

The Programs for Strength Calculation in Pipelines

Jelena Priss, Ivan Klevtsov
Tallinn University of Technology
lenapriss@hotmail.com, Klevtsov@staff.ttu.ee

Abstract

The trend of development Estonian oil industry, related to European Union strict technological requirements, needs developing methods of pipeline optimization on the basis on strength condition analysis. This paper presents an overview and comparative analysis of 4 strength calculation programs (START, RAMPA, LV pipe II, CAESAR II). The following factors were used for analysis: computational algorithms and basic standards, technical specs, application areas, graphics function, error checker and reports. There are mentioned the risks of the usage of manual strength calculation.

Keywords

Pipeline construction, strength calculations, standards, programs, manual calculation.

Introduction

This paper draws on ongoing PhD thesis “Piping optimization on the basis of strength condition analysis”. The paper is structured as follows. After an overview of the theoretical issues the paper will provide an overview of the programs analysis for pipeline construction.

The paper considers the description of four different programs (START, RAMPA, LV pipe II, CAESAR II) for strength calculation. The programs are analyzed by standard, program developer, technical specs, language, application areas, graphics function, error checker and reports.

Pipeline construction

Pipeline is basically a transport structure. Products for transport: liquid, gaseous, toxic and explosive. Technological areas are sewerage plants and water management facilities, power engineering, chemical and petrochemical industry, nuclear power engineering.

Strength calculations are necessary in the design of pipelines. Strength calculation gives an opportunity

to choose the configuration of pipeline and, at the same time, to avoid unnecessary pipeline complication. It is necessary to arrange the supports taken into consideration so that they do not reduce pipeline compensating capacity. Strength calculation allows finding correct solution for supports placements, their types and characteristics.

Programs characteristic and comparison

Requirements to technical calculation of program

The main requirements to technical calculation of the program are considered in this part of paper. The program is supposed to calculate:

- Reactions, forces and moments in supports and connected equipment
- Pipeline forces and moments
- Displacements
- Strength and stress calculations according to standard EVS-EN 13480
- Nozzle loads
- Wind loads
- Friction
- Fatigue

The main characteristics of strength calculation programs are given in Table 1.

Table 2 shows feature comparison of programs RAMPA, START, LV pipe II and CAESAR II.

START

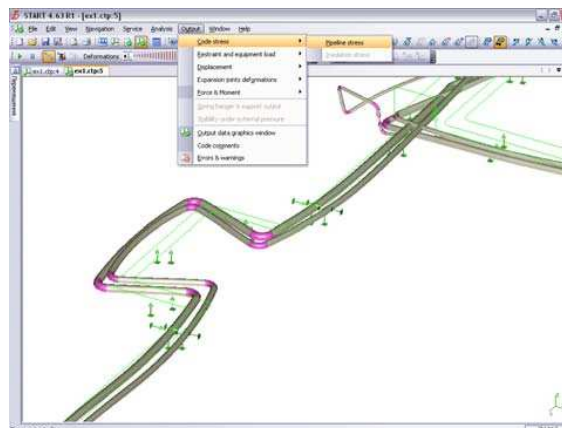


Figure.1. START user interface

Table 1 .Strength calculation programs characteristics

Program	RAMPA	START	LV pipe II	CAESAR II
Standard	Russian Federation Standard	Russian Federation Standard	EVS-EN 13480	International ISO
Developer	ISTC „Dipriz“ Russian Federation	NTP „Truboprovod“ Russian Federation	“Lauterbach Verfahrenstechnik” Germany	„COADE“ USA
Language	Russian	Russian	German, English	English
Products for transport	Steam, hot water, oil, gas	Steam, hot water, oil, gas	Steam, hot water, oil, gas	Steam, hot water, oil, gas
Technical specs	Microsoft Windows 2000 / DOS (Disk Operating System)	Microsoft Windows XP	Microsoft Windows 2000 / XP / Vista and as Excel 2000	Microsoft Windows XP/ Windows Vista
Application areas	Pipeline construction	Pipeline construction	Thermal process engineering, pressure vessel design and pipeline construction	Process and plant design, pipeline construction
Graphics function	3D	3D	3D	3D
Error checker and reports	Integrated	Integrated	Integrated	Integrated

Table 2. Requirements to technical calculation of program

Program	RAMPA	START	LV pipe II	CAESAR II
Support reactions	x	x	x	x
Forces and moments	x	x	x	x
Elbow ovality	x	-	-	-
Displacements	x	x	x	x
EVS-EN 13480	-	-	x	x
Nozzle loads	x	x	x	x
Wind loads	x	x	x	x
Friction	x	x	x	x
Fatigue	x	x	x	x
Spring hangers properties	x	x	x	x

START is the most widely used pipe stress analysis program in Russia and CIS countries. START is widely used by major plants and design companies in chemical, oil and gas, power, metallurgy and other industries. The START program is fully certified according to Russian standards.

Strength and rigidity analysis for steam and hot water pipelines, main gas and oil pipelines, process steel pipings. Branched 3D pipelines with various design of end and intermediate supports, with various expansion joints made in the form of

corrugated, lens-shaped, stuffing box, or bellows type pipe compensators under static and cyclic loading of various nature (temperature expansion, concentrated and distributed loads, support movement, tension, and compression) are calculated. If required, the program automatically selects spring supports and calculates their tightening torque. Pipeline and fixtures strength and bearing capacity assessment is done for various Russian standards (conformity with norms confirmed by Certificate of Gosstroy RF ROSS RU.SP11. N 00003 Gosstroy RF № 0075985).

CAESAR II



Fig. 2. CAESAR II user interface

CAESAR II makes it easy to input and display all the data needed to accurately define a piping system analysis model. Input can be accessed or modified on an element-by-element basis, or datasets can be selected to make global changes. The CAESAR II input graphics module makes quick work of developing analysis models while clearly indicating areas of concern and providing an excellent idea of the piping system's flexibility. Colour-coded stress models and animated displacements for any stress load case are available. Besides the evaluation of a piping system's response to thermal, weight and pressure loads, CAESAR II analysis the effects of wind, support settlement, seismic loads and wave loads.

The CAESAR II program includes an integrated error checker. Reports are clear, accurate concise and fully user definable.

CAESAR II incorporates table look-ups for piping materials and components plus expansion joints, structural steel sections, spring hangers and material properties including allowable stress. This ensures correct datasets are used for each analysis. CAESAR II is certified according international piping codes.

Features:

- Static and dynamic analysis
- Intuitive analysis model creation
- Cutting-edge graphics
- Load and view plant model
- Comprehensive error checking
- User-definable reports
- Wind and wave analysis
- Seismic and support settlement analysis
- International piping codes
- Extensive material databases
- Steel databases and modelling

LV PIPE II

The LV PIPE II user interface is completely integrated into MS EXCEL. The EXCEL environment enables the user to implement his own data and links and to create the documentation according his preferences. Results of a calculation are totally separated from the input (EXCEL sheets).

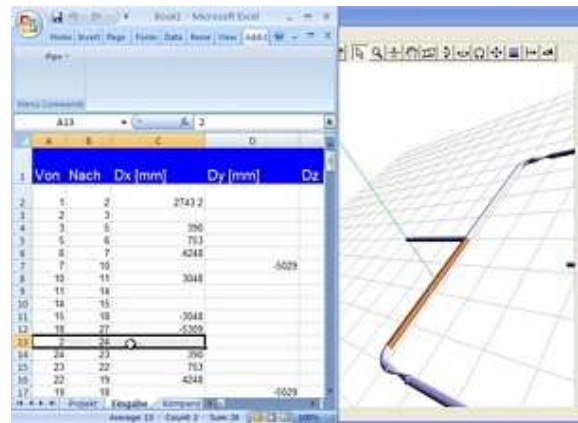


Fig. 3. LV PIPE II user interface

Features:

- Maximum number of allowable displacement cycles is documented
- The displacement of the pipe system can be presented animated for every load case
- The node numbers are presented perspective (same size) to grant the utmost clarity in presentation. Numbers and names are scaleable and rotatable.
- Pipes marked in the Excel sheet are highlighted in the graphics simultaneously
- CAD-Options: Export of graphics as 2D or 3D-DXF for further use (Stresses presented in colours)

RAMPA

RAMPA carries out verifying calculation of strength in which, besides the internal pressure, it takes into account the action on the pipeline of additional operational loads from the following factors:

- Weight of the metal, the transported fluid, heat-insulation and the fittings of pipeline system
- Thermal expansions (self-compensation) of the pipeline
- Thermal expansions and other deformations in structures of the attached equipment and supporting system
- Possible residual curvature of the pipeline as a result of accumulation of plastic creep deformations, so-called "self-extensions"

At verifying calculation of durability of the pipeline the program defines equivalent stresses for all its testing sections and typical details (arc and sector elbows, tees), compares to allowed stress and comes to the conclusion of performing of standard conditions. Besides strength estimation the program calculates design loads on the equipment and supporting constructions at verifying calculation of pipeline system where the special stage of calculation is carried out for spring suspension (assembly, simplifying system adjustment).

The maximum equivalent stresses in pipeline sections are defined on the basis of main stress components with application of the theory of the

greatest tangential pressure (the third theory of strength or the theory of H. Treska)

The RAMPA program is fully certified according to Russian standards.

Manual calculation

Durability and resistance of pipeline depends on different external factors: thermal expansion, concentrated and distributed loads, displacements of the supports, stretching. These factors are caused by random temperature fluctuation of transported product. There is a risk for the pipeline system to make strength calculation manually. For the estimation of the pipeline stability it is necessary to make calculation with program.

Standard

All strength calculations should be done according to standard EVS-EN 13480.

Conclusion

The paper presents a comparative analysis of programs applicable for design of pipelines operating under different temperature, internal pressure and external mechanical loads.

Present analysis helps to consider programs availability on the energy market.

Strength calculation programs analysis is necessary for the future researches in this field.

The next steps for ongoing PhD thesis are:

- Test the demo version of programs
- Analysis of pipeline strength calculations

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