the design constraints on member stresses and truss geometry as well as a cost function.

The cost function includes the costs of material, cutting and grinding of strut ends, assembly, welding and painting.

In the stress constraint of the vertical column a lateral force is considered acting on the truss node to avoid the lateral buckling. Therefore the column should be checked for compression and bending.

The optimization is performed using the Rosenbrock's hillclimb direct search method complemented by a discretization to obtain available circular hollow sections.

The results show that the optimum truss height is determined by the geometric constraint prescribing the minimum inclination angle of diagonals. The cost comparison shows that the strengthened pipe is much cheaper than the larger pipe without strengthening.

KEYWORDS: Oil pipeline, structural optimization, welded steel structure, tubular truss.

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