



Dewasa ini, perkembangan teknologi dibidang otomotif di dunia termasuk Indonesia membuat peralihan kendaraan bermotor yang menggunakan bahan bakar minyak berganti menjadi tenaga listrik (*Electric Vehicles*). Berdasarkan analisis perkembangan otomotif dan kebijakan pemerintah terhadap kendaraan listrik di Indonesia, diprediksi mulai tahun 2035 setidaknya akan terkumpul 200.000 ton pertahun limbah baterai Litium berjenis NMC (*Nickel-Mangannese-Cobalt*). Oleh karena itu perlu diperlukan pendirian industri pengolahan limbah baterai sehingga dapat diolah dan digunakan kembali menjadi bahan pembuat baterai. Pabrik pengolahan *blackmass* baterai berjenis NMC menggunakan proses *leaching*, presipitasi, dan kristalisasi evaporatif. Logam yang mengalami reaksi *leaching* dengan Asam Sulfat dan Hidrogen Peroksida akan membentuk logam sulfat dan dipisahkan menggunakan presipitasi bertingkat dengan NaOH hingga membentuk *Mixed Hydroxide Precipitates* (MHP) dan Persenyawaan Litium. Persenyawaan litium akan membentuk litium karbonat sedangkan MHP akan diproses lebih lanjut dengan *ammoniacal leaching* untuk membentuk senyawa nikel dan kobalt. Hasil dari *ammoniacal leaching* akan dimurnikan masing-masing dengan presipitasi dan *leaching*. Pada tahap terakhir, nikel sulfat dan kobalt sulfat dibentuk dalam nikel sulfat heksahidrat dan cobalt sulfat heptahidrat sebagai produk akhir.

Proses pengolahan *blackmass* baterai NMC sebanyak 20.000 ton pertahun (330 hari, 24 jam), setidaknya membutuhkan bahan baku H_2SO_4 98% sebanyak 45.312 MT/tahun, H_2O_2 30% 12.163 MT/tahun, NaOH pellets 12.525 MT/tahun, Na_2CO_3 99% 14.875 MT/tahun, NH_4OH 7945 MT/tahun, $(\text{NH}_4)_2\text{SO}_4$ 1.972 MT/tahun. Selain itu juga dibutuhkan bahan-bahan penunjang utama seperti *make-up water* sebanyak 7161,35 m³/hari, 4.391 kg/jam, 15,5 MMBTU/jam batubara, serta listrik sebesar 32,47 MW. Sebagian proses yang bersifat eksotermis juga memerlukan air pendingin. Kebutuhan pendingin total adalah sebanyak 100,1 m³/jam. Akhir dari pengolahan pabrik ini akan dihasilkan precipitat logam sebagai produk utama yaitu 310,3 kg/jam Litium Karbonat 96,4%, 562,21 kg/jam Kobalt Sulfat Heptahidrat, 1158,3 kg/jam Nikel Sulfat Heksahidrat, dan 249,09 kg/jam grafit. Selain itu juga dihasilkan produk samping berupa 5826,46 kg/jam Natrium Sulfat 99%, 249,0933 kg/jam crude Besi (II) Hidroksida – Alumunium Hidroksida, 124,54 kg/jam crude Tembaga (II) Hidroksida dan Mangan (II) Hidroksida. Pabrik ini dirancang untuk berdiri di tanah dengan luas 250 ha dengan luas bangunannya sebesar 100 ha. Modal untuk berdirinya pabrik berupa modal tetap sebesar US\$ 38.330.096,03 dan Rp 116.143.697.491,39 sedangkan modal beroperasinya pabrik berupa working capital adalah sebesar US\$6.560.554,40 dan Rp225.942.426.755,18. Berdasarkan analisis ekonomi yang di perhitungkan akan menghasilkan *profit* bersih sebesar US\$18.285.437,52/tahun, dengan parameter ROI dan POT sebelum pajak sebesar 40,83% dan 2,02 tahun. Selain itu didapatkan juga nilai BEP dan SDP sebesar 40,88% dan 23,41%, serta nilai DCFRR sebesar 24,38%. Berdasarkan penilaian parameter-parameter kelayakan ekonomi, pabrik pengolahan limbah *blackmass* baterai yang dirancang ini menarik untuk didirikan.

iv

ABSTRACT

Nowadays, the development of technology in the automotive sector in the world including Indonesia has made the transition of motor vehicles that use fuel oil to electric power (Electric Vehicles). Based on the analysis of automotive developments and government policies on electric vehicles in Indonesia, it is predicted that starting in 2035 at least 200,000 tons of NMC (Nickel-Manganese-Cobalt) Lithium battery waste will be collected per year. Therefore, it is necessary to establish a battery waste processing industry so that it can be processed and reused as a battery making material. The NMC type battery blackmass waste processing plant uses leaching, precipitation, and evaporative crystallization processes. The metal that undergoes a leaching reaction with Sulfuric Acid and Hydrogen Peroxide will form metal sulphate and is separated using multilevel precipitation with NaOH to form Mixed Hydroxide Precipitates (MHP) and Lithium Compounds. Lithium compounds will form lithium carbonate while MHP will be further processed with ammoniacal leaching to form nickel and cobalt compounds. The results of ammoniacal leaching will be purified by precipitation and leaching respectively. In the final stage, nickel sulphate and cobalt sulphate are formed into nickel sulphate hexahydrate and cobalt sulphate heptahydrate as the final products.

The NMC battery blackmass waste processing process of 20,000 tons per year (330 days, 24 hours), at least requires raw materials of 98% H_2SO_4 of 45,312 MT/year, 30% H_2O_2 12,163 MT/year, NaOH pellets 12,525 MT/year, 99% Na_2CO_3 14,875 MT/year, NH_4OH 7945 MT/year, $(\text{NH}_4)_2\text{SO}_4$ 1,972 MT/year. In addition, the main supporting materials are also needed such as make-up water as much as 7161.35 m^3 /day, 4,391 kg/hour, 15.5 MMBTU/hour coal, and electricity of 32,47 MW. Some exothermic processes also require cooling water. The total cooling requirement is as much as 100,1 m^3 /hour. The end of the processing of this plant will produce metal precipitates as the main product, namely 310,3 kg/hour of Lithium Carbonate 96,4%, 562,21 kg/hour Cobalt Sulphate Heptahydrate, 1158,3 kg/hour Nickel Sulphate Hexahydrate, and 249,09 kg/hour graphite. In addition, by-products are also produced in the form of 5826,46 kg/hour of 99% Sodium Sulphate, 249,0933 kg/hour of crude Iron (II) Hydroxide - Aluminum Hydroxide, 124,54 kg/hour of crude Copper (II) Hydroxide and Manganese (II) Hydroxide. The plant designed to stand on land with an area of 250 ha with a building area of 100 ha. The capital for the establishment of the factory is in the form of fixed capital of US\$ 38.330.096,03 and Rp 116.143.697.491,39 while the operating capital of the factory in the form of working capital is US\$ 6.560.554,40 and Rp225.942.426.755,18. Based on the economic analysis that is calculated, it will generate a net profit of US\$ 18.285.437,52 / year, with ROI and POT parameters before tax of 40,83% and 2,02 years. In addition, the BEP and SDP values are also obtained at 40,88% and 23,41%, and the DCFRR value of 24,38%. Based on the assessment of economic feasibility parameters, the designed blackmass battery waste processing plant is attractive to be established.

Keywords: *Battery, Leaching, Precipitation, Lithium Carbonate, Nickel Cobalt Hexahydrate, Cobalt Sulfate Heptahydrate*