

**ANALISIS PERFORMA MODEL STRUKTUR KONTROL PROSES
TENNESSEE EASTMAN PADA KONDISI SERANGAN INTEGRITAS
DAN DENIAL OF SERVICE**

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INTISARI

Transformasi industri 4.0 meningkatkan efisiensi operasional melalui integrasi sistem fisik dan digital, namun juga membuka celah serangan siber. *Cyber-physical attacks* (CPA) seperti serangan *denial of service* (DoS) dan serangan integritas berpotensi mengganggu kestabilan sistem kontrol industri. Proses Tennessee Eastman (TE) memiliki dua model struktur kontrol, Ricker dan Skogestad, namun belum diketahui model mana yang lebih tahan terhadap serangan siber. Oleh karena itu, diperlukan analisis perbandingan performa kedua sistem dalam menghadapi serangan siber.

Penelitian ini melakukan simulasi proses TE ketika mengalami serangan siber. Analisis dilakukan berdasarkan indikator performa proses, yaitu laju produksi, kualitas produk, dan biaya operasional. Model dengan galat lebih rendah pada laju produksi dan kualitas produk, serta kerugian biaya operasional yang lebih rendah, menunjukkan model yang memiliki performa lebih baik dalam menghadapi serangan.

Hasil penelitian menunjukkan model struktur kontrol Skogestad lebih unggul dalam menjaga kualitas dan efisiensi biaya. Sementara itu, model Ricker lebih baik dalam mempertahankan laju produksi, dengan galat 0,083480 m³/h (integritas) dan 0,120985 m³/h (DoS), dibandingkan Skogestad sebesar 0,099932 m³/h dan 0,133488. Skogestad mencatat galat kualitas produk lebih rendah, yaitu 0,481716 %mol dan 0,379491 %mol, dibandingkan Ricker yang mencapai 0,563486 %mol dan 0,520288 %mol. Dari sisi biaya, kerugian operasional Ricker lebih tinggi, yakni \$4.138,55 dan \$6.492,36, sedangkan Skogestad hanya \$2.184,09 dan \$2.192,42.

Kata kunci: Tennessee Eastman, struktur kontrol, *Denial of Service*, integritas

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PERFORMANCE ANALYSIS OF CONTROL STRUCTURE MODELS IN THE TENNESSEE EASTMAN PROCESS UNDER INTEGRITY ATTACK AND DENIAL OF SERVICE

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ABSTRACT

Industry 4.0 transformation enhances operational efficiency through the integration of physical and digital systems but also opens up vulnerabilities to cyberattacks. Cyber-physical attacks (CPA) such as denial of service (DoS) attacks and integrity attacks have the potential to disrupt the stability of industrial control systems. The Tennessee Eastman (TE) process has two control structure models, Ricker and Skogestad, but it is not yet clear which model is more resilient to cyberattacks. Therefore, a comparative performance analysis of both systems under cyberattack scenarios is needed.

This research simulates the TE process when subjected to cyberattacks. The analysis is based on performance indicators, including production rate, product quality, and operational costs. The model with lower errors in production rate and product quality, along with lower operational cost losses, is considered to have better performance in dealing with cyberattacks.

The results of the study show that the Skogestad control structure model outperforms in maintaining product quality and cost efficiency. Meanwhile, the Ricker model performs better in maintaining production rate, with errors of 0.083480 m³/h (integrity) and 0.120985 m³/h (DoS), compared to Skogestad's 0.099932 m³/h and 0.133488 m³/h. Skogestad recorded lower product quality errors, with values of 0.481716 %mol and 0.379491 %mol, compared to Ricker's 0.563486 %mol and 0.520288 %mol. In terms of costs, Ricker's operational losses were higher, at \$4138.55 and \$6492.36, while Skogestad's losses were only \$2184.09 and \$2192.42.

Keywords: Tennessee Eastman, control structure, Denial of Service, Integrity

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