

ABSTRAK

ANALISIS PENGARUH KEKASARAN PERMUKAAN PIPA TERHADAP *MAYOR LOSSES* MENGGUNAKAN METODE SIMULASI CFD

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Sistem perpipaan merupakan salah satu komponen penting dalam proses distribusi fluida yang banyak digunakan pada sektor industri maupun domestik. Salah satu faktor yang memengaruhi efisiensi sistem perpipaan adalah kehilangan energi akibat gesekan fluida dengan dinding pipa (*major losses*). Besarnya *major losses* dipengaruhi oleh beberapa parameter, salah satunya adalah tingkat kekasaran permukaan pipa. Penelitian ini bertujuan untuk menganalisis pengaruh variasi kekasaran permukaan pipa terhadap *major losses* menggunakan metode *Computational Fluid Dynamics* (CFD) serta membandingkan hasil simulasi dengan perhitungan teoritis. Penelitian dilakukan secara numerik menggunakan perangkat lunak ANSYS Fluent 2021 R2 dengan model pipa lurus horizontal sepanjang 10 m dan diameter $\frac{3}{4}$ inch (19,05 mm). Fluida yang digunakan adalah air pada suhu ruang dengan debit 30 L/menit. Variasi kekasaran permukaan direpresentasikan oleh tiga jenis material pipa, yaitu *Polyvinyl Chloride* (PVC), *Polypropylene Random Copolymer* (PPR), dan *stainless steel*. Parameter yang dianalisis meliputi *pressure drop*, *major losses*, distribusi tekanan, distribusi kecepatan, serta *wall shear stress*. Nilai *major losses* teoritis dihitung menggunakan persamaan Darcy-Weisbach, kemudian dibandingkan dengan hasil simulasi CFD. Hasil penelitian menunjukkan bahwa variasi kekasaran permukaan pipa memberikan pengaruh terhadap nilai *pressure drop* dan *major losses*. Hasil simulasi CFD menghasilkan nilai *pressure drop* sebesar 19.451 Pa pada pipa PVC, 19.540 Pa pada pipa PPR, dan 19.538 Pa pada pipa stainless steel. Nilai *major losses* teoritis diperoleh sebesar 1,82 m, sedangkan hasil simulasi CFD masing-masing sebesar 1,988 m untuk PVC, 1,996 m untuk PPR, dan 1,996 m untuk stainless steel. Perbandingan antara hasil teoritis dan simulasi menunjukkan persentase kesalahan kurang dari 10%, sehingga metode CFD dinilai mampu merepresentasikan karakteristik aliran fluida dengan baik. Perbedaan hasil antar pipa relatif kecil karena ketiga nya memiliki nilai kekasaran permukaan yang masih berada pada rentang rendah

Kata kunci: *Computational Fluid Dynamics (CFD)*, kekasaran permukaan pipa, *major losses*, *pressure drop*, *wall shear stress*.

ABSTRACT

ANALYSIS OF THE EFFECT OF PIPE SURFACE ROUGHNESS ON MAYOR LOSSES USING COMPUTATIONAL FLUID DYNAMICS (CFD) SIMULATION

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Pipeline systems are essential components in fluid distribution processes widely used in industrial and domestic applications. One of the factors affecting the efficiency of a pipeline system is energy loss caused by friction between the flowing fluid and the inner pipe wall, known as *mayor losses*. The magnitude of *mayor losses* is influenced by several parameters, one of which is the surface roughness of the pipe. This study aims to analyze the effect of pipe surface roughness on *mayor losses* using the *Computational Fluid Dynamics* (CFD) method and to compare the simulation results with theoretical calculations. This research was conducted numerically using ANSYS Fluent 2021 R2. The simulation model consisted of a horizontal straight pipe with a length of 10 m and a diameter of $\frac{3}{4}$ inch (19.05 mm). Water at room temperature was used as the working fluid with a flow rate of 30 L/min. Variations in surface roughness were represented by three pipe materials: Polyvinyl Chloride (PVC), Polypropylene Random Copolymer (PPR), and stainless steel. The analyzed parameters included *pressure drop*, *mayor losses*, pressure distribution, velocity distribution, and wall shear stress. The theoretical value of *mayor losses* was calculated using the Darcy–Weisbach equation and compared with the CFD simulation results. The results indicate that variations in pipe surface roughness affect both *pressure drop* and *mayor losses*. The CFD simulation produced *pressure drop* values of 19,451 Pa for the PVC pipe, 19,540 Pa for the PPR pipe, and 19,538 Pa for the stainless steel pipe. The theoretical *mayor losses* value was 1.82 m, while the CFD simulation produced values of 1.988 m for PVC, 1.996 m for PPR, and 1.996 m for stainless steel. The comparison between the theoretical calculations and CFD results showed an error percentage of less than 10%, indicating that the CFD method is capable of accurately representing the fluid flow characteristics. The differences among the three pipe were relatively small because they have low surface roughness values, resulting in similar flow resistance characteristics.

Keywords: *Computational Fluid Dynamics (CFD), pipe surface roughness, mayor losses, pressure drop, Wall shear stress.*