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Mini Factory Laboratory from Technology Reverse Engineering Ballet Reactors in Struvite Formation

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Abstract. Reverse Engineering (RE) can be interpreted as procedures and processes in dismantling an object to find out the materials, working methods, or technology used so that the object can function properly. Design activities using the reverse engineering concept make it easier for students to understand product specifications, product advantages and disadvantages, product production processes and production cost estimates before designing new products. The laboratory is one place that can be used to carry out the reverse engineering process. The bulkhead reactor is an alternative to the stirred tank reactor with the aim that the resulting product is maximized both in terms of quantity and morphology or shape of the material. The benefit of disassembling this product is as a first step in understanding the concept of reverse engineering in the task of designing machines or tools. From the results of the study, it was found that the formation of struvite occurred at pH 9 using an air flow rate of 1 l/minute.

Keyword: *Laboratory, New tool, Reverse engineering, Bulkhead reactor.*

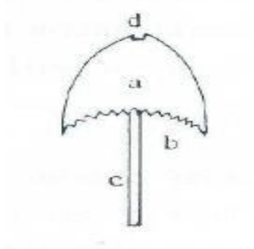
1. Introduction

Reverse engineering or reverse engineering is a process in manufacturing that aims to reproduce or recreate existing models, either components, sub-assemblies, or products without using existing design document data or working drawings [1]. This method is done so that the new product has an advantage over the previous product [2].

Stirred tank flow reactor (RATB) is a process tool used in reacting a chemical reaction that takes place continuously. In large-scale industries, RATB is more often applied because of its adjustable operating capacity. The stirred tank flow reactor operates at steady state conditions and is easy to control the temperature, the residence time of the reactants in the reactor is determined by the flow rate (discharge) of the feed and incoming and outgoing reactants, so the residence time is very limited so it is difficult to achieve a high conversion rate of reactants per reactor volume. high, because it requires a reactor with a very large volume [3]. The use of this reactor is not good when used to produce the morphology of a crystal because the crystals formed must be hit by a stirrer if the process has not been completed.

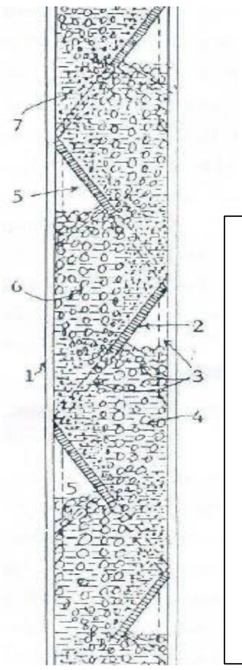
The insulated reactor is the result of the reverse engineering process as a substitute for the stirred tank flow reactor. Inside the insulated reactor, there are bulkheads made of used plastic, sliced into an ellipse-like curve and equipped with small teeth. The ellipses are cut in half along their short axis, in this section they are sliced into small teeth along the arch. The teeth are meant to break large air bubbles into small bubbles. By using this bulkhead reactor, it is hoped that the reaction process will be more perfect, the crystal form obtained is clearer so that it is easy to analyze [4].

Struvite (Magnesium Ammonium Phosphate) is a kind of white crystal containing elements of magnesium, ammonium and phosphate. This crystal was first discovered in a sewer system in the Middle Ages in the city of Hamburg, Germany by geologist and geographer Heinrich Christian Gottfried von Stuve in 1845. Struvite is a problem in itself for industry, especially in various processing locations that have high turbulence, such as bends. pipes, valves, pumps and separators because with the emergence of struvite it can reduce the effective area of the pipe up to 60%, so regular pipe cleaning is required. Cleaning struvite in these places is very difficult, and expensive. In addition, cleaning must also stop ongoing processing operations [5].



Information:
a) Half ellipse
b) Teeth
c) Support
d) Indentation for attaching supports

Figure 1. Bulkhead from above



Information:
1. Reactor
2. Arrangement of bulkheads in reactor
3. Bulkhead support
4. Air bubbles
5. Air trapped in bulkhead corner
6. Liquid
7. Precipitation

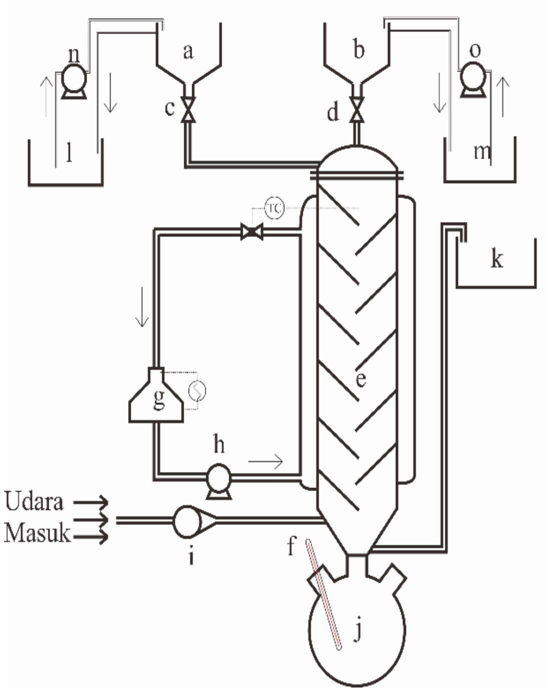
Figure 2. The arrangement of the bulkhead in the reactor

The process of formation of struvite crystals is strongly influenced by physical and chemical parameters, such as the pH of the solution, the level of supersaturation, agitation, crystal size, temperature, and the presence of interfering ions in the solution. Stirring is one of the important aspects in the crystallization process, because increasing the stirring speed will affect the speed of the crystal formation reaction that occurs in the system, increasing the particle size, and the speed of deposition. The crystallization process using a stirred reactor is less profitable because the crystals formed are less fine because the crystals are broken by the stirrer leaf when the stirring process is carried out [6]

Struvite is formed through a precipitation process that involves a physico-chemical process to form a precipitate that can be separated from the solution. According to [7]. The formation of struvite occurs if the Ion Activity Product (IAP) of Mg^{2+}, NH^{4+} and PO_4^{3-} is greater than the Solubility Product (KSP). With the PH of the solution from 8.4 to 9.

2. Research Method

Make a MAP solution with a concentration ratio of $Mg:NH_4:PO_4 = 1:1:1$ and make a 1N KOH solution as a pH indicator. Filling the bulkhead reactor with MAP until it reaches a height of from the reactor and KOH to control the pH of the solution, the temperature is set at 30 ^oC.



a) MAP storage tank
b) KOH . holding tank
c) MAP faucet
d) KOH faucet
e) Partition
f) Thermometer
g) Water storage tank
h) Water pump
i) Rotameter
j) Sediment storage tank
k) Struvite solution storage tank
l) MAP overflow storage tank
m) KOH overflow tank
n) MAP pump
o) KOH pompa pump

Figure 3. Bulk reactor arrangement

The air flow was run at a rate of 1 L/min. Entering the KOH little by little by opening the faucet on the hose so that the pH of the mixed MAP and KOH solution reaches the desired pH. After the desired pH is reached, wait for 5 minutes until the state is steady after which the process is stopped. The results of the process are collected and then filtered using filter paper. The struvite precipitate obtained was dried after drying and analyzed using SEM.

3. Result and Discussion

From the results of SEM analysis, it can be seen that the shape of the struvite crystals produced is very clear. The use of the Stirred Tank Flow Reactor (RATB) results in a non-specific crystal structure due to the rotation of the stirrer. This will make it difficult to determine the morphology or shape of these crystals whether the crystals formed are really struvite crystals as seen in Figure 4a and 4b. While the process of forming struvite crystals using an insulated reactor, the crystal structure is rod-shaped with a pointed tip (orthorhombic).

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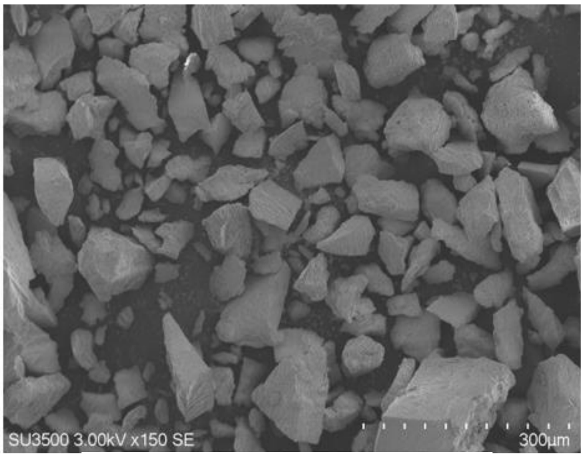

Figure 4 (a). Struvite formation using RATB

Figure 4 (b). Struvite formation using bulhead reactor

The effect of temperature on the formation of struvite in a mixture of $MgCl_2.6H_2O$ and $(NH_4)2HPO_4$ solution at a temperature of 25-300 ºC. The results obtained indicate that struvite is formed at a temperature of 25-37 ºC and then other crystals are formed at temperatures above 37 ºC [8]. The formation of struvite from a synthetic waste using a Fluidized Bed Reactor was formed at a pH of 9.5.

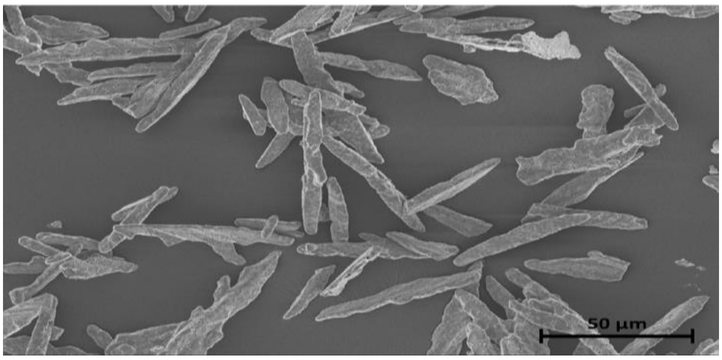

Figure 5. SEM Analysis

From the results of SEM analysis, it can be seen that the shape of the struvite crystals produced is very clear. The use of the Stirred Tank Flow Reactor (RATB) results in a non-specific crystal structure due to the rotation of the stirrer. This will make it difficult to determine the morphology or shape of these crystals whether the crystals formed are really struvite crystals as seen in figure 5. While the process of forming struvite crystals using an insulated reactor, the crystal structure is rod-shaped with a pointed tip (orthorhombic).

4. Conclusion

The use of a bulkhead reactor which is the result of reverse engineering technology from a stirred tank flow reactor (RATB) is an alternative to using a reactor in the process of forming struvite. This is because the insulated reactor is only equipped with serrated bulkheads that function to break up incoming air bubbles. Thus the reaction process in the formation of struvite becomes more perfect than using a stirred tank flow reactor.

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