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Perancangan Machine Guard untuk Meminimalkan Risiko Kecelakaan Kerja pada Hopper Mixing Machine
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

INTISARI

Industri manufaktur ban menggunakan *hopper mixing machine* sebagai peralatan utama dalam proses pencampuran bahan baku menjadi *compound*. Kondisi eksisting pada area *conveyor* intro hingga *hopper* masih memiliki akses terbuka yang memaparkan operator pada bahaya mekanis, seperti *pinch point*, *entanglement*, risiko terjatuh ke dalam *hopper*, dan *crushing*. Kondisi ini belum memenuhi prinsip keselamatan mesin sesuai standar internasional sehingga diperlukan solusi rekayasa berupa *safety guard*. Penelitian ini bertujuan merancang *safety guard* tipe "*lion cage*" pada area *hopper* mesin *mixing* sebagai upaya pengendalian risiko kecelakaan kerja, serta mengevaluasi pengaruhnya terhadap kondisi ergonomi kerja operator. Metode penelitian yang digunakan adalah metode pengembangan *(design and development method)*, meliputi identifikasi masalah, *risk assessment* awal, pemodelan CAD, hingga evaluasi desain melalui analisis *safety distance, Finite Element Analysis* (FEA), analisis ergonomi menggunakan metode *Rapid Upper Limb Assessment* (RULA), dan *risk assessment* akhir. Hasil perancangan berupa *safety guard* berbahan baja struktural SS400 yang dilengkapi *access door* dengan mekanisme gas spring serta sistem interlock sebagai *fail-safe system*. Hasil analisis menunjukkan bahwa rancangan telah memenuhi persyaratan *safety distance* sesuai ISO 13857:2019, memiliki kekuatan struktur yang aman berdasarkan hasil FEA, serta tidak menimbulkan beban postur kerja tambahan yang signifikan bagi operator berdasarkan hasil RULA. Hasil *risk assessment* menunjukkan bahwa seluruh potensi bahaya yang teridentifikasi berhasil diturunkan tingkat risikonya dari kategori tinggi menjadi rendah setelah penerapan *safety guard*. Dengan demikian, rancangan *safety guard* yang dikembangkan terbukti efektif meningkatkan keselamatan kerja tanpa mengurangi kenyamanan ergonomi maupun efisiensi operasional mesin.

Kata Kunci: *safety guard, machine safety, hopper mixing machine, risk assessment, Finite Element Analysis*, ergonomi, RULA

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ABSTRACT

The tire manufacturing industry relies on hopper mixing machines as the primary equipment for compounding raw materials. The existing condition of the conveyor intro area leading to the hopper remains openly accessible, exposing operators to mechanical hazards such as pinch points, entanglement, the risk of falling into the hopper, and crushing. This condition does not yet comply with international machine safety standards, thus requiring an engineering solution in the form of a safety guard. This study aims to design a "lion cage" type safety guard on the hopper mixing machine as a risk control measure for workplace accidents, and to evaluate its influence on operator work ergonomics. The research applied a design and development method, comprising problem identification, initial risk assessment, CAD modeling, and design evaluation through safety distance analysis, Finite Element Analysis (FEA), ergonomic analysis using the Rapid Upper Limb Assessment (RULA) method, and a final risk assessment. The resulting design is a safety guard constructed from SS400 structural steel, equipped with an access door mechanism assisted by a gas spring and an interlock system functioning as a fail-safe mechanism. The analysis results show that the design satisfies the safety distance requirements of ISO 13857:2019, possesses adequate structural strength based on FEA results, and does not impose significant additional postural strain on the operator based on the RULA assessment. The risk assessment results indicate that all identified hazards were successfully reduced from a high to a low risk level following the implementation of the safety guard. These findings confirm that the developed safety guard design effectively improves workplace safety without compromising operator ergonomic comfort or the operational efficiency of the machine.

Keywords: safety guard, machine safety, hopper mixing machine, risk assessment, Finite Element Analysis, ergonomics, RULA