Mini production suction dredge for small scale tin mining in Bangka Belitung Island Indonesia

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Abstract. Mini Production Suction Dredge (MPSD) has been made for the people of Bangka Belitung Province Indonesia which is known as a cheap, safe and straightforward technology ship to mine tin sand from surface land under the sea level. This MPSD creates more safe production operation since the previous ships by using a traditional small boat for catching the fish. The main reason why this MPSD was created because there is no diving activity for an operator to drive the suction pipe flexibly under the sea which in some cases make the divers have problems and get injured seriously or fatality. The MPSD is a welded construction of 4 x 10 meters ship which is equipped with the suction unit, 24 HP diesel engines to drive two suction pumps, the tin separation jig and the steering winch. The basic construction of the dredge consists of 2 sides of 0.8-meter diameters x 10 meters of the steel pontoon. It operates on the sea waves which take the sand up to 15 meters deep from the mean sea level and allows no diving activity in 1 mile away from the coastline. Through its operation, the MPSD operated more stable and safer than the previous operation.

1. Introduction
Indonesian tin mining primarily takes place on the Bangka Belitung islands, which produce 90% of Indonesia's tin. Tin mining is considered the largest economic driver, making a significant contribution to the provincial economy. Since May 1998, a new style of governance has taken hold in Indonesia: democracy. Since then, small-scale mining has become more intensive and more diverse in Indonesia. For instance, small-scale mining has expanded from diamonds and gold, to include tin and coal [1]. It is reported that about 10,000 artisanal medium and small-size (SMEs) miners support more than 50,000 people. Artisanal SMEs mining contributes up to 80% of Indonesia’s tin exports [2]. Tin mining in Indonesia is conducted both onshore and offshore [3] Tin mining activities can be carried out by small-scale miners and even by individuals with no particular experience and knowledge of best practices in mining [4]. As a consequence, illegal mining practice often takes place, and this involves the use of insecure devices, lack of knowledge regarding the tin mining working process, and limited funds for a mining operation. This, in turn, leads to dangerous incidents, accidents and even fatalities. Risks of
hearing loss, drowning, heatstroke, dehydration and poor water, and sanitation and hygiene practices were the most significant OHS risks in SMEs. No miners on the site wear personal protective equipment (PPE), including goggles, boots, earplugs, respirators, gloves or coveralls. According to the media, dangerous events are more prevalent among illegal miners, but can also be observed in legitimate companies and legal small-scale mining enterprises [5],[6],[7].

The mining techniques to produce the tin sand from the land surface or alluvial are using the water gun with the gravel pumps. The water is pumped to the land surface, and through the elevated surface, it goes to the sluice box which is equipped with the riffle to catch the feed (mud mixed with many kinds of the materials including the tin sand). After some hours of that such operation, people then stir up the feed with the hoes to make the tin sand stand in the sluice box and the other materials are expelled with the water flows since they are lighter than tin sand. Figure 1 illustrates the Bucket Dredge which is operated on the sea level; tin sand is produced by digging the land surface under the sea level using the buckets. The buckets bring the feed up to the washers through the screen to separate the sand from the stones. The feed goes to the jigs which catch the tin sand with a principle of specific-weight different basis.

![Figure 1. Bucket dredge](image)

Beside the Bucket Dredge, there is a Cutter Suction Dredge to open the line of the Bucket Dredge operations. This dredge can remove the land, sand or mud surface under the sea level to the other places through the pipelines. The cutter is used to stir up the land and then sucked by the gravel pump through the suction pipe in the ladder. Since the end of the 1970 era, the higher capacity of the cutter suction dredge has been used to peel and remove the overburden of the land surface under the sea. Figure 2 illustrates it.
This kind of the sea tin mining technique is valid until now and conducted by the tin mining companies. People who conduct the small scale tin mining in the sea use a simple technique to get the tin sand. Using 24 HP fish boat, it is equipped with one 22 HP diesel engine to drive the 4-inch suction pump. A flexible hose is used to deliver feed from land surface to 1 X 2-meter the sluice box. To get alluvial from approximately 10 meters down deep the sea level, someone has to dive and to keep the nose of the flexible hose while he sucks the feed. The divers dive with the aids of the breathing system consisting of a small air pump, masker and hose to transfer the fresh air from the air pump to the masker. Hundreds of them produce the tin sand, but many of them get injured or died because of the accident.

Facing many problems regarding to the small scale tin mining in the sea, makes local government, university and tin companies have to do something to fix those problems. The solution is not only in technical aspects but also in the environmental and the economic aspects. The last two aspects, i.e., the environmental and the economic aspects, have been discussed and the results are directed to the protected area of mining, which is concerned to the environmental issues and safety mining process in the sea. Meanwhile, in the economic aspect, Mini Production Suction Dredge (MPSD) will be sold to people through a credit system paid by tin sand and sell it to the tin company as the producer of this MPSD.
2. Research Method

The research began with a discussion between the company and the university, in this case PT Timah as the sponsor of the making of a mini suction boat. The discussion was intended to produce the decisions about the ship design, how the ship works and about the shipbuilding management. To design the mini suction vessels, CAD software is used which will produce a bill of material with details of the material and its dimensions. The MPSD was built in Dok Air Kantung, Sungailiat, Bangka Indonesia which involves the welding and construction workers. The finished ship was tested on the sea of Tanjung Pesona, Sungailiat with the help of a tugboat. The test results were then reported to PT Timah. For the narrative, review data were sought from one main database: Google Scholar.

3 Research Results and Discussion

3.1 Design Considerations

The design of MPSD should be paid attention to:

1) The dredge should be made from the medium-strong material which withstand to 1-2 meters sea waves and can operate approximately 3 years with the minimum maintenance.
2) It operates without divers since there are many accidents happened in previous operations.
3) It should be easy and safe operated.
4) Not necessarily equipped with the propeller driven engine since it will be pulled with small boat or the fish boat. Its operation is not exceeded 1 mile from the coastal area.
5) The process of mining uses the suction system and the sluice box to wash the feeds.
6) It has its drive system to self-position in the certain surrounding area of the production.

The discussion has been made to make many options of the design of MPSD through PT. Timah and the local government. The design then approved to be manufactured. Figure 3 shows the design of MPSD.

3.2 Structure of MPSD and Its Working Principles

The main structure of MPSD is consisting of 5 unit i.e.:

1. Pontoon System and Dredge Construction
2. Weighted Suction System
3. Suction Pumps System
4. Feed Wash System
5. Drive Winch System

Those 5 main structures of MPSD will be explained as follows:

1) **Pontoon System and Dredge Construction:** consist of 2 pontoons with the dimension 0.8 m diameter X 10 m long, side by side with maximum 4 m width. Constructed with the weld joint, the pontoons are united with the dredge construction. Figure 4 illustrates its pontoon and dredge construction.

![Figure 4 The basic dredge construction](image)

2) **Weighted Suction System:** this system consists of the weighted suction pipe, the drive system to control the deep position of weighted suction pipe. The weighted suction pipe is used to make sure the nose of suction pipe will go down and touch the land surfaces. Besides, if the MPSD
waved because of sea waves, this tool can stir up the feed before sucked up. Figure 5 illustrates weighted suction system.

![Figure 5. The weighted suction system](image)

3) **Suction Pumps System**: the system is equipped with 24 HP diesel engines which drives 1 gravel pump, 1 self-priming pump. 15 m long flexible hose with 4 inches diameter is used to transfer the feed from weighted suction pipe to the sluice box. From the gravel pump to the sluice box, MPSD used 4 inches PVC pipes. Figure 6 illustrates it.

![Figure 6 The suction pump system](image)

4) **Feed Wash System**: this is a sluice box made from the hard wood plates. 3 kinds of the boxes have 3 steps of processes. The first step is to receive the feeds from the ends of 4 inches PVC pipe. The high speed of the feeds velocity comes from it makes this box prevent from splashing out of the feeds and directed it to the second box. The second and third box have the same function to let the feeds flows and the tin sand will stay there while the other lighter material flows together with the water flows. These boxes have 3–4 degrees declined position to the horizontal line.

5) **Drive Winch System**: This system allows MPSD moves right and left side on the rear dredge, while the MPSD is tightened by anchor approximately 10 m by means of the plastic rope to the front side of MPSD. To moves MPSD, the winch system used to pull the plastic rope to the side; meanwhile it lets rope to the other side by rotating the steering winch. Figure 7 illustrates the drive winch system.
The process of making MPSD was carried out after the planning process was carried out together with PT Timah. The design chosen is a design that meets the necessary criteria, including safety criteria and environmental issues. In terms of work safety criteria, MPSD allows operators to no longer have to dive and take land under the sea. As for environmental issues, apart from the mining process being carried out in a legal location and verification of soil conditions and possible pollution, MPSD allows the use of more efficient machines to reduce pollution levels compared to conventional ships. It is a hope that this MPSD will change the unconventional small ships used by a group of people under a contracted system with PT Timah and this would reduce the number of waste as sand and mud that becomes sediment covering coral reef, algae habitat, and other marine biota such as swamp deposit, the alluvium and the persing metamorphic complex [8,9]. MPSD needs to be socialized as a mini dredger that is environmentally friendly and has a high level of safety and does not cause conflict against the community as has happened in several places [10].

4. Conclusions
The MPSD was made as the combination of Bucket Dredge, Cutter Suction Dredge and Sluice Box in the design and the working principles. Pay attention to the work safety issue, economy and simple technology by using this dredge has an important role in creating middle technology for the better life of the people in Bangka Belitung Island. Operated by 2 operators, the MPSD makes the operation efficient and safe since no one of them needs to dive into the deep sea. The MPSD now operated in the sea and will mass produce to change the previous system which has many serious problems. With the aid of the simple technology, MPSD exactly implement the effective and easy way to operate. Based on the experiment, this dredge can be improved by adding propeller which is connected to the diesel engine.
through coupling and with steering system, this MPSD can move by its own power.

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