**Title:** Pipeline Dynamic Thermal Response Experimental Data

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**Organisations:**

1. University of Leeds
2. University of Teeside

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**Description:**

These datasets were collected and generated as part of a PhD project to evaluate the dynamic thermal responses of pipelines in thermal energy networks. The datasets consist of three main components: (i) Experimental and modelling data for a lab-scale district heating pipeline, specifically designed and built in the building physics lab at the School of Civil Engineering, University of Leeds, (ii) monitoring and modelling data for a full-scale district heating pipeline under real operating conditions, using available data from an operational district heating pipeline, (iii) modelling data for the dynamic storage of thermal energy in district heating pipelines.

**Cite as:**

Meibodi, S.S. and S.J. Rees (2023) Pipeline Dynamic Thermal Response Experimental Data, University of Leeds. Dataset. <https://doi.org/10.5518/1439>

**Related Publication:**

*Modelling district heating pipelines using a hybrid dynamic thermal network approach.*

Journal: ‘Energy’

Authors: S. Meibodi, S. Rees, F. Loveridge

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**Contents**

The data file contents correspond to that used to generate figures in the publication:

S. Meibodi, S. Rees, F. Loveridge (2023*). Modelling district heating pipelines using a hybrid dynamic thermal network approach.* Submitted to Energy.

There are three spreadsheet files as described below. There are data from one experimental source and three types of model. Model results are compared with experimental data from two published sources. In total there are

1. UoL experimental data: collected during a PhD project in the School of Civil Engineering
2. DTN Model: results from a ‘Dynamic Thermal Network’ model of ground heat transfer
3. DTN-PFST Model: results from a combined DTN and ‘Plug Flow Stirred Tanks’ pipeline model
4. 3D Finite Volume Model: results from a detailed numerical model of the experimental pipeline
5. Full-scale system data (Ciuprinskas and Narbutis, 1999): operational data from a district heating system in Vilnius.
6. Published numerical model data (Gabrielaitiene et al., 2008); Dénarié, 2019: published numerical results compared with the data from the Vilnius system.

**Filename**: Experimental and modelling Data-Ex Setup.xlsx

Measurement and Modelling Data for the Lab-Scale District Heating Pipeline

This dataset includes measurement data of the inlet and outlet temperature (in degrees Celsius) of the buried pipeline in the experimental setup for two main experiments of imposing a step change to the ground surface and pipeline surface. It also contains corresponding modelling data obtained from the DTN model, Combined DTN-PFST model, and 3D finite volume model. The dataset covers a span of 42 hours of experiments with a timestep of 200 seconds. The data is presented in four sheets, representing the transmittive and admittive weighting factor series for the buried pipeline system (Figure 3), results of two main experiments involving a step change to the ground surface and pipeline surface (Figure 6), corresponding modelling errors (Figure 7), and heat transfer from the ground surface (Figure 8).

There are four sheets in this file that have the following data definitions:

|  |  |
| --- | --- |
| Sheet name | PipelineStepChange |
| Number of Rows | 757 |
| Data (Column) Headings | Units |
| Time (h) | h |
| Inlet Temperature- Measured | Celsius |
| Outlet Temperature- Measured | Celsius |
| 3D model- OpenFOAM | Celsius |
| DTN model | Celsius |
| Combined DTN-PFST model | Celsius |
| Error (3D model) | K |
| Error (DTN model) | K |
| Error (Combined DTN-PFST model) | K |

|  |  |
| --- | --- |
| Sheet name | GroundStepChange |
| Number of Rows | 757 |
| Data (Column) Headings | Units |
| Time (h) | h |
| Inlet Temperature- Measured | Celsius |
| Outlet Temperature- Measured | Celsius |
| 3D model- OpenFOAM | Celsius |
| DTN model | Celsius |
| Combined DTN-PFST model | Celsius |

|  |  |
| --- | --- |
| Sheet name | Weighting Factors Series |
| Number of Rows | 272 |
| Data (Column) Headings | Units |
| Time (h) | hours |
| Ground Surface admitive WF (-) | - |
| Pipeline Surface admittive WF (-) | - |
| Transmittive WF (-) | - |

|  |  |
| --- | --- |
| Sheet name | GroundHeatTransfer |
| Number of Rows | 757 |
| Data (Column) Headings | Units |
| Time (h) | hours |
| Measured heat transfer | W |
| 3D model-OpenFOAM | W |
| DTN model | W |
| Combined DTN-PFST | W |

**Filename**: Experimental and modelling Data-DH system.xlsx

Measurement and Modelling Data for the Full-Scale District Heating Pipeline

To validate the novel models developed in this research for modelling the operational district heating pipeline under real operating conditions, available experimental data from a district heating pipeline in Vilnius was used (Ciuprinskas and Narbutis, 1999). The dataset is divided into two sheets, one corresponding to the validation of the combined DTN-PFST model (Figure 9), and the other sheet presents comparisons between simulation results obtained from the combined DTN-PFST model and two other numerical models (Gabrielaitiene et al., 2008; Dénarié, 2019), predicting the outlet temperature response of the Vilnius district heating pipeline (Figure 10).

K.Ciuprinskas,B. Narbutis, An experimental investigation of heat losses in the district heating network, Energetika. 2 (1999) 35–40.

I. Gabrielaitiene, B. Bøhm, B. Sunden, Evaluation of approaches for modeling temperature wave propagation in district heating pipelines, Heat Transfer Engineering 29 (1) (2008) 45–56. doi:10.1080/01457630701677130.

Dénarié, A., Aprile, M., & Motta, M. (2019). Heat transmission over long pipes: New model for fast and accurate district heating simulations. *Energy*, *166*, 267–276. https://doi.org/10.1016/j.energy.2018.09.186

There are two sheets in this file that have the following data definitions:

|  |  |
| --- | --- |
| Sheet name | Validation DH System-1 |
| Number of Rows | 71 |
| Data (Column) Headings | Units |
| Time (h) | hours |
| Inlet temperature (Cº) | Celsius |
| Outlet Temperature (Cº) | Celsius |
| Combined DTN-PFST Model (Cº) | Celsius |

|  |  |
| --- | --- |
| Sheet name | Validation DH System-2 |
| Number of Rows | 51 |
| Data (Column) Headings | Units |
| Time (h) | hours |
| Outlet Temperature | Celsius |
| Combined DTN-PFST Model | Celsius |
| FEM [Gabrelaitiene et al (2008)] | Celsius |
| Improved PF model [Denarie et al. (2019)] | Celsius |

**Filename**: Modelling Data for Pipeline Dynamic Storage.xlsx

Modelling the Pipeline Heat Storage

The dataset consists of three sheets, including fluid temperature variation along the pipeline calculated by the combined DTN-PFST model at four different times (Figure 11), predicted temperature responses of the pipeline at six different distances calculated by the combined DTN-PFST model (Figure 12), and the cumulative energy stored in the pipeline (in kilojoules) (shown in Figure 13).

There are four sheets in this file that have the following data definitions:

|  |  |
| --- | --- |
| Sheet name | Cummulative Energy Stored |
| Number of Rows | 20 |
| Data (Column) Headings | Units |
| Length | m |
| Cumulative Energy at time 50 s | kJ |
| Cumulative Energy at time 100 s | kJ |
| Cumulative Energy at time 150 s | kJ |
| Cumulative Energy at time 200 s | kJ |
| Cumulative Energy at time 250 s | kJ |

|  |  |
| --- | --- |
| Sheet name | Fluid Temperature DTN-PFST |
| Number of Rows | 24 |
| Data (Column) Headings | Units |
| Length | m |
| Fluid temperature at time 50 s | Celsius |
| Fluid temperature at time 100 s | Celsius |
| Fluid temperature at time 150 s | Celsius |
| Fluid temperature at time 200 s | Celsius |

|  |  |
| --- | --- |
| Sheet name | Fluid Temperature Numerical |
| Number of Rows | 20 |
| Data (Column) Headings | Units |
| Length | m |
| Fluid temperature at time 50 s | Celsius |
| Fluid temperature at time 100 s | Celsius |
| Fluid temperature at time 150 s | Celsius |
| Fluid temperature at time 200 s | Celsius |

|  |  |
| --- | --- |
| Sheet name | Pipe Temperature Responses |
| Number of Rows | 501 |
| Data (Column) Headings | Units |
| Time | seconds |
| Temperature at 10m | Celsius |
| Temperature at 20m | Celsius |
| Temperature at 40m | Celsius |
| Temperature at 60m | Celsius |
| Temperature at 80m | Celsius |
| Temperature at 100m | Celsius |

Methods

Details of the experimental and numerical methods used to generate the data can be found in the related PhD thesis:

Salavati Meibodi, Saleh (2020) [*Modelling Dynamic Thermal Responses of Pipelines in Thermal Energy Networks.*](https://etheses.whiterose.ac.uk/28160/) PhD thesis, University of Leeds.

Available at https://etheses.whiterose.ac.uk/28160/

Details are also summarized in the publication.

S. Meibodi, S. Rees, F. Loveridge (2023*). Modelling district heating pipelines using a hybrid dynamic thermal network approach.* Submitted to Energy.