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Investigation of the Effect of Time on Elutriation of Limestone Particles

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ABSTRACT:

The efficiency of separating limestone particles by the elutriation method is affected by several factors, including particle size distribution, liquid flow rate, and duration of the separation process. This Study focuses on the effect of time on the separation efficiency of limestone particles by elutriation methods. It is also analyzed here that the longer the elutriation process, the more effective the separation. However, there is a limit to this efficiency, beyond which the separation process becomes less effective due to the formation of particle agglomerates or changes in fluid dynamics.

Key words: Elutriator, Literature survey, Elutriation time, separation efficiency.

Introduction:

Elutriation is a separation technique that uses a fluid medium to separate particles based on their size and density [1]. In This method, a mixture of particles is introduced into an upwardly flowing fluid at a controlled velocity. As the fluid flows, the particles are separated according to their size and density. Smaller and lighter particles are carried further up inside the column by the fluid flow, while larger and denser particles settle to the bottom of the column. This method commonly used in various industries to separate particles of different sizes and densities. This method uses a fluid flow to separate particles based on their sedimentation rate [8, 2], and separation efficiency can be affected by several factors, including process time. The effect of time on the efficiency of separation by elutriation is a subject of interest and investigation in scientific research. In this study, the existing literature on the effect of time on the separation efficiency of elutriation methods will be discussed. The various factors that can affect separation performance will be explored by us, including particle properties, fluid properties, flow rate, and the size and geometry of the elutriation apparatus.

Literature review:

Separation of solid particles into different fractions based upon their size, shape and specific gravity [9] is called classification.Classification methods are based on the rate of settling of particles into different parts of narrow size range particles where fluid remains stationary or flows in the opposite direction of the settling movement of the particles [2]. It works by suspending a mixture of particles in a fluid and then allowing the larger, heavier particles to settle while the smaller, lighter particles remain suspended. The separated particles can then be collected by removing the fluid.

Particle Separation efficiency by elutriation method refers to the effectiveness of a particle separation process in removing particles from a fluid or gas stream. It is usually expressed as a percentage and represents the ratio of the weight of classified material in to the overflow to the weight of classifiable material in the feed in the fluid or gas stream. For example, if a separation process removes 97 unit out of 100 unit in a fluid stream, the separation efficiency would be 97%. Several studies have investigated the effect of time on the efficiency of separation by elutriation methods. In general, elutriation processes can be affected by time in several ways [2]:

Settling time:

The time required for particles to settle out of a liquid or gas stream and reach a stable position in the elutriation column. In some elutriation processes, particles are allowed to settle before the fluid is introduced. The settling time can affect primary particle distribution and separation efficiency. Longer settling[6,3] times may lead to better separation, as the particles are more likely to form distinct layers based on their size and density.

Agglomeration:

Agglomeration of particles refers to the process by which small particles come together to form larger aggregates or clusters [3]. In some cases, particles may agglomerate or stick together during elutriation. This can happen if the particles are too small or if the fluid conditions are not optimal. Longer time in the elutriation process can increase the likelihood of agglomeration, which can reduce the efficiency of the separation.

Holding time:

The holding time is the time that the particles spend in the fluid. Once the fluid is introduced, the particles are carried away from the separation zone at a certain rate, which is determined by the fluid velocity and the particle properties [3]. It can affect the efficiency of the separation. Longer holding times may lead to better separation, as the particles have more time to interact with the fluid and be carried away from the separation zone.

Attrition:

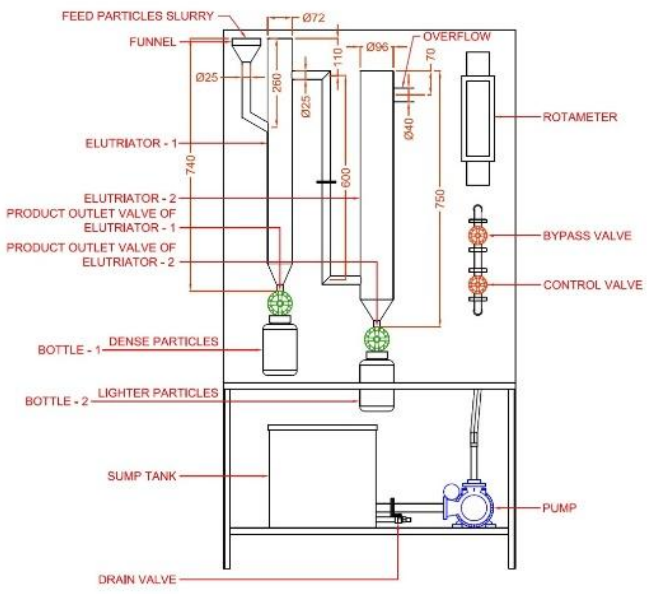
Attrition is the process by which particles are broken or destroyed by collision with each other or with the walls of the elutriation column. Elutriation can also cause wear and tear on the particles, especially if the fluid velocity is high or the particles are abrasive [3]. Longer time in the elutriation process can increase the amount of attrition, which can affect the particle size distribution and the efficiency of the separation.

The effect of time on elutriation process depends on the specific application and the properties of the particles being separated. Longer settling and holding times may lead to better separation, but can also increase the likelihood of agglomeration and attrition [3]. This is because longer elutriation times allow for more time for the particles to settle and for the fluid to wash away the smaller particles. However, if the elutriation time is too long, larger particles may also be carried away, which can reduce the efficiency of particle separation.

A study by V Smutny and J. Kren investigated the effect of time on the elutriation of weed seed from 200 gm.soil samples [5]. The device significantly reduce the time by 35.5-42.9% compared to hand elutriation of weed seeds. But this study did not mention any specific time for elutriation process or efficiency.

Again, some studies have reported elutriation times of around 10-15 minutes for particles of 100-200 μm using specific elutriation equipment and methods. However, other studies have reported longer elutriation times of several hours for larger particles. The optimum elutriation time for particles of 100-200 μm may need to be determined through experimentation, taking into consideration the specific equipment and elutriation method used.

Experimental Setup:



A Double Column Elutriator

Experimental Study:

Limestone samples of 100 gm size ranging from 100 μm to 200 μm are taken into the hopper of the elutriator setup for testing at a fixed water flow rate of 300 LPH (Liter Per Hour) for different time periods. The elutriation time for the sample Lime Stone can be shortened by series connection of

elutriator columns [3, 4]. The quality of separation depends on the time of elutriation, stability of liquid flow, completeness of dispersion, nature of velocity in the column [7, 3, 4]. The result of the recovery percentage of limestone particles as in the following table:

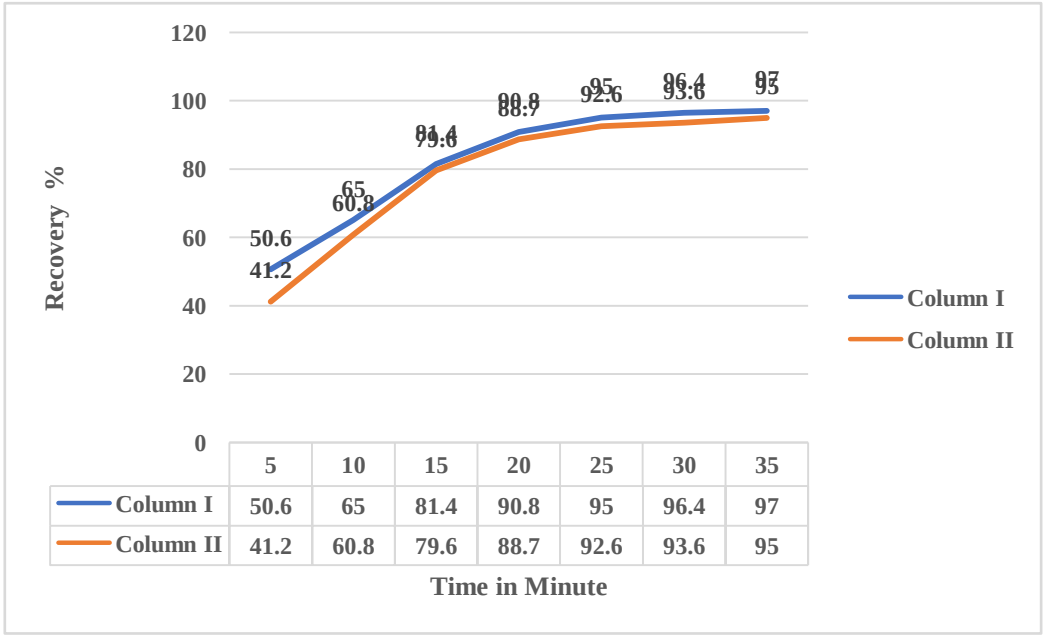
Table for Elutriator Column I

Exp. No.	Elutriation time in minute	Feed Particle wt. In gm.	Product (Coarse) Particle wt. in gm.	Recovery % of particles
1	5	50	25.3	50.6
2	10	50	32.5	65
3	15	50	40.7	81.4
4	20	50	45.4	90.8
5	25	50	47.5	95
6	30	50	48.2	96.4
7	35	50	48.5	97

Table for Elutriator Column II

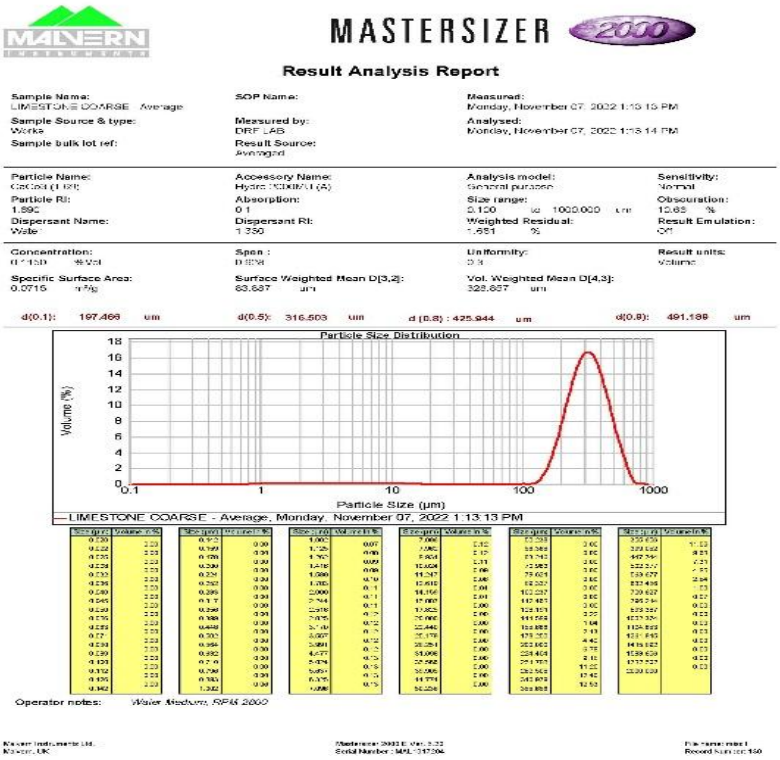
Exp. No.	Elutriation time in minute	Feed Particle wt. In gm.	Product (Fine) Particle wt. in gm.	Recovery % of particles
1	5	50	20.6	41.2
2	10	50	30.4	60.8
3	15	50	39.8	79.6
4	20	50	44.35	88.7
5	25	50	46.3	92.6
6	30	50	46.8	93.6
7	35	50	47.5	95

Elutriation time analysis:

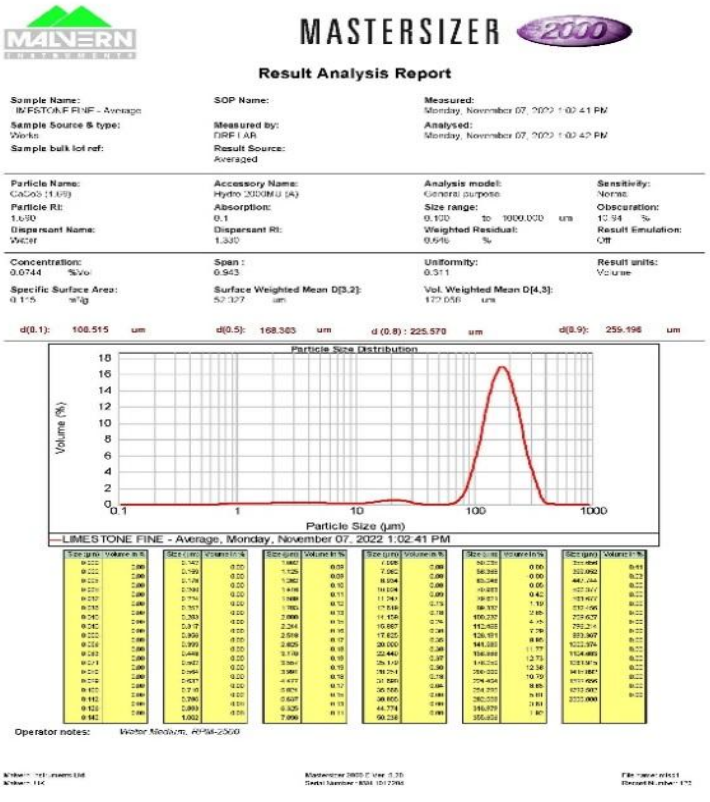


Recovery % vs. Elutriation time

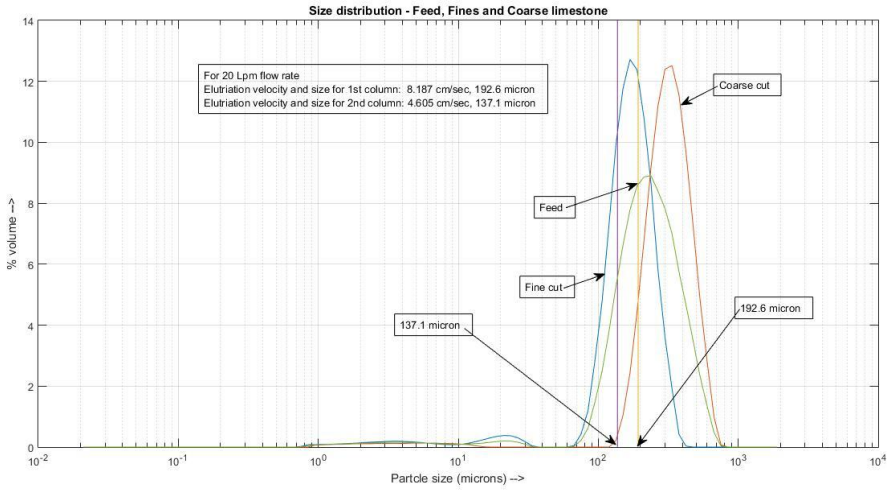
Particle Size Analysis (Coarse):



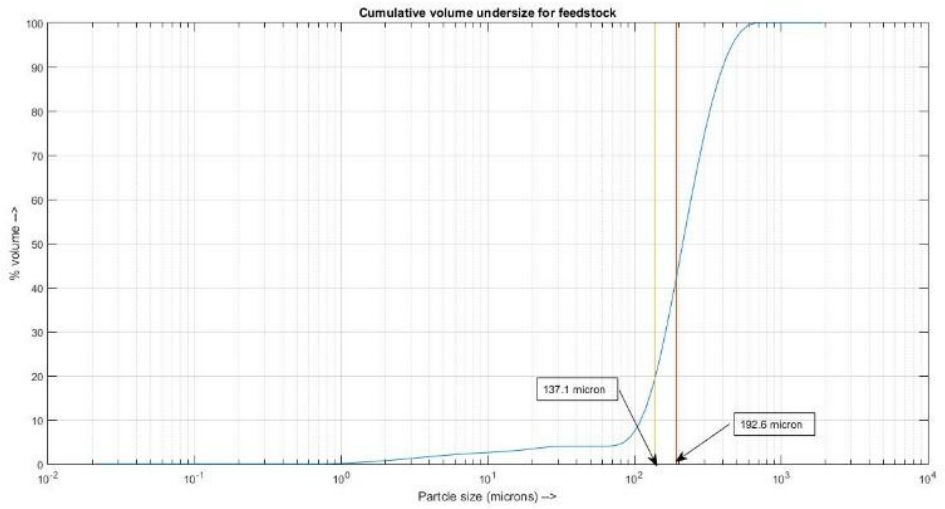
Particle Size Analysis (Fine):



Analysis of size distribution of particle after separation:



Analysis of volume percentage of Feed:



Conclusion:

Many studies have investigated the effect of time on the efficiency of separation by elutriation methods. Here we find that the percentage of limestone particle recovery initially decreases sharply, then more slowly until it finally becomes almost constant. Longer elutriation times lead to higher yields of limestone particles. Here we found that an elutriation time of 30 – 35 min was optimal for separating limestone particles from sediment.

The study suggests that the time required for elutriation significantly affects the efficiency of separation. The longer the elutriation process is allowed to continue, the greater the degree of separation achieved. However, there may be practical limitations to the length of time that elutriation can be performed, such as the stability of the sample and the completeness of the dispersion of the sample. Additionally, the study highlights the importance of optimizing the elutriation conditions to maximize separation efficiencies, such as adjusting the stability of liquid flow and particle size distribution. Overall, elutriation remains a useful and widely used technique for separating particles based on their size and density, and further research is needed to continue improving its efficiency and effectiveness.

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