ANALYSIS OF THE PROCESS OF IRON SAND PROCESSING INTO SPONGE IRON IN ORDER TO SUPPORT THE DEFENSE INDUSTRY OF STEEL RAW MATERIALS

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Abstract - The number of iron sand reserves is mostly spread in the coastal waters of Indonesia, from the coast of Sumatra, the southern of Java to Bali, the beaches of Sulawesi, beaches in East Nusa Tenggara (NTT), and the northern coast of Papua. Total reserves for ore are 173,810,612 tons and metal as much as 25,412,652.62 tons. But its utilization was not optimal because PT. Krakatau Steel, and PT. Krakatau Posco has produced steel plates only 24,000 to 36,000 tons per year. While the need for steel plates for the shipping industry each year requires 900,000 tons per year. With the need for raw material for steel plates in the form of iron sponges with Fe ≥ 60%, PT. Krakatau Steel is still imported from abroad. The proof is PT. Krakatau Steel before and during the year 2000 still imported Iron Ore Pellets from the countries of Sweden, Chille and Brazil for 3,500,000 tons per year. This condition is the cause of the national steel industry unable to compete with the foreign steel industry because imported raw materials are subject to import duties. This is an opportunity to build a steel raw material company because all this time the steel raw material industry in Indonesia has only two companies. This condition encourages the manufacture of iron sponges, with the process of making iron sponges with technology adapted to installed production capacity. This study analysed the manufacture of iron sponges using Cipatujah iron sand, as raw material for the manufacture of iron sponges, with the results obtained in the form of iron sponges with the highest levels of Fe ≥60.44%. This can be used for the purposes of raw materials for steel making PT. Krakatau Steel (PT. KS), because so far PT. KS claims that Fe <60% local sponge iron products. This can encourage the independence of steel raw materials, which impacts on the independence of the defence industry. But the government must also protect and prioritize steel raw materials for national production for national steel production. With the national government steel industry, the consortium of vendors supplying raw material (iron sponge) to maintain the quality and supply of continuous sponge iron.

Keywords: iron sand, iron pellet, iron sponge

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INTRODUCTION

Iron sand is a sand deposit containing iron particles, commonly found in coastal areas. Iron sand is formed from rocks containing iron minerals which are eroded by weather, surface water and waves that accumulate and washed out ocean waves. The colour of iron sand is basically dark ash and black. Generally, iron sand contains opaque minerals mixed with mineral granules such as quartz, calcite, feldspar, amphibole, pyroxene, biotitic, and tourmaline. Iron sand usually contains magnetite, titaniferous magnetite, ilmenite, limonite, and hematite. Iron sand consists of basaltic and volcanic andesitic.[4] Generally, iron sand is used as raw material for steel and magnetic industries, the content is taken from this industry is iron ore concentrate. In addition to the steel and magnet industries, the ceramic and refractory industries also use iron sand, but only its silicic concentrates are taken.[5]

The amount of iron sand is widely spread throughout the coast of Indonesia, from the coast of Sumatra, the coast of southern Java as well as Bali, the coast of Sulawesi, the coast of East Nusa Tenggara, the coast of Maluku and Papua, with 173,810,612 tons of ore and metals, 63 tons.[6] The need for steel plate raw materials in the form of an iron sponge with Fe ≥ 60%, PT. Krakatau Steel still imports from abroad. During PT. Krakatau Steel before and during the 2000s still imported Iron Ore Pellet from Sweden, Chilli and Brazil as much as 3,500,000 tons per year.[7]

This condition is the reason why the national steel industry cannot compete with the foreign steel industry because imported raw materials are subject to import duties. This is an opportunity to build a steel raw material company because so far the steel raw material industry in Indonesia has only two companies. This condition encourages the making of iron sponges, with the process of making iron sponges with technology adapted to the installed production capacity.

RESEARCH METHOD

Experimental Method

The method in this study was observation

[4] http://www.tekmira.esdm.go.id, diakses pada 9 september 2018

[5] GT. Austin, *Shreve's Chemical Process Industries*, Fifth Edition, (New York: McGraw-Hill Book Co., 1985).

[6] Pusat Sumber Daya Geologi, *Pasir Besi di Indonesia Geologi, Eksplorasi dan Pemanfaatannya (Indonesian)*, (2014), p. 65

[7] Loc. cit

accompanied by experiments on the process of making iron sponges. The concept is almost the same as baking, but what distinguishes the iron sponge from the mixing process is the iron sponge using molen mix, while the process of making cookies mixes using a mixer. The data used was both secondary and primary data. The secondary data was in the form of literature references. Whereas the primary data was quantitative data in the form of observation and sampling or example to the location of iron sand mines in Cipatujah Area, West Java Province; Kota Agung, Tanggamus-Lampung; and Lumajang Regency, East Java Province.

While the samples to be examined were iron sand samples for the location of Tanggamus Regency, Cipatujah-Tasikmalaya Regency, as well as iron sand samples from Lumajang-East Java Regency. The data analysed in this study were both primary data and secondary data including a sampling of iron sand, iron sand mining process flow, the flow of the production process of iron pellets, and laboratory test data.

Sampling Method of Iron Sand

Based on data in the field, the taking of iron sand sample in the field can be carried out in 2 (two) ways: *increments* or *riffle splitters*. The sample must be

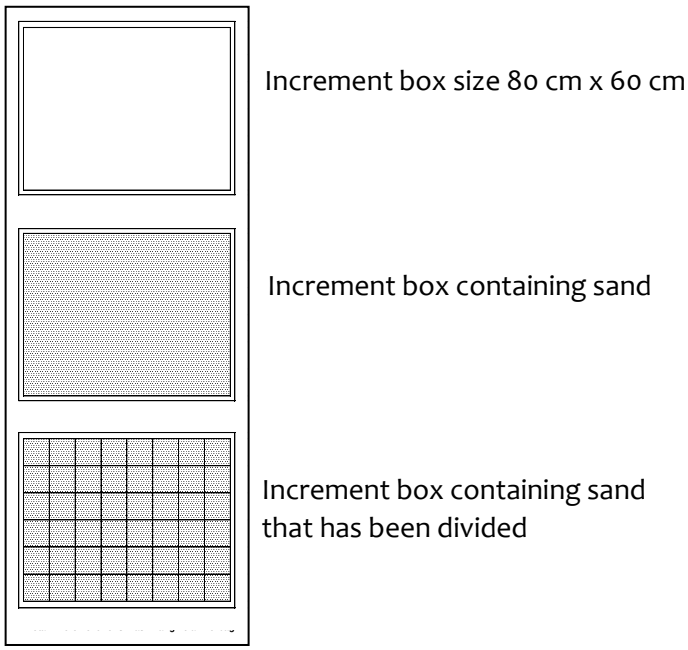


Figure 1. Sketch of the Reduction Tool Sample with the Incremental Method
Source: Centre for Geological Resources, Processed by Author, 2018

homogeneous from each depth interval. The samples must be representative that guarantees accuracy in chemical analysis, calculation of resources or reserves of iron sand deposits. The collection of the sample was based on standard procedures in the exploration of coastal iron sand deposits.

In this study, a sampling of iron sand in each study location consisted of iron sand samples on the surface (top sand), and iron sand samples ± 2 meters above ground level (top soil). Then the iron sand sample was inserted into the plastic sample which was then processed according to the applicable standard provisions, namely drying with the sun's heat. Activities carried out in the preparation process using the increment method refer to the Japan Industrial Standard.

Iron Sand Mining Process

In this study, the iron sand mining process was carried out by open mining techniques, namely the method of mining carried out on the surface of the mine land, because based on geological maps, distribution maps in the study area of iron sand ± 2 meters from the topsoil.

In this study, planning and design of iron sand using mechanical mining techniques. This is because this mining technique is far more environmentally (Go Green) than other techniques. Mechanical mining technique is a technique of excavation using mechanical equipment such as a truck/ conveyor, excavator, scraper, loader, and a bulldozer to move material to the processing unit. At the mining site (Cipatujah) the presence of iron sand with shallow distribution or above the groundwater level. The mining phases can be seen in Figure 2.

For the process of making iron sponges carried out by the experimental method by making three sponge iron samples. Iron Sponges A-1, Iron Sponges A-2, and Iron Sponges A3. The three raw materials for making iron are the same namely iron sand samples taken from Cipatujah District, Tasikmalaya Regency, West Java Province.

The iron sand samples are then made Iron Sponges A1, Iron Sponges A-2, and Iron Sponges A-3, with each being treated differently. In making sponge iron, it is divided into 2 (two) stages, preparation of iron sand sample and iron ore pelletizing process.

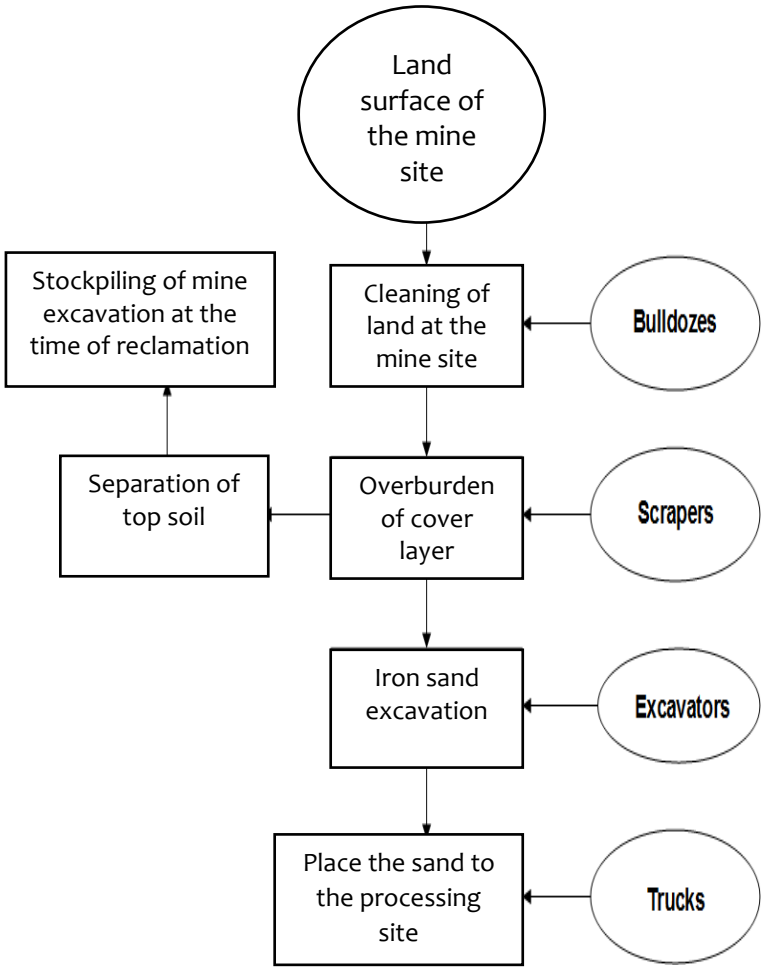


Figure 2. Flow Chart of Iron Sand Mining Process for Research Site
Source: Processed by Author, 2018

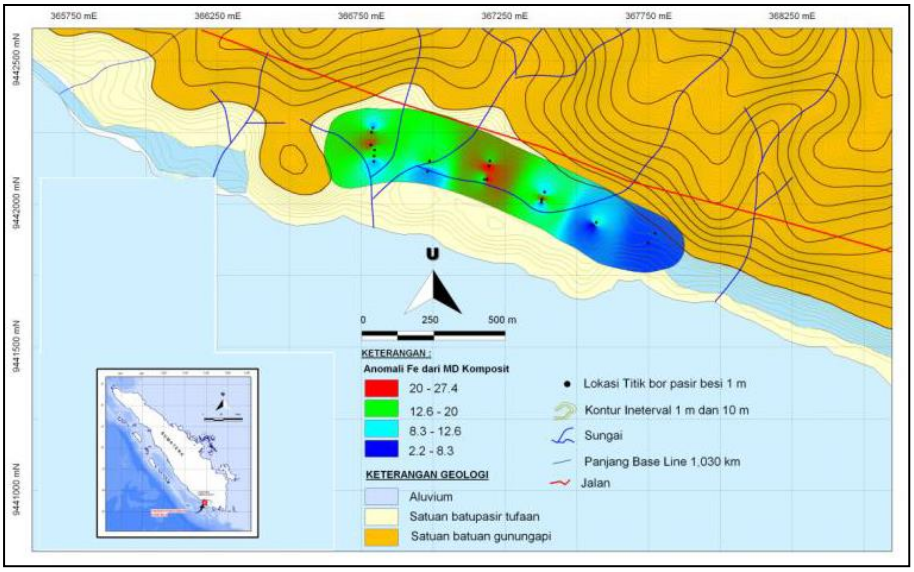


Figure 3. Lampung Regional Composite Magnetite Degree (MD) Map
Source: Processed by Author, 2018

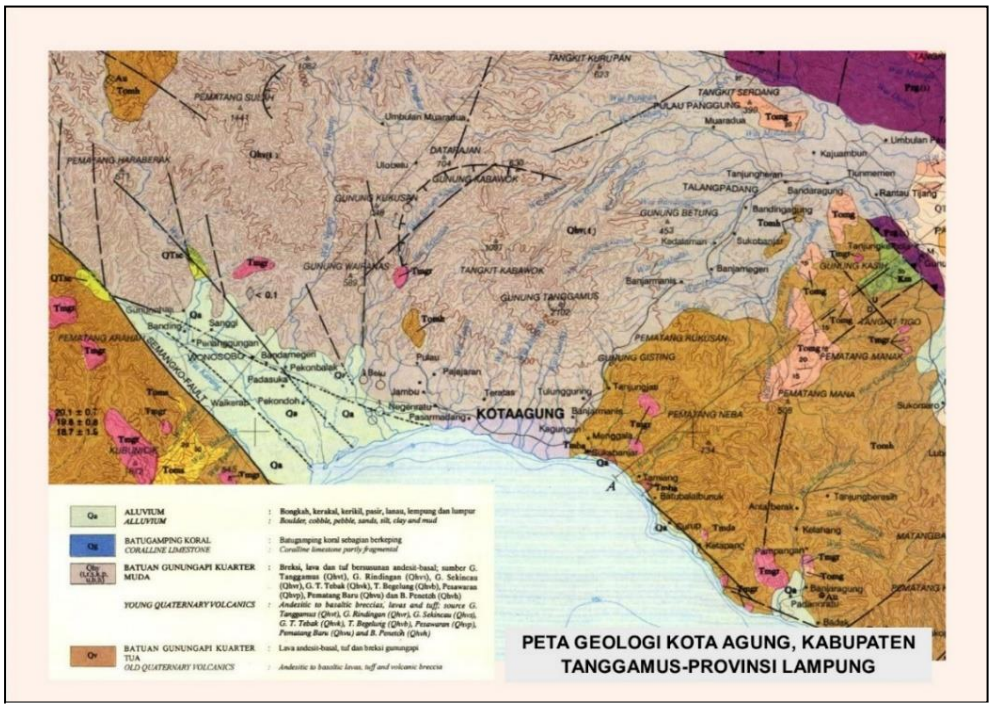


Figure 4. Lampung Regional Composite Magnetite Degree (MD) Map
Source: Processed by Author, 2018

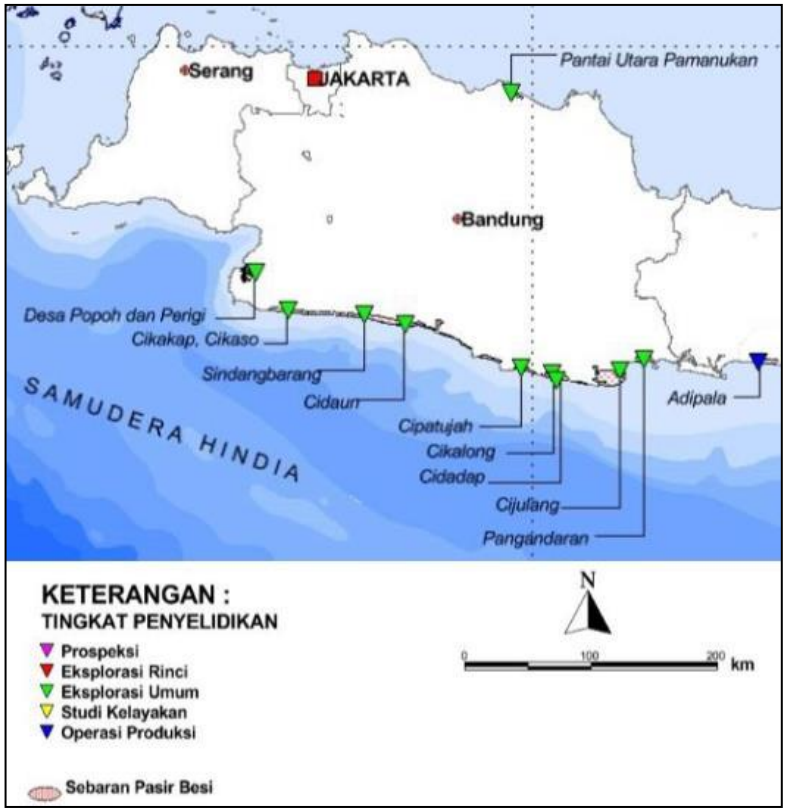


Figure 5. Iron Sand Distribution Map in West Java Province
Source: Processed by Author, 2018

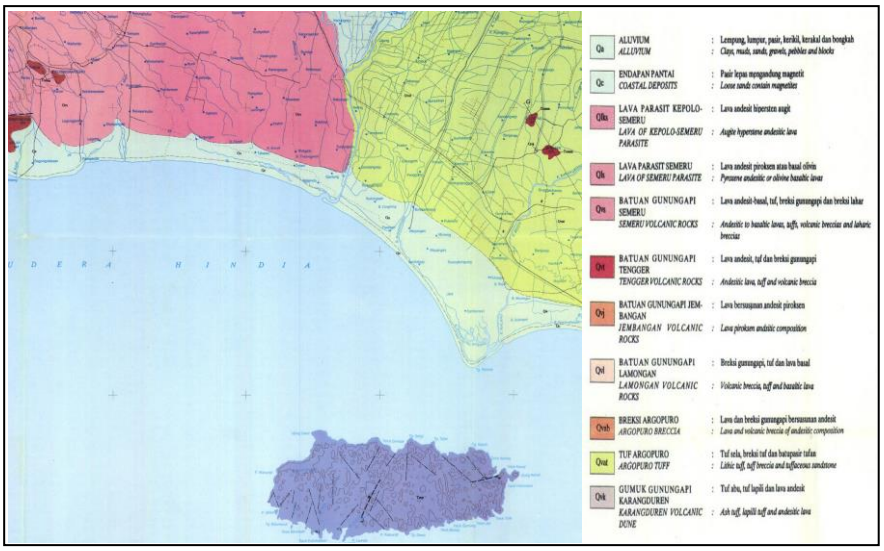


Figure 6. Lumajang Geological Map in East Java Province
Source: Processed by Author, 2018

a. Preparation of Iron Sand Sample

The process of iron sand sample preparation is carried out with 4 (four) stages:

- The sample of iron sand filtered using filter/screen No. 3 namely the separation of iron sand from dirt.
- The iron sand sample of treatment screen No. 3 is separated from the impurity by using a magnetic separator.
- The iron sand sample which has been separated from the impurity is then filtered again by filtering it with screen 0.2 to get smoother results and from impurities.
- Afterwards, the sample results of screen No. 2 is re-filtered using screen No. 1 to get smoother results and from impurities.

Figure 7. The sample of Iron Sand
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

(a) (b)

Figure 8. (a) Iron Sand Sample Screen No.3; (b) Screen No 3
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

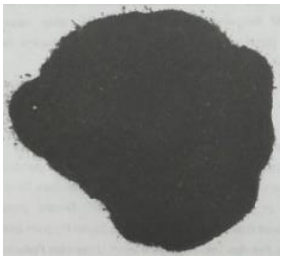
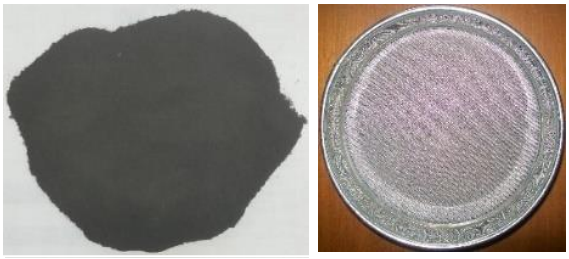


Figure 9. The sample of Iron Sand Results from Magnetic Separation
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018



(a) (b)

Figure 10. (a) Sample of Iron Sand Screen No. 2, (b) Screen No. 2
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

(a) (b)

Figure 11. (a) Sample of Iron Sand Screen No. 1, (b) Screen No. 1
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

Figure 12. Iron Sand Sample Screening Process
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

b. Iron ore Pelletizing Process

In this experiment, 3 (three) types of iron pellets were used in pelletizing of iron ore:

- Pelletizing of iron ore using pure iron pellets. A-1

  Tapioca is heated by mixing it with hot mineral water. After it is mixed well, pour the iron sand, stir until the tapioca mixture with iron sand is mixed well. Pour the mixture above into the mould; arrange the mould on the plate. Put the plate into the microwave and set the microwave at 4000C for 5 minutes. For adhesive, tapioca flour is used with a mixture of 5 parts of silica sand: 1 part of tapioca or 20%.
- Pelletizing of iron ore using iron sand and A-2 silica sand

  Tapioca is heated by mixing it with hot mineral water. After mixing silica sand

Figure 13. Iron Ore Pellets Processed by Microwave Process
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

Figure 14. Silica Mixed Iron Pellets Processed by Microwave
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

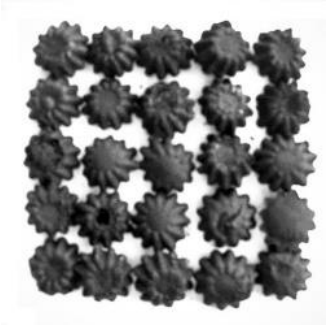


Figure 15. Activated carbon mixed iron pellets Processed by Microwave
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

Figure 16. Baking Pan for Mold
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

Figure 17. Iron Sponges Mold
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

Figure 18. Microwave
Source: Lab. TDG and IP, Faculty of Defence Technology - Indonesia Defense University, Processed by Authors, 2018

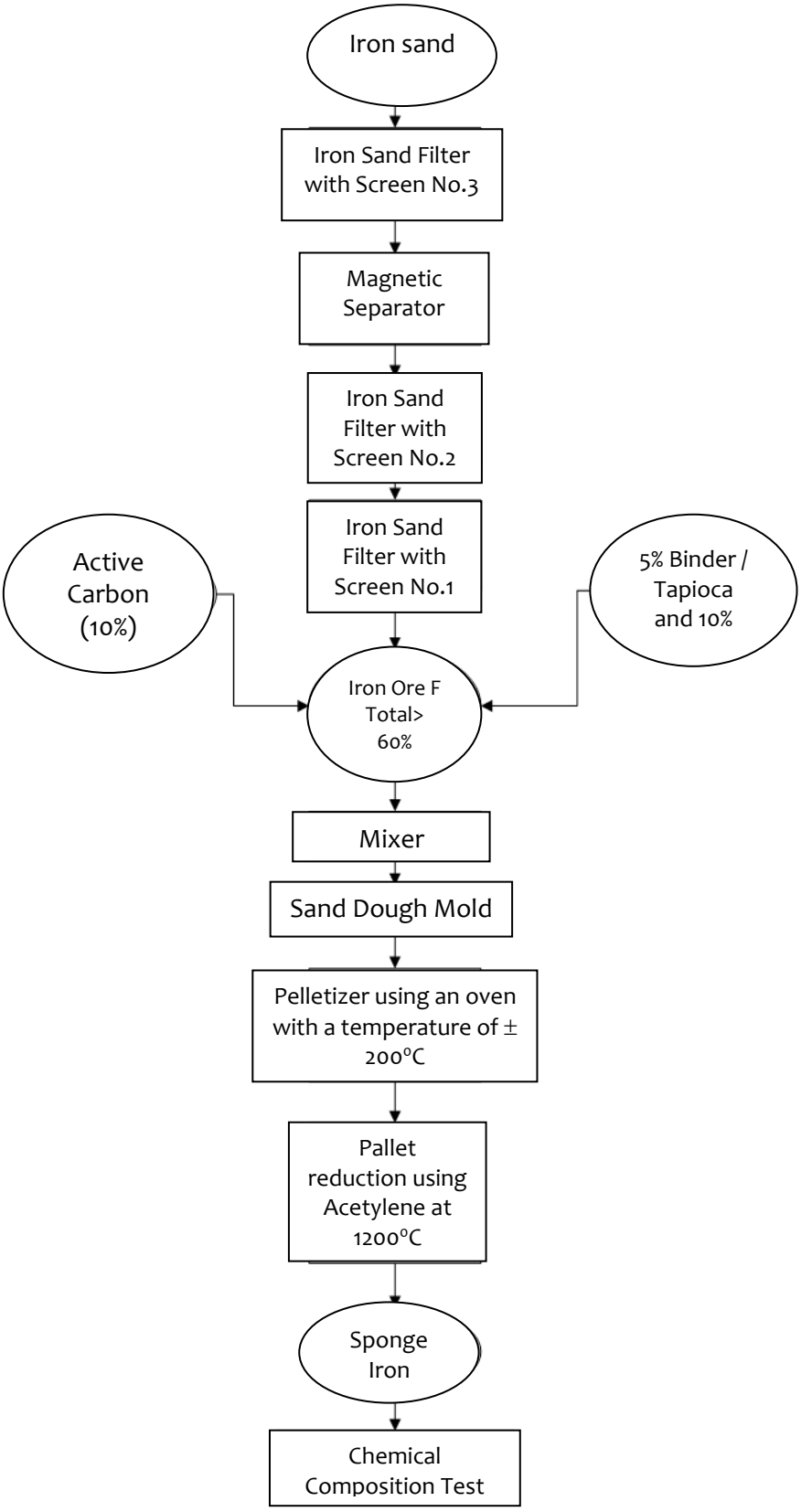


Figure 19. Experimental Process of making Iron Sponges
Source: Anguntoro, "Characteristic Test of Reduction of Iron Sponge Using Las Astelin Burner from Ngebum Kendal Iron Sand", Journal of Mechanical Engineering S-1, Vol. 3 No. 4, 2015.

Table 1. Chemical Results of Iron Sand and Iron Pellets Sample

Description	A1	A2	A3	A4	A5
SiO_2	1,91%	1,02%	5,06%	5,68%	61,84%
Fe_2O_3	85,61%	86,34%	82,29%	82,22%	33,35%
Al_2O_3	0,68%	0,72%	0,70%	0,69%	6,04%
Fe	59,93%	60,44%	57,60%	57,55%	23,34%
Mn	1,32%	0,96%	0,87%	0,95%	0,79%
TiO_3	9,98%	10,46%	10,97%	9,96%	7,48%
Specific Gravity	1,75	1,70	1,69	1,69	1,67

Source: Lab. Chemical Test, B4T, Industrial Research and Development Agency, Ministry of Industry 2018

with tapioca, stir them well, pour iron sand, and stir them until evenly. Pour the mixture above into the mould; arrange the mould on the plate. Insert the plate into the microwave with 4000C, in 5 minutes. For adhesives, use a mixture of tapioca with a mixture of 5: 1: 1, 5 parts silica sand, 1 part silica sand and 1 part tapioca sand or 20% silica and tapioca.

- Pelletizing of iron ore using iron sand mixed with A-3 activated carbon.

  Tapioca is heated by mixing it with hot mineral water. After mixing the activated carbon, pour it until the mixture is evenly (homogeneous). Pour the mixture above into the mould; arrange the mould on the plate. Put the plate into the microwave and set it at 4000C, in 5 minutes. For adhesives, tapioca flour with a mixture of 5: 1: 1 is used, namely 5 parts silica sand, 1 part activated carbon and 1 part tapioca or silica and tapioca (20%).

After the sponge iron is made, to find out the pure Fe content of each sponge iron sample, then a laboratory test in the form of chemical analysis will be carried out at the Central Material and Technical Goods (B4T), while the tested sample consists of 5 (five) samples in the form of 2 (two) samples namely iron sand on the surface (A-5), iron sand samples at a depth of 2 meters down (A-4), and 3 (three) products of the experiment, namely Iron Pellet A-1 (iron sand concentrate plus tapioca as a binder), Iron A-2 Pellet (iron sand concentrate + silica sand plus tapioca as a binder), and Iron A-3 Pellet (iron sand concentrate + Activated carbon plus tapioca as a binder). The iron sand and product

samples are in the form of iron pellets which are iron sand Cipatujah, Tasikmalaya Regency, West Java Province.

Based on the results of laboratory tests conducted by the Centre for Material and Technical Products (B4T), the Industrial Development Research Agency of the Ministry of Industry of the Republic of Indonesia, the results of the chemical analysis test using the ASTM C 575-05 method can be seen in Table 1.

Results and Discussion

The discussion in this study presents sampling of iron sand, iron sand mining, processes of making iron sponge pellets, and the laboratory test results.

- The sampling of Iron sand

  In taking iron sand samples, the most important thing to note is that in the field preparation the readiness of the equipment used in the sample collection must be adjusted to the location of the sample taken. In addition to the equipment used, the primary data is data on drill logs, distribution data, and geological data. In addition to these data, a hydrogeological map of the location of the study area is needed to determine the method in sample collection techniques and mining techniques if the research location was exploited.

  For standard sampling methods, it does not have to follow one of the standards. But it must be in accordance with the conditions of location, environment, and technical data of samples to be taken.

- Iron Sand Mining

  The method and mining technique to be used must be adjusted to the geological characteristics of the area or location to be exploited. This is to anticipate the occurrence of work accidents and natural disasters such as earthquakes and landslides.

  Besides the geological characteristics, the condition of the land around the location must be a concern. For the three locations of the study area, the locations around the coast, especially for Cipatujah and Lumajang, are located on the coast of the Indian Ocean or the southern coast of Java Island, where most of the people work as fishermen and farmers. In addition, the southern coast of Java Island is an earthquake-prone area.

  Regarding mining techniques that will be used in the study area, it is better to use Go Green mining methods that are in accordance with

the conditions of the surrounding environment, both the condition of the soil structure and the profession of the surrounding community.

- Making Iron Pellets from Iron Sand Samples

  The methods, techniques, and technology of equipment that will be used in the manufacture of Iron Pellets as well as Iron Sponges, are adjusted to the designation and requirements needed by the user. The methods, techniques and technology that will be applied in the making of iron pellets and sponge iron must be adjusted to the planned production capacity according to the user's request. We recommend that the methods, techniques and technology of the equipment used must be effective.

  Appropriate technology will optimize production results, provide benefits in the form of cheap production costs, easy to build, easy to maintain, easy to use, safe to use, and Go Green.

- Laboratory Test Results

  Looking at the results of laboratory chemical tests, discussion regarding the results of a laboratory test is needed, especially the results of the percentage of Fe. There was a difference between the three iron pellet samples (A-1, A-2, A-3), but got the same treatment for the iron pellet mixture when drying with a temperature of ± 4000C.

  The A-1 iron pellets were treated by adding a binder (20% tapioca adhesive) with Fe degree of 59, 93%. The iron A-2 pellets were treated by adding 20% silica sand and 20% tapioca adhesive with Fe degree of 60.44%. While iron A-3 pellets were treated by adding 20% activated carbon which resulted in Fe degree of 57.50%.

  The results obtained from the three treatments of making iron pellets, that the treatment of iron A-2 pellets produced pure Fe with a degree of 60.44%, which was treated by adding silica sand as much as 20%. Addition of 20% of silica sand would increase the level of pure Fe by 2.89%, from the level of samples which was only 57.55%. The addition of silica sand to increase the level of pure Fe in this study needs to be tested further, by conducting further research.

Conclusions

Conclusions and recommendations in a study are not final decisions that are binding but are an optimal reference that

can be used in decision making in accordance with the problems at hand.

Based on the research objectives, experimental results, and data analysis and discussion, the results of this study can be summarized as follows:

1. In the process of processing iron sand into iron sponges in the framework of the independence of the defence industry's steel raw materials, it must be adapted to existing resources such as human resources, process technology, utilities, and supporting equipment, adapted to the plan and design of installed capacity.
2. In addition to the processing that will be planned and designed, which affects the independence of national steel raw materials is the capacity of mine reserves, and the concentration of iron ore must contain Fe ≥ 60%. In this study, the levels of iron ore concentrate contained Fe ≥ 60.44%, which so far had been assumed that the iron sand content in Indonesia was less than 60% (Fe ≤ 60%). This was used as an excuse by the national steel company of the government not to use local iron sand, iron pellet or iron sponge products.
3. For the progress and independence of national steel raw materials, the national iron sand management company that produces the needs of iron sponge and iron pellets must obtain government policy in the form of protection and the top priority as a supplier of steel raw materials for national steel production. Because so far the need for steelmaking raw materials for national production in this case PT. Krakatau Steel (Persero), and PT. Krakatau Posco, one of the subsidiaries of PT. Krakatau Steel (Persero) and Posco, South Korea, which have been using imported raw materials, namely 3,500,000 tons of Iron Ore Pellets per year from Sweden, Chilli, and Brazil.

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