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STUDY ABOUT THE FLUID LOSSES IN THE BRANCHING PIPES

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Abstract: *This paper aims to determine the losses of branched pipe sections according to the ratio of flow areas, inclination of the adjacent pipe, and source flows ratio.*
This paper proposes a method for analyzing the dynamics of real fluid flow through pipe bends. The method can contribute to an optimal design of pipe networks. Along with linear load losses, local losses are particularly important for these piping systems, their analysis for determining coefficients of load losses being of prime importance. Besides the classical experimental attempts to study these tests we can try a method of theoretical analysis based on flow simulation, more accessible to different variants of the pipes. The variation of major structural and functional parameters of the flow is emphasized by the simulation of the flow. We can determine areas of hydraulic energy losses and can appreciate the value of the main flow parameters. Simulations were performed using Fluent 6.3 software and digital data were processed for obtaining graphs with Mathcad 14. Piping systems were represented with SolidWorks program. The Flow simulation allows an analysis of current lines, areas of turbulence and highlighting the hydrodynamic parameters of flow.

Key words: *fluid loss, dead flow, wavy flow, cross section, input/output flow.*

1. INTRODUCTION

Study of local losses in pipes is characterized by values of local loss coefficient and is usually determined by experimental tests. These losses are due to increased turbulence, vortex areas serviced by existing edges to change the direction of flow, the characteristic geometric construction, etc. [1 and 7].

To highlight the areas mentioned we use flow simulation software FLUENT 6.3, which predicts the flow parameters, especially the variation speed, static pressure, dynamic pressure and the Reynolds number. Analysis of these variations can be used to determine how the variation of local losses and hydraulic load influence the conditions required for pipe connections. For the cases presented in the paper, hydraulic minor loses coefficient values were well determined by experimental measurements, values that can be used for calculations in practical applications.

Our study aims to highlight through conducted simulations how the variation of hydrodynamic parameters and areas of turbulence or vortices maintained are leading to loss of hydraulic load. The research is part of a broader set of studies on minor loses in different cases of hydraulic pipe joints. Some simulations are performed for each case of the main modes of variation of flow parameters and it is shown how these changes influence the minor loss coefficients.

2. SUDDEN CONTRACTION

Most pipe systems consist of more than one straight circular pipes. Head loss information for essentially all components is given in dimensionless form and is based on experimental data [2 and 3].

The most common method used to determine these losses or pressure drops is to specify the loss coefficient ζ, which is defined as [1, 4, and 5]:

$$\zeta = \frac{\Delta p}{\rho \frac{v^2}{2}} \tag{1}$$

The pressure drop across a component that has a loss coefficient $\zeta = 1$ is equal to the dynamic pressure $\rho \frac{v^2}{2}$, where:

ζ = minor loss coefficient
p_{loss} = pressure loss, Pa or N/m^2,
ρ = fluid density, kg/m^3,
v = flow velocity, m/s,
h_{loss} = head loss, m,
g = acceleration of gravity (m/s^2).

The equation

$$h_{loss} = \frac{\Delta p}{\gamma} = \zeta \frac{v^2}{2g} \tag{2}$$

shows that for a given value of ζ the loss is proportional to the square of the velocity.

Figure 1 shows the variation between head loss and velocity, the square of the velocity [1 and 9].

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Any fluid may flow from a recipient into a pipe through any number of different shaped entrance regions as Fig. 2 shows.

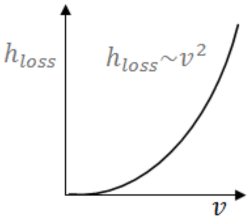
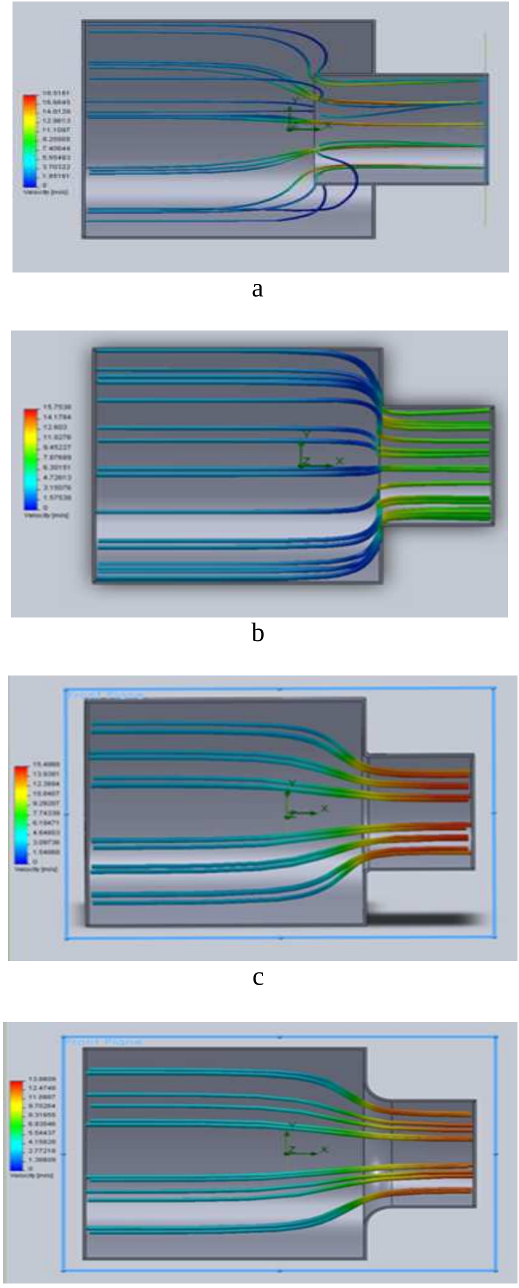


Fig. 1. The variation of the head loss vs. flow velocity.


a

b

c

d

Fig. 2. Loss coefficient for entrance flow conditions: *a* – inward projecting pipe, ζ = 0.8; *b* – square-edged inlet, ζ = 0.5; *c* – slightly rounded, ζ = 0.2; *d* – rounded inlet, ζ = 0.04.

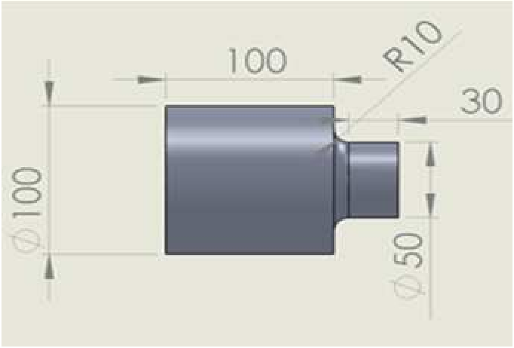


Fig. 3. SolidWorks representation for a branched pipe.

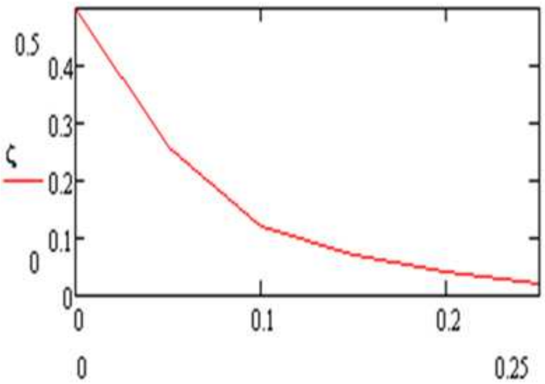


Fig. 4. Entrance loss coefficient ζ as a function of *a* for a sudden contraction.

When connecting pipes, minor loses occur depending on many constructive and functional factors.

The goal is how to change the combination of pipes with minor loss coefficient.

Figure 3 shows a branched pipe, a practical case for which it was determined the variation of the coefficient for minor loses for local radius of the tool point, where we noted with *a* the ratio between radius and diameter of the pipe output.

Figure 3 is achieved using Solid Works program, and Fig. 4 using Mathcad 14.0 program [8 and 10].

For the four cases presented in Fig. 2 simulations of the flow were carried out, which have revealed static and dynamic pressure variations, the flow velocity and Reynolds number characteristic.

Since the head loss rate is proportional to the square of the velocity, as shown in Fig. 1, we aimed to speed variation in the cases presented.

The observed variation in how different speeds can appreciate the minor loss for the four cases, decreasing losses due to local load factor which decreases from 0.8 to 0.04 for a diameter ratio range of 0.2, is presented in Fig. 5.

For a branched pipe as shown in Fig. 6a, the velocity is shown in Fig. 6b, variation in dynamic pressure in Fig. 6c, and static pressure along the flow are shown in Fig. 6d.

For an input speed of 3 m/s in both sections of the entry there is an increase of flow velocity up to 100% in the exit pipe with a turbulent central core with higher speed.

Dynamic pressure is proportional to the square of speed is a significant increase in the output.

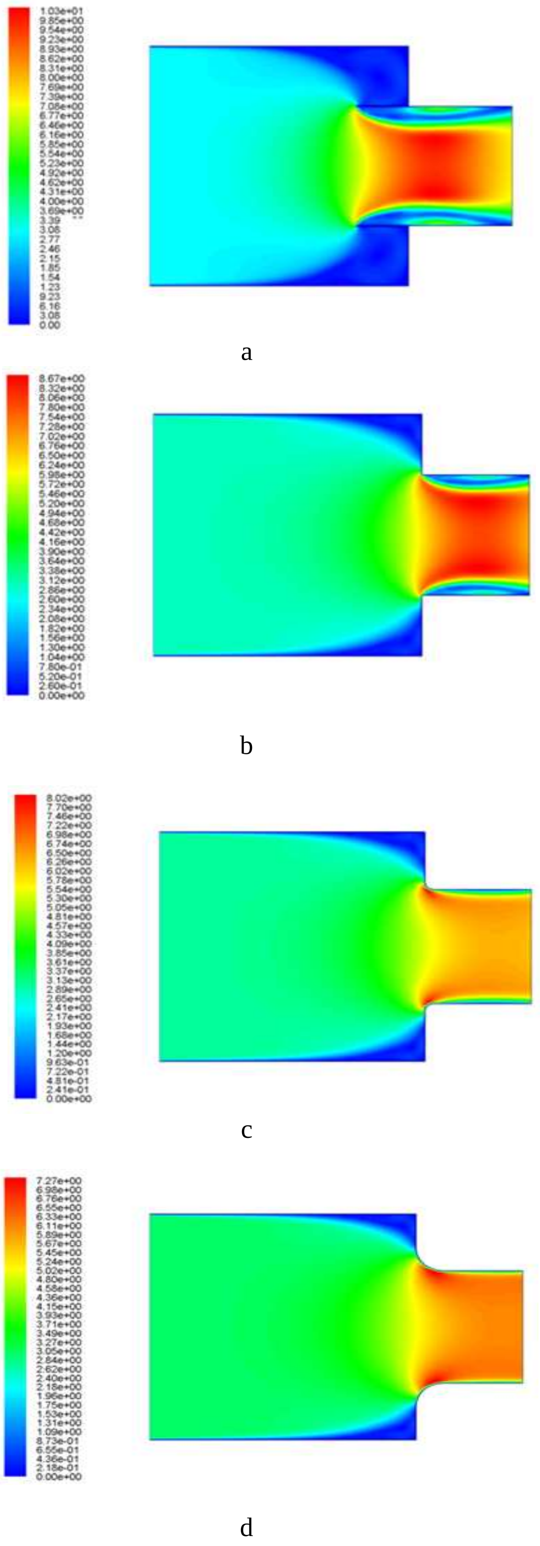


Fig. 5. Entrance flow conditions and variation in the flow velocity: *a* – $\zeta = 0.8$; *b* – $\zeta = 0.5$; *c* – $\zeta = 0.2$; *d* – $\zeta = 0.04$.

For static pressure it is a decrease of values along the flow, being offset by increased dynamic pressure.

3. SUDDEN EXPANSION

A head loss is produced when a fluid flows from a pipe into a tank or other recipients as is shown in Fig. 7.

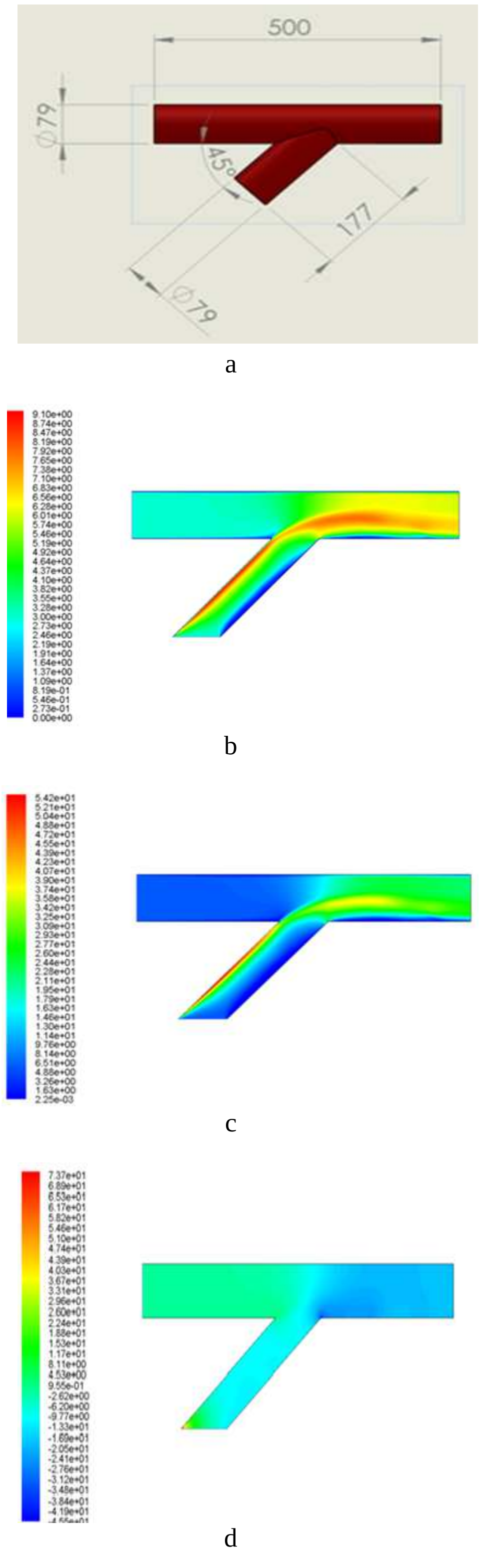
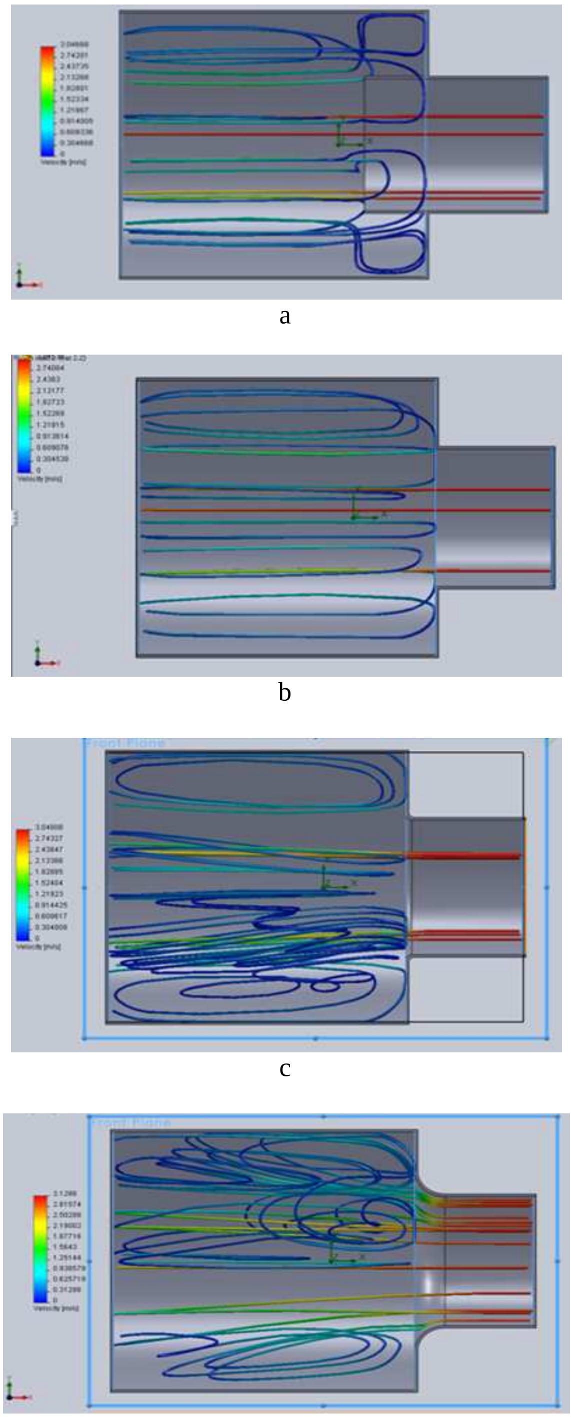


Fig. 6. Branched pipe: *a* – Solid Works representation; *b* – velocity; *c* – dynamic pressure; *d* – static pressure.

Local loss coefficient calculation load can be achieved using Borda-Carnot formula [1, 6, 7, and 8]:

$$\zeta = \left(\frac{A_2}{A_1} - 1\right)^2 \tag{3}$$

where A_2 is the section with large area and A_1 is the smaller section.


a

b

c

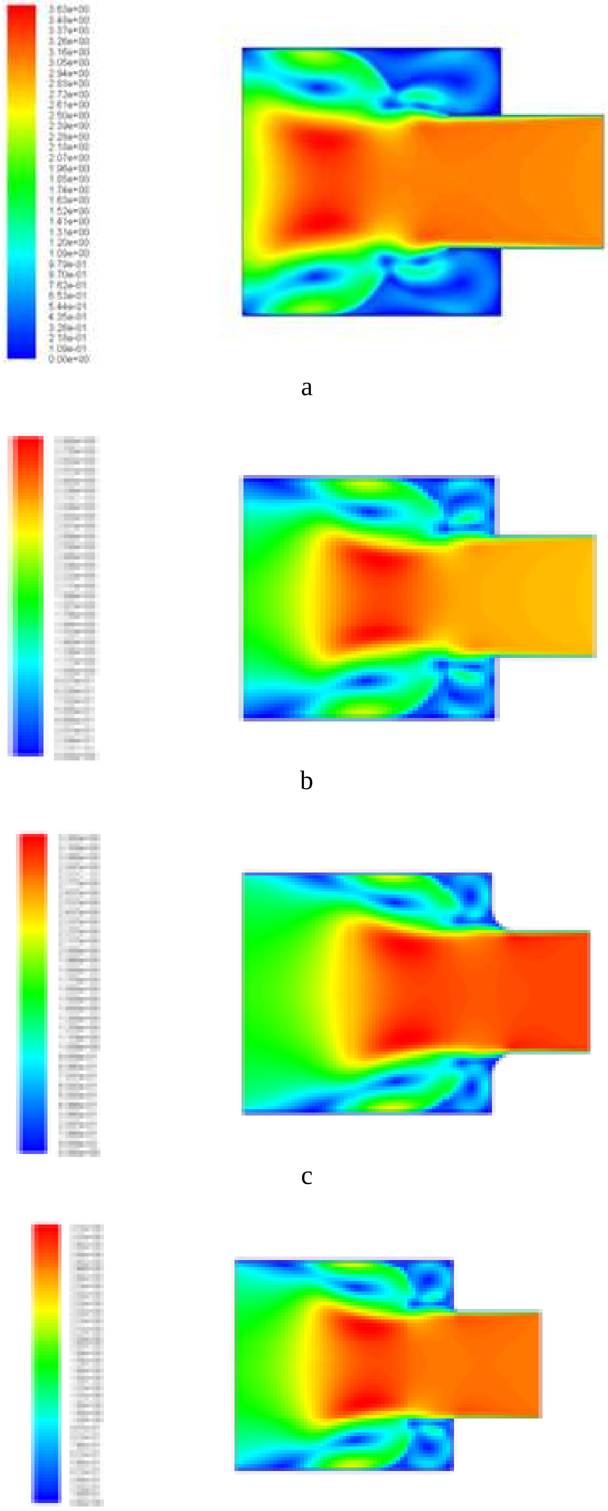
d

Fig. 7. Exit flow condition and loss coefficient: *a* – reentrant; *b* – sharp edge; *c* – slightly rounded; *d* – well rounded.

In Fig. 8 the velocity distributions are represented in Fluent 6.3 for the four cases presented in Fig. 7, the left side showìng a representation of the grid values of the color-flow rates.

For the pipe bends with a backward flow (Fig. 9) derived from the one shown in Fig. 6 (right to left) it is presented the simulation flow with the differences in static pressure (Fig. 9a), dynamic pressure (Fig. 9b), flow velocities (Fig. 9c), and flow Reynolds number (Fig. 9d).

It can be seen the important areas of pressure variations, high turbulence areas with significant loss of load and velocity with high values.


a

b

c

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Fig. 8. Exit flow conditions and variation in the flow velocity.

Analysis of each particular case allows us to observe that the simulated flow causes loss and hydrodynamic parameters calculation important to the variation of flow.

The analysis method proposed by this work does not exclude the experimental verifications for local loss coefficients determinations, but it highlights the plane image or three-dimensional images of the flow.

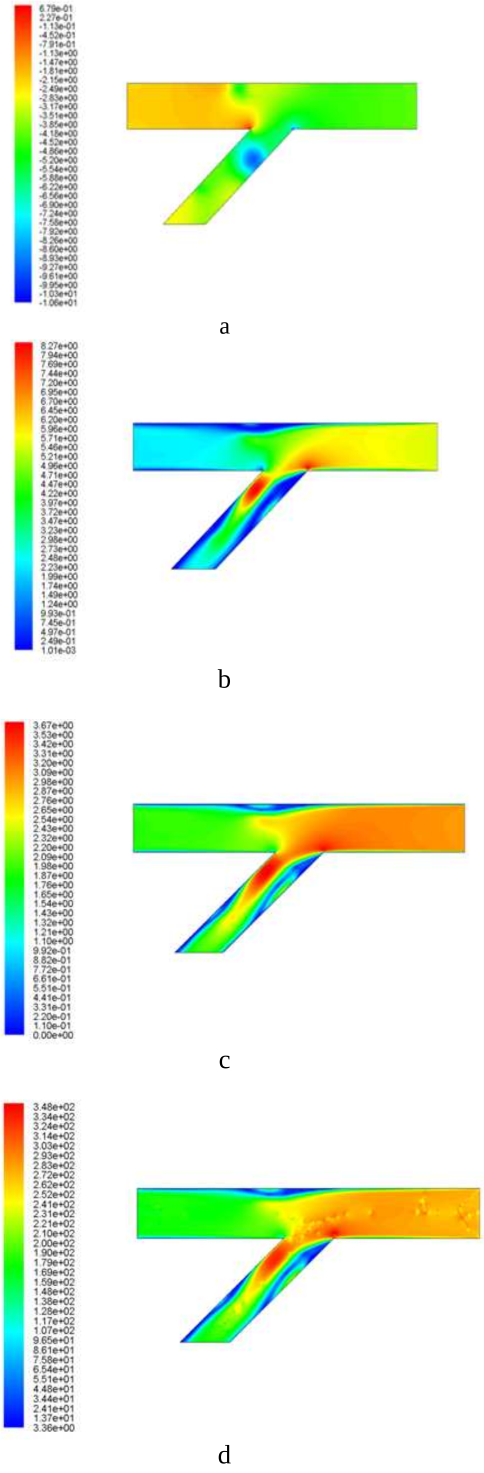

Fig. 9. Branched pipe: *a* – static pressure; *b* – dynamic pressure; *c* – velocity; *d* – reynolds number.

4. CONCLUSIONS

Simulations highlight the achieved values flow rates for different areas of study including field joints of pipes and square according to the speed variation to study the energy loss.

This theoretical method for analyzing the dynamic behaviour of fluids in different cases of branch pipes are completed by experimental methods for determining coefficients of load losses or hydraulic flow coefficients.

Besides the linear energy losses that take into account the dynamic viscosity, kinematic viscosity and density, Reynolds number, relative roughness of the walls and the dimensions, the local losses that are proportional to the square of speed take into account the structural characteristics that cause turbulence, the vortices and thus energy losses.

The visualization of power lines using computer programs, shows the variation of the main hydrodynamic parameters and can give us information on about local appearance and maintenance of the minor loss.

Correlation of hydrodynamic parameters such as static pressure, dynamic pressure, total pressure and flow Reynolds number allows punctual analysis of a case of pipe joints that occurs in an application.

Experimental methods can sometimes be difficult or impractical, that alternative methods using flow simulation are particularly welcome, with completion of the experimental results for verifying through surveys for corrections. This method allows a rapid analysis of flow with clear views on many hydrodynamic parameters and enables optimum performance of the various sections of pipe [11].

The working method proposed in this paper allows optimizing designed equipment hydrodynamics and effective behavior analysis of existing work in different systems.

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