

## ABSTRAK

*Controlled Release Fertilizer* Ammonium Sulfat (CRF ZA) merupakan pupuk kimia ZA yang dimodifikasi dengan penambahan lapisan inhibitor untuk mengatur pelepasan nutrisi yang akan diserap oleh tanaman. Penambahan lapisan inhibitor ini dapat mengurangi frekuensi pemupukan tanaman dan mencegah terjadinya eutrofikasi, pencemaran air dan emisi gas rumah kaca akibat pemupukan berlebih. Sebagai negara pengimpor CRF ZA tertinggi dengan jumlah impor sebesar 2.279 ton/tahun, perancangan pabrik CRF ZA ini merupakan upaya untuk mempertahankan kemandirian pangan nasional. Pabrik CRF ZA dirancang untuk didirikan pada tanah seluas 12,45 ha di daerah Maduran, Roomo, Kecamatan Manyar, Kabupaten Gresik, Provinsi Jawa Timur. Pemilihan lokasi didasarkan pada pertimbangan kemudahan akses bahan baku dan pasar CRF ZA berupa perkebunan tebu.

Produksi CRF ZA terdiri dari 3 proses utama, yakni sintesis ammonium sulfat, granulasi, serta proses *coating* ammonium sulfat dengan menggunakan polimer berupa poliuretan. Bahan baku produksi terdiri dari ammonia sebanyak 52.455,9490 ton/tahun dan asam sulfat sebanyak 153.310,7918 ton/tahun serta etilen glikol sebanyak 1.856,4497 ton/tahun dan *methylene diphenyl isocyanate* (MDI) sebanyak 30.086,6416 ton/tahun sebagai bahan baku proses *coating*. Sintesis pupuk ZA dilakukan menggunakan metode *direct neutralization* di dalam *bubble reactor* yang beroperasi pada suhu 105°C dan tekanan atmosferis. Hasil produk berupa *slurry* kemudian dikeringkan pada *rotary dryer* hingga mencapai kadar air 0,70 % sebelum digranulasi dengan bantuan *binder* berupa aluminium sulfat untuk mencapai ukuran padatan 2 mm. Pupuk ZA hasil granulasi akan dilapisi dengan poliuretan melalui reaksi polimerisasi antara etilen glikol dan MDI di dalam *coating drum* yang beroperasi pada suhu 90°C.

Proses produksi CRF ZA membutuhkan bahan baku pendukung berupa air baku yang diperoleh dari Teluk Lamong sebanyak 614,5659 ton/jam dan Sungai Bengawan Solo sebanyak 11,8384 ton/jam. Selain itu, dibutuhkan juga udara proses sebanyak 14.835.472,7364 m<sup>3</sup>/jam dan udara instrumen sebanyak 2.085,0064 m<sup>3</sup>/jam serta gas alam sebagai bahan bakar *boiler* sebanyak 330 ton/jam. Kebutuhan listrik pabrik diperoleh dari Perusahaan Listrik Negara (PLN) sebesar 2.516,3277 kW.

Dari sisi struktural, pabrik CRF ZA berbentuk perseroan terbatas dengan struktur organisasi fungsional. Total pekerja yang dibutuhkan ialah 309 orang dengan masa kerja selama 330 hari dalam 1 tahun. Dalam operasinya, pabrik CRF ZA menerapkan standar *process safety information* dan *environmental management system* berdasarkan ISO 14001.

Berdasarkan hasil evaluasi ekonomi, pupuk CRF ZA yang diproduksi dijual dengan harga Rp 22.500,00 kg. Dengan mempertimbangkan kematangan teknologi produksi dan pasar pupuk CRF ZA, pabrik ini tergolong industri berisiko tinggi dengan nilai POT sebelum pajak sebesar 1,74 tahun, POT setelah pajak sebesar 2,49 tahun, ROI sebelum pajak sebesar 44,13%, ROI setelah pajak sebesar 28,69%, BEP sebesar 38,71%, SDP sebesar 21,38%, dan DCFRR sebesar 25,74%. Berdasarkan nilai – nilai parameter keuntungan tersebut, pabrik ini menarik dari segi ekonomi dan layak untuk dikaji lebih lanjut.

Kata kunci: *controlled release fertilizer* ZA, amonia, asam sulfat, poliuretan

## ABSTRACT

Controlled Release Fertilizer Ammonium Sulfate (CRF ZA) is a modified form of ZA chemical fertilizer that incorporates an inhibitor layer to regulate the controlled release of nutrients for plant absorption. This addition of an inhibitor layer offers several benefits, including reducing the frequency of crop fertilization and mitigating the risks of eutrophication, water pollution, and greenhouse gas emissions caused by excessive fertilization. As the primary importer of CRF ZA, with an annual import volume of 2,279 tons, the establishment of a CRF ZA plant is a strategic effort to maintain national food independence. The proposed plant is intended to be situated on a 12.45 ha land in the Maduran area, Roomo, Manyar District, Gresik Regency, East Java Province. The selection of this location is based on considerations such as easy access to raw materials and a readily available market in the form of sugarcane plantations.

The production of CRF ZA involves three main processes: ammonium sulfate synthesis, granulation, and ammonium sulfate coating using polyurethane polymers. The required raw materials for production include 52,455.9490 tons/year of ammonia, 153,310.7918 tons/year of sulfuric acid, 1,856.4497 tons/year of ethylene glycol, and 30,086.6416 tons/year of methylene diphenyl isocyanate (MDI) for the coating process. The synthesis of ZA fertilizer is carried out through the direct neutralization method in a bubble reactor operating at 105°C and atmospheric pressure. The resulting slurry product is subsequently dried using a rotary dryer until it reaches a moisture content of 0.70% before being granulated to a solid size of 2 mm with the aid of aluminum sulfate as a binder. The granulated ZA fertilizer is then coated with polyurethane through a polymerization reaction between ethylene glycol and MDI in a coating drum operating at 90°C.

The CRF ZA production process requires additional raw materials, including 614.5659 tons/hour of raw water from Lamong Bay and 11.8384 tons/hour from the Bengawan Solo River. Additionally, 14,835,472.7364 m<sup>3</sup>/hour of process air, 2,085.0064 m<sup>3</sup>/hour of instrument air, and 330 tons/hour of natural gas as a boiler fuel are necessary. The plant's electricity demand is obtained from the Perusahaan Listrik Negara (PLN) in amounts of 2,516.3277 kW.

Structurally, the CRF ZA plant is established as a limited liability company with a functional organizational structure. The plant requires a total workforce of 309 individuals, operating for 330 days per year. In terms of operation, the CRF ZA plant adheres to process safety information and environmental management system standards based on ISO 14001.

Based on the economic evaluation conducted, the CRF ZA fertilizer is projected to be sold at a price of IDR 22,500.00 per kilogram. Considering the maturity of production technology and the existing market demand for CRF ZA fertilizer, this plant falls into the high-risk industry category, with a pre-tax payback period of 1.74 years, an after-tax payback period of 2.49 years, a pre-tax return on investment (ROI) of 44.13%, an after-tax ROI of 28.69%, a breakeven point (BEP) of 38.71%, a discounted cash flow rate of return (DCFRR) of 25.74%, and a shutdown point (SDP) of 21.38%. These profit parameters indicate that the plant is economically viable and warrants further study.

**Keywords:** controlled release fertilizer ZA, ammonia, sulfuric acid, polyurethane