INTISARI

Penelitian ini bertujuan untuk menganalisis distribusi aliran dan mengevaluasi tingkat erosi dinding pipa pada sistem perpipaan *quench gas*. Fokus penelitian adalah untuk memahami karakteristik aliran fluida, mengidentifikasi zona rawan erosi, serta menilai dampaknya terhadap umur pakai sistem perpipaan, yang memiliki peran penting dalam perancangan dan keandalan sistem manufaktur perpipaan pada industri minyak dan gas.

Metode penelitian menggunakan pendekatan *Computational Fluid Dynamics* (CFD) dengan penerapan *Discrete Phase Model* (DPM) yang dikombinasikan dengan *Generic Erosion Model*. Studi dilakukan pada dua konfigurasi jalur pipa (*Train A dan Train B*) dengan variasi laju aliran massa (100%, 40%, 30%) dan fraksi uap (1,00; 0,95; 0,90; 0,85). Partikel padat yang diinjeksi berupa *iron sulfide* dan *magnetic oxide* dengan distribusi ukuran mengikuti fungsi *Rosin–Rammler*.

Hasil simulasi menunjukkan bahwa kecepatan maksimum aliran pada Train A dan Train B masing-masing sebesar 97,5 m/s dan 97,0 m/s, masih berada di bawah batas erosi API RP 14E sebesar 116,15 m/s. Laju erosi maksimum tercatat 1,05 mm/tahun untuk Train A dan 0,91 mm/tahun untuk Train B pada kondisi fraksi uap 0,85, dengan zona kritis teridentifikasi pada *elbow* dan *venturi throat*. Evaluasi umur pakai menunjukkan bahwa pada kondisi fraksi uap rendah, umur pakai pipa menurun signifikan hingga di bawah 25 tahun. Oleh karena itu, diperlukan strategi mitigasi berupa pengendalian fraksi uap >95%, pengurangan laju aliran massa ≤40%, serta pemilihan material dengan ketahanan erosi tinggi pada area kritis.

Kata Kunci: Manufaktur Perpipaan, Analisis Distribusi Aliran, *Computational Fluid Dynamics* (CFD), *Discrete Phase Model* (DPM), Generic Erosion Model, Erosi, Fraksi Uap, Jalur Quench Gas.

ABSTRACT

This study aims to analyze the flow distribution in quench gas piping and to evaluate pipe wall erosion using Computational Fluid Dynamics (CFD). The focus of the research is to understand the characteristics of fluid flow, identify erosion-prone zones, and assess their impact on the service life of piping systems, which is essential for the design and reliability of industrial piping manufacturing.

The methodology employs the Discrete Phase Model (DPM) with a generic erosion model. The study was conducted on two pipeline configurations (Train A and Train B) by varying mass flow rates (100%, 40%, 30%) and vapor fractions (1.00; 0.95; 0.90; 0.85). Solid particles injected into the flow include iron sulfide and magnetic oxide, with particle size distribution represented by the Rosin-Rammler function.

Simulation results indicate that the maximum flow velocities in Train A and Train B reached 97.5 m/s and 97.0 m/s, respectively, remaining below the API RP 14E erosion velocity limit of 116.15 m/s. The maximum erosion rates were found to be 1.05 mm/year (Train A) and 0.91 mm/year (Train B) at low vapor fraction conditions (0.85). Critical erosion zones were identified at the 90° elbow and the venturi throat, which are prone to accelerated material degradation. The remaining life evaluation reveals that under low vapor fraction conditions, the service life of the piping system may decrease to less than 25 years. Therefore, mitigation strategies are required, including maintaining vapor fractions above 95%, reducing mass flow rates below 40%, selecting erosion-resistant materials, and implementing periodic maintenance based on lifetime prediction to ensure long-term reliability of the piping system.

Keywords: *Pipeline Manufacturing, Flow Distribution Analysis, Computational Fluid Dynamics (CFD), Discrete Phase Model (DPM), Generic Erosion Model, Erosion, Vapor Fraction, Quench Gas Pipeline.*