Development of an application of a pipeline network calculation

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Abstract. The main stages of development of a pipe network calculation application at the coding level in C# language are presented. Databases are implemented by Microsoft SQL Server. Visual Studio was used as an integrated development environment for code writing, as well as a rich set of control elements written using .NET Framework. The necessary solutions for the task was developed after complementing the functionality of these code control elements.

Transport of oil is one of the important stages of oil delivery. Many transport networks of oil to the refineries and storage units are created. There are four methods of oil transport [1-10]:

| Type of transport       | Note                                                                 |
|-------------------------|----------------------------------------------------------------------|
| Pipeline                | Pipelines are commonly used. They are not energy-intensive and have a lower carbon footprint. |
| Rail transport          | Rail transport has low capital costs, but low speed, carbon emissions and accidents. |
| Truck tank              | It is the limited method of oil transportation due to storage capacity, but truck tanks have the greatest flexibility for many directions of oil delivery. |
| Water transportation    | It is the cheapest way of oil transport (Compared to the pipeline, barges are cheaper by 20 -35% depending on the route). A disadvantage is speed. |
Although there are different options for transporting oil, the decision on which method to use is usually reduced to cost and location. Short-distance transport is carried out by feeding or distribution pipelines and, in some cases, by trucks. When land routes are not available, tankers are the only option for oil delivery to the market. Transportation over short distances can be achieved using rail, truck tank or pipelines. Truck tanks are less efficient than other methods, but their particular advantage is that they provide direct movement from source to destination. As to railway wagons, they must be disconnected and processed at stations and may require cross-routing, which makes the process more administratively difficult.

In the future, it can be expected that these methods of transportation will continue to be used unless a radically new method of transportation is found. Therefore, most of the technologies in oil transportation methods are aimed at reducing emissions, increasing efficiency or preventing spills.

Spills and unintentional emissions are an important problem faced by oil transportation and storage methods. Tanker spills can pollute coastal environments, while as rail and pipeline spills can pollute wildlife habitats or settlements depending on the location. Gas leaks have the same harmful effects.

Recently, pipelines have caused a big public interest. The proposed pipeline projects, such as Keystone XL, were a central element of environmentalists because of their potential impact on the environment and as a symbol of the continued investment of society in energy infrastructure with intensive use of carbon.

At the moment, more than 2000 oil and gas fields have been discovered in Russia. Most of the oil and gas reserves are located in Western Siberia. Oil production in the Urals—Volga region and North of Russia is also developed. There are also potential oil deposits, the fields of which are at the initial stage of development in Eastern Siberia and the Russian Far East.

It is worth noting that the regions of the eastern part are focused on the exit to China and Japan. Oil delivery requires pipelines and relevant infrastructure. Respectively, oil transport needs to be developed, perfecting, automated.

The largest oil deposits in Russia are located in the central part. However, these oil deposits are far from potential consumers.

The elements of oil production, such as pipes, tanks, oil pumping stations, pumps, have already expired in many sections of the main oil pipelines. Most of the elements require modern automation and power supply systems.

The main oil pipelines have been built for many years and elements of different generations have been combined into a one scheme. Different elements of the same purpose reduce the reliability of pipelines.

Therefore, it is necessary to:

1. Create an application for automate parts of the transportation process [9-10] of manufacturing components such as gases and Newtonian and non-Newtonian liquids.
2. Take into account the need to have databases containing various information that is suitable for use in transportation of production fluids and gases.

To analyse the resulting pipeline system. Make a conclusion about possible emergency situations. Give the information about these situations (possible breaching (guillotine ruptures), pipeline cracks.

According to the objectives, it is necessary to implement:

- **Databases**
  It is necessary to store data on the characteristics of the transported substances, on the installations that allow the movement of the substance, on the materials used in the construction of the main oil pipelines.

  This task is implemented by Microsoft SQL Server. It is an open, flexible platform that allows to use a variety of programming languages and operating systems. Using SQL Server, it is possible to create your own application that can include advanced analytics. The platform enables to create applications with breakthrough scalability, high performance and availability in accordance with the safety, compliance and performance requirements.

- **Interface**
Thanks to the interface it is possible to enter data into the application, which is necessary for various calculations of the pipeline network. Data entry implies the presence of forms to fill in. They are the basic element of the application, so the Windows Forms GUI library is selected to implement the task. Appropriately, the application is created in C#.

In production, various substances, which have different properties and type of calculation, are transported by pipeline. It is necessary to divide substances into gases and liquids for ease of calculation. The liquids are divided into Newtonian and non-Newtonian according to the viscosity index.

Figure 1. “Menu” form.

A Windows Forms application is created. The first form is as a menu. Figure 1 presents three buttons, each of which re-route to a new form to calculate the selected substance and find the necessary installation for transportation via the main oil pipelines.

Figure 2. Implementing the transition between forms.

To correctly transform to the new form, it is necessary to write four lines (figure 2).

Figure 3. “Gas10” form (Data input form for the calculation of the pipeline network (gas)).

So that the user can return to the menu it is necessary to enter from the elements panel to the menuStrip form. The element is shown at the top of figure 3. It is possible to implement the transition
to the forms of the application periphery using this element. The function called on the button is similar to the previously considered function.

User must enter the corresponding values, signed by label elements, in the textBox that is fields of elements. A pictureBox with pictures of measures is located near for clarity.

Since the values entered into the fields are a line of string type, it is necessary to convert to a line of double type for which to use double.Parse() method. This means that the user should not be able to enter any symbol in the field. For this the “doubler” function (figure 5) is defined for KeyPress event (figure 4) in the properties of each textBox element.

![Figure 4. KeyPressEvent.](image)

```csharp
private void doubler(object sender, KeyPressEventArgs e)
{
    char ch = e.KeyChar;
    if (!Char.IsDigit(ch) && (Keys)ch != Keys.Back && ch != ',')
        e.Handled = true;
}
```

**Figure 5. “Doubler” function.**

It need to set the tabIndex value, which allows to switch between input elements by the Tab key, in the property of each textBox for the convenience of data input.

![Figure 6. Output of the results of solving the problem.](image)

```csharp
public double p1, p2, p3, v1, v2, v3, G;

private void Gas1_Load(object sender, EventArgs e)
{
    info.Text = "Compressor productivity = " + Math.Round(G);
    chart.Series[6].Points.AddXY(p1, v1);
    chart.Series[6].Points.AddXY(p2, v2);
    chart.Series[6].Points.AddXY(p3, v3);
}
```

**Figure 6. Output of the results of solving the problem.**

Figure 6 shows part of the code that displays compressor performance and adds three points, that are shown the pressure at the abscissa axis and corresponding gas volume at the ordinate axis, to the Chart element.

Databases are needed for pipeline materials, liquids and their characteristics. It is implemented by adding a SQL Server database to the project and creating the necessary tables.

The completed view of the first data entry form is shown in figure 7.
Figure 7. Data input form for pipeline network calculation (liquid).

The comboBox is one of the elements that were not paid attention. It allows to select one of the options that can take from the database via DataSet. So “Liquid” comboBox contains a column from the Ro table with the names of liquids. A “Material” comboBox contains a “Material” column from the "Assortment“ table, which stores the assortment of available pipelines. It should be noted that the "Assortment“ table stores records with duplicate names. Therefore, the “SELECT DISTINCT (Material) FROM dbo.Assortment” command is created for the "Assortment" table in the DataSet.

The user is able to edit database tables. To do this, it is necessary to transit to another form by pressing the corresponding button in the menuStrip element.

The calculation result is the selection of the pump and compressor taking into account the maximum period of trouble-free operation. The obtained results are the basis of the code for the expert control complex with controlled parameters of transport, both liquid and gas.

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