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OPTIMIZATION OF DECANTATION PROCESS FOR PLANT PROTEIN EXTRATION AND ITS DATA ANALYSIS BY PYTHON

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Abstract: Decanter is a unit operation that is broadly utilized for Solid-Liquid stage separation. Improvement of Decanter is extremely critical equipment for food or compound industry since better separation. the necessity of one more unit operation is reduced and decreases the general expense of cycle. these days it is exceptionally considered a general issue of better separation. So, a lot of research is going on to optimize the decantation process for Decanter. The current research study work is done to enhance the efficiency of decantation process for Soya Protein extraction. For that decanter separation preliminary completed on products boundary, for example Feed flow rate, bowl speed, Differential RPM, and Dam plate. Trial samples were examined in a lab centrifuge. The Ideal Condition were a feed rate of 150 LPH, Bowl Speed 5200 RPM, Differential RPM 10, and dam plate R62. On this condition extremely less TSS was noticed. Which is extremely useful for an additional cycle. Currently python is very marvelous tool which is widely used for data analysis. In our research work Python used for data analysis. All the correlationdata graph ,plot were obtained by python.

Keywords – Decanter Centrifuge, Soy protein, Solid-Liquid stage separation.

1. INTRODUCTION

Because of the current situation of the human way of life, the day-to-day dietary eating routine isn't adjusted. The adjusted healthy benefit is diminishing The absence of protein in the Indian eating regimen is one of the main pressing issues among all age gatherings. Soy is notable as a practical wellspring of the protein. Be that as it may, soy proteins contain different inhibitory substances, severe taste, and beany flavor which isn't appealing to individuals. Consequently, there is a need to present some imaginative impressions in the conventional course of soy protein extraction which is sufficiently powerful to create high protein satisfied with advantageous qualities. The market income of soy protein in the nation is projected to develop at a CAGR of 8% from 2022 to 2027 to catch the worth of $478.7 million by 2027. The use of soy protein across the food business shares the most elevated portion of the overall industry. Over the most recent couple of years, devouring protein-rich food in everyday eating regimens has expanded in India. Developing soy protein-based food makers in the nation think about this as an open door and want to extend the soy protein items range. The country's drink industry has changed essentially over last ten years with rising shoppers requesting the juices, enhanced water, and carbonated water containing solid and normal fixings. Such a pattern has prompted the consistently developing use of soy protein across the refreshment industry.[1] The soy protein concentrates market is assessed to hold the biggest portion of the general soy protein market in 2019. The biggest portion of this section is credited to its minimal expense than different kinds of soy protein and developing interest from the meat and creature feed industry. Likewise, soy protein concentrate is generally utilized as a utilitarian or nourishing fixing in an assortment of food items, mostly in prepared food varieties, breakfast cereals, and some meat items, as would be considered normal to help the soy protein amasses market essentiallyin the following couple of years.[2] In the soy protein, extraction process decanter centrifuge plays a very important role because it separates the liquid-solid as compared to other equipment but its optimization is also required because it provides good results on the optimum parameter

Basically, there are two methods of soy protein extraction acid precipitation in which acidic treatment is done and all the protein precipitated by their isoelectric point but in this method, we will get the inhibitory substances, bitter taste, and beany flavor which is not attractive to the people. and another alkali treatment in which by the use of alkali protein get soluble in water and slurry fed to decanter so that solid-liquid separation done. But here the performance of the decanter is very crucial in the whole process because if the decanter gives a clear liquid so it will reduce the need for a further unit operation which is good in an economic manner because it reduces the overall cost as well as operating cost which helps to any industry. For clear liquid we have to optimize all parameters like feed flow rate, bowl speed, differential speed, and selection of dam plate so without the optimization of decanter it is a very tedious task for further unit operation because unclear liquid goes to the next unit operation like UF, NF and RO the solids of liquid gets stuck in membrane and which leads to low performance of all the membrane which is not good for the process. so it must do the optimization of the decanter after clear liquid from the decanter. further treated by the membrane separations like MF, UF, and RO.After this Slurry gets in the spray dryer.

2. Literature Review

Alan Craig Bentham, M.A.(1990) has examined the suitability of a scroll decanter centrifuge for the removal of yeast cell debris from yeast homogenate. The cells were disrupted by high-pressure homogenisation and borax was used to aggregate the cell wall material by selectively cross linking carbohydrates having cis1,2 diol groups. The effects of adjusting centrifuge parameters on the clarification of the homogenate, protein recovery and sediment dewatering were examined. The dewatering of homogenate solids was related to the shear modulus of the sediment. The formation of aggregates of biological materials and their subsequent separation are key steps in the biological industry. Two systems involving the formation and dewatering of biological aggregates have been studied. In the first, study soya protein was precipitated and then ultrafiltered in hollow-fibre membranes. It was shown that high protein concentrations could be obtained by appropriate choice of membrane geometry and pumping equipment. Rheological measurements of the suspension were used to explain the permeate flux rates at high protein. concentration. The feasibilty of using microfiltration for precipitate dewatering was assessed by studying the flux and protein transmission characteristics of flat-sheet microporous membranes.[2]

Josephine Rumpus's(1997) aim of the is to scale down industrial centrifuges so that they can be used with small amounts of material to obtain process information at an early stage in process development. Practical work was carried out using real process systems such as homogenised yeast flocculated with polyethylenimine (PEI) to selectively remove contaminating lipids, nucleic acids and cell debris from a solution of soluble protein. The scale up of centrifugal operations has been carried out in the pastusinga combination of S theory applied to laboratory bottle centrifugation and expert experience. He also reported that he separation capacity of a scroll decanter centrifuge is limited by solids conveyance, a turbulent settling zone and shear breakage. Rheological instrumentation was used to predict dewatering performance of biological sediments in a series of mass balanced pilot scale trials. Laboratory scale separations yield enough information to predict initial pilot scale trials using an operating line for the scroll decanter centrifuge. Scale down experiments revealed that shear of suspension in the feed zone creates permanent floe damage and also that the shearing action of the conveyor assists dewatering and contributes to softening of the sediment.[3]

Mr. Carlsman(2008) and his team main goal was to determine the possibility to improve the sugar and ethanol process both from an economical and energy saving perspective. The idea was to investigate the possibilities to use a decanter centrifuge in the sugar/ethanol process to Extract the remaining sugar from the rotating vacuum filter (RVF)cake. Replace the RVF with a decanter. Their assignment was planned to be carried out with two different tests. Their first test was to extract the remaining sugar from the cake in the RVF. The second step was to test the efficiency of the decanter to separate the molasses from the clarifier. Depending on the results from the first separation this test can be continued with a second separation of the liquid. And they found that The RVF uses a lot of energy, is very bulky, dirty and creates a lot of smell. The second test was to investigate the possibility to replace the RVF with one or two decanters. Possibly benefits by replacing the RVF with a decanter Energy savings ,Installation savings ,Cheaper purchase ,Less space requirements More pleasant working environment due to a closed.of five years. The time series monthly data is collected on stock prices for sample firmsand relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE -100 Index is taken from yahoo finance.[4]

3. Mechanism Of Decanter Centrifuge

Decanter is a unit operation is which is utilized for stage separation(Solid-Liquid). The slurry is brought into the axis through an admission pipe and onto a conveyor. Utilizing an inward feed compartment, the transport moves the slurry through a spout into the bowl. The bowl pivots at high velocities to initiate diffusive powers. High-velocity turn isolates the strong material from the fluid in no time flat. The transport conveys the strong material upwards where it is released through a spout. The strong material is eliminated, and the cleansed fluid is let out of a different result. The capacity to filter a fluid makes decanter axes ideal for squander water treatment offices. In any case, there is an assortment of businesses for which such rotators assume a significant part. Like other decanter gear, rotators are easy to introduce and don't need an establishment to expand upon. Their effectiveness saves time and materials and is a fundamental part of some regular industries.[5] "The solid scroll-release decanter now generally known as the decanter axis has, for sure, become the workhorse of a wide scope of fluid/strong partition exercises. Its application to the dewatering of waste sleds has made it a most significant instrument in fighting natural pollution. This has spread the word and broadly valued piece equipment.

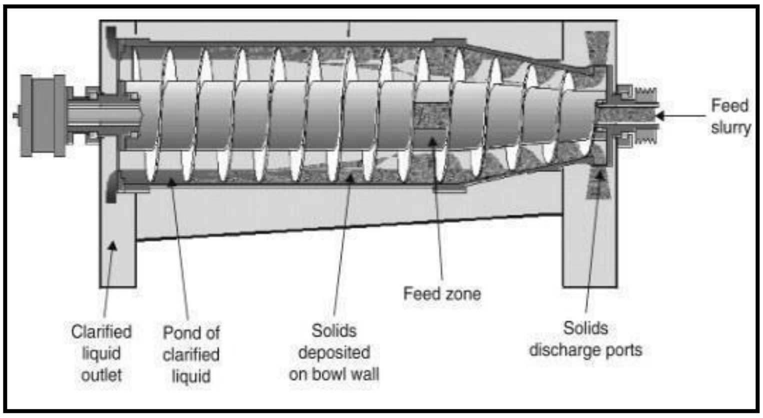

Figure 3 Decanter Centrifuge

4. DETAILS FOR STUDY

The objective of the present work is to achieve better separation and liquid slurry should have less TSS and clear liquid so that there is no requirement for another unit operation because which reduce the overall cost of the process for that decanter optimization is needed. And its optimization can be done by varying feed flow rate, bowl speed, differential speed, dam plate. Data analysis done by python which gives good graphical way for better Understanding of data and In future scale up can be done by applying machine learning algorithms which can predict the best optimize parameter

5. BENEFITS OF DECANTER CENTRIFUGE

The decanter axis offers invigorating benefits over other equipment. Decanter Centrifuge can be improve by the specific application and work on specific application .so it has application of use in food as well as in chemical industry like, Ethanol Production, Process industry applications ,Mineral handling industry, Kaolin dirt and calcium carbonate handling, bentonite and titaniu dioxide makers Oil/gas investigation and petrochemical industry Oil and gas investigation, petroleum processing plants and related ventures, greasing up oil added substances and waste oil stream reusing Organic substance industry Organic transitional and finished results Polymer industry Thermoplastics including PVC, polypropylene, polystyrene, manufactured elastic and strands Inorganic synthetic industry Bleaching specialists, acids, silica items and composts Ethanol creation Processing of grain liquor spent wash and molasses fermenter deposits Starch handling Based on wheat, maize, custard, cassava and potatoes Waste reusing Recovery and reusing of waste streams.

Food applications are Animal protein Fish and meat side-effect handling Surimi handling Edible protein recuperation Brewery Recovery of concentrate, wort, and yeast Coffee and tea Extraction of moment espresso and tea Dairy Recovery of casein, lactose, whey fines, and cheddar fines Edible oil Clarification of palm oil, olive oil and squeezed seed oil Juice Extraction from organic product, berries, and vegetables Pectin Recovery of separated gelatin Vegetable protein Extraction from Soyabeans, oil seeds and leguminous harvests Wine Must and wine explanation.

6.. RESEARCH METHODOLOGY

For Soya protein extraction, Soya grits and water is taken in 1:10. And mix well with blender and pass to slurry tank and agitate the slurry for 1 hr at very low RPM so that less foam will occur. Here 25% NaOH is added slowly till pH is 9 to 9.5. after this slurry is passed to the decanter through the dosing pump at a different flow rate so that it can be optimized. with the different flow rates, bowl speeds, differential RPM, and dam plate trials done. from the different trial liquid samples collected at mid-time of the process. the liquid was taken to the glass tube and weigh the 100 grams and run with a lab centrifuge at the same RPM(on a trial run)for 20 min. and after that total, suspended solids were observed and supernatants were removed from the glass tube and weighed the weight of TSS and note down. and further data analysis was done by Python.

Materials

Soya Grits: In the Experiment, Untoasted Soya grits were used. in which consist of 52% protein is there. for the desired particlesize we need to grind. It is very rich source of protein. Normally Its consists 50- 54% protein. For trial its grinded in medium size.

Figure 6.1.1 Soya Grits ;Raw Material

NaOH - 25% Of NaOH used(Commercial Grade)

Figure 6.1.2 NaOH: Chemical

Equipments.

pH meter: At the slurry tank after adding NaOH pH was measured. And before the starting, the trial calibration is done bystandard.

Figure 6.2.1 pH Meter

Lab Centrifuge: after every trial, TSS is determined by the lab centrifuge of 100 g of the sample taken and centrifuge at the same RPM as Trial RPM.

Figure 6.2.2 Lab Centrifuge

Blender- it used for to blend the grits and water

Figure 6.2.3 Solid-Liquid Blender

Feed pump For decanter – Dosing pump used for the feeding because it is used for low flowrate.

Figure 6.2.4 Feed pump for Decanter Centrifuge

Decanter Centrifuge- Its unit operation for the solid-liquid(Phase) Separation. It is widely used for the chemical and foodindustry for separate clear liquid from slurry.

Figure 6.2.5Decanter Centrifuge

Laboratory analytical techniques

Determination of TSS: for this from every trial 100 grams of liquid sample were collected at mid and run in the lab centrifuge at the same RPM which is run in the trial for 20 min. supernatants removed the weigh the solid weight.

Trial No.	Moisture in solids(%)
1	88.28
2	87.76
3	86.05
4	85.6
5	84.7
6	83.6
7	82.99
8	81.47
9	81
10	80.02

Table 6.3.1 TSS of every Trial

Solid Moisture - Weigh 5-gram sample and spread on patty dish and placed on 104°C for 4 hr. after 4 hr removed sample from oven and place for cool in room temperature, weigh the dried sample and moisture content determined.

Trial No.	TSS(per 100 grams)
1	5.75
2	5.36
3	4.99
4	4.15
5	3.87
6	2.87
7	2.45
8	1.99
9	0.5
10	0.02

Table 6.3.2 Moisture Content of solid for every Trial

Experimental methods

6.4.1Optimization of decantation process

The decanter can be adjusted to suit individual requirements by varying the following control parameters:

Feed rate The lower feed rate, the better separation. Solid retention time in the bowl can be increased by reducing the feed rate. According to Leung (2007 pp. 96), "decreasing feed rate increases the liquid residence time, and allows more efficient settling of suspended solids". This can be achieved by controlling the feed rate via the feed pump. This allows the solid to remain in the 'beach' area longer, allowing a clearer liquid. Chemical reaction: Gravitational and centrifugal sedimentation rates can be low when particle size of the feed slurry is very fine (Tarleton and Wakeman 2007). [6]

Bowl Speed-By varying the rotational speed of the bowl, the G-force can be adjusted to suit the application.The higher speed, the better separation. (Mannual Of alfa laval decanter 3.5)Depending on the feed waste and the desired treatment outcome, operation of a decanter can be optimized by changing the bowl speed (revolutions per minute, rpm), also known as the rotational speed. the larger the bowl diameter and the bowl speed, the higher the G force (also known as centrifugal force)[7]

Differential speed- The dryness of the cake can be increased when operating with a lower differential speed, but the separated liquid will be less clear and vice versa. The torque increases with the lower Δn (the difference in speed between bowl and screw conveyer. The differential speed can be regulated automatically to compensate for varying content of solids in the feed. Scroll speed (conveyor speed): The screw conveyor (scroll) rotates at a different speed than the bowl. The scroll scrapes the solids away from the sides of the bowl, and then conveys them in the opposite direction to the dry area of the bowl. By lowering the differential speed, this will increase residence time of the solid, thereby increasing dryness of the sludge cake.[8]

Liquid level & Differential Speed- Adjust the liquid level (pond depth) to give the optimal balance between liquid clarity and solids dryness by selecting different plate dams. In general terms, the separated liquid becomes more clear and the cake more wet when diminishing the liquid radius and vice versa. The drying area is an inclined section of the bowl where further dewatering occurs before it is discharged. Weir plates (also known as the overflow weirs) can be changed for different applications to determine the depth of the pond. A smaller weir height or a shallow pond depth leads to a decrease in residence time for the slurry, which gives rise to a decrease in liquid quality but a dryer solid (Porteous 1990; Leung 2007)[9]

Preparation of slurry-For extraction of Soya grits and water is taken at 1:10. And mix well with blender and pass to slurry tank and agitate the slurry for 1 hr at very low RPM so that less foam will occur. Here 25% NaOH is added slowly till pH is 9 to 9.5

Pilot Scale Trials – For Soya protein extraction, Soya grits and water is taken in 1:10. And mix well with blender and pass to slurry tank and agitate the slurry for 1 hr at very low RPM so that less foam will occur. Here 25% NaOH is added slowly till pH is 9 to 9.5. after this slurry is passed to the decanter through the dosing pump at a different flow rate so that it can be optimized. with the different flow rates, bowl speeds, differential RPM, and dam plate trials done. . after the slurry tank slurry is passed to the decanter where solid and liquid get separated and liquid is passed to UF and in UF Diafiltration is done and Retentate slurry passed to spray dryer and we gets Soya protein. the optimization is required in unit operation decanter and UF because here protein is getting extracted from the different trial liquid samples collected at mid-time of the process. the liquid was taken to the glass tubeand weigh the 100 grams and run with a lab centrifuge at the same RPM(on a trial run)for 20 min. and after that total, suspended solids were observed and supernatants were removed from the glass tube and weighed the weight of TSS and note down. and further data analysis was done by Python. To optimize the decantation process by varying the parameter concerning each other and trial conducted and data collected.

Parameter	Value
Trial No.	1
Feed Flow rate(LPH)	350
Bowl Speed(RPM)	4400
Differential RPM	18
Dam Plate	R61
Moisture in solids(%)	88.28
TSS(per 100 grams)	5.75

Trial No. 01

Parameter	Value
Trial No.	2
Feed Flow rate(LPH)	330
Bowl Speed(RPM)	4550
Differential RPM	17
Dam Plate	R61
Moisture in solids(%)	87.76
TSS(per 100 grams)	5.36

Trial No. 02

Parameter	Value
Trial No.	3
Feed Flow rate(LPH)	300
Bowl Speed(RPM)	4670
Differential RPM	16
Dam Plate	R61
Moisture in solids(%)	86.05
TSS(per 100 grams)	4.99

Trial No. 03

Parameter	Value
Trial No.	4
Feed Flow rate(LPH)	270
Bowl Speed(RPM)	4780
Differential RPM	15
Dam Plate	R61
Moisture in solids(%)	85.6
TSS(per 100 grams)	4.15

Trial No. 04

Parameter	Value
Trial No.	5
Feed Flow rate(LPH)	250
Bowl Speed(RPM)	4880
Differential RPM	14
Dam Plate	R61
Moisture in soilds(%)	84.7
TSS(per 100 grams)	3.87

Trial No. 05

Parameter	Value
Trial No.	6
Feed Flow rate(LPH)	210
Bowl Speed(RPM)	4950
Differential RPM	13
Dam Plate	R62
Moisture in solids(%)	83.6
TSS(per 100 grams)	2.87

Trial No.06

Parameter	Value
Trial No.	7
Feed Flow rate(LPH)	190
Bowl Speed(RPM)	5050
Differential RPM	12
Dam Plate	R62
Moisture in solids(%)	82.99
TSS(per 100 grams)	2.45

3.5.3.7 Trial No. 07

Parameter	Value
Trial No.	8
Feed Flow rate(LPH)	170
Bowl Speed(RPM)	5100
Differential RPM	11
Dam Plate	R62
Moisture in solids(%)	81.47
TSS(per 100 grams)	1.99

3.5.3.8 Trial No. 08

Parameter	Value
Trial No.	9
Feed Flow rate(LPH)	160
Bowl Speed(RPM)	5150
Differential RPM	10
Dam Plate	R62
Moisture in solids(%)	81
TSS(per 100 grams)	0.5

3.5.3.9 Trial No. 09

Parameter	Value
Trial No.	10
Feed Flow rate(LPH)	150
Bowl Speed(RPM)	5200
Differential RPM	10
Dam Plate	R62
Moisture in solids(%)	80.02
TSS(per 100 grams)	0.02

3.5.3.10 Trial No.10

Figure 6.4.3 All Trial

After the different trial by varying the parameter it investigated in Trial No. 10 that lower feed rate, differential RPM and higher bowl speed gives better separation. By varying different parameter have different results.

7. RESULTS AND DISSCUSION

Optimization of Decantation Process

The last 10 trials were conducted and found that at the lower feed flow rate, differential RPM ad with higher bowl speed better separation, and lower TSS is achieved.

Trial No.	Feed Flow rate (LPH)	Bowl Speed (RPM)	Diffrential RPM	TSS (per 100 gram)	Moisture in soilds%	Dam Plate
1	350	4400	18	5.75	88.28	R61
2	330	4550	17	5.36	87.76	R61
3	300	4670	16	4.99	86.05	R61
4	270	4780	15	4.15	85.6	R61
5	250	4880	14	3.87	84.7	R61
6	210	4950	13	2.87	83.6	R62
7	190	5050	12	2.45	82.99	R62
8	170	5100	11	1.99	81.47	R62
9	160	5150	10	0.5	81	R62
10	150	5200	10	0.02	80.02	R62

Table 7.1 Data of all Trial

Effect of changes in feed flow rate on TSS: The lower the feed rate, the better separation. If the flow rate is high then there will be a chance of higher TSS because of Lower residence time. This is can be investigated in our trial by decreasing the feed rate lower TSS Observed.

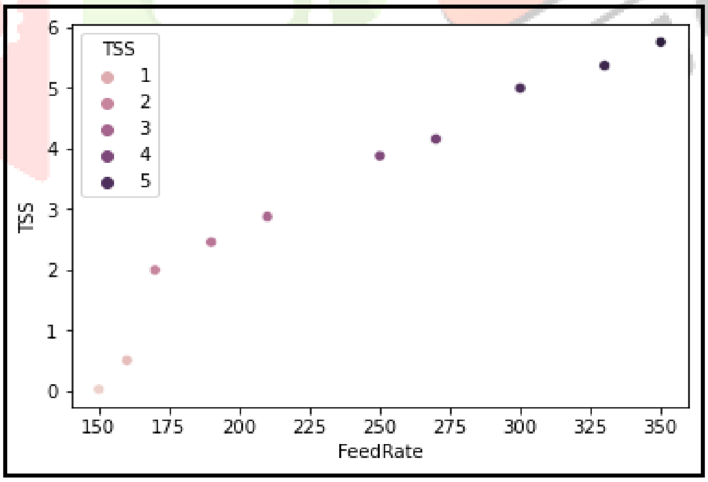

Figure 7.2 Effect of changes in feed flow rate on TSS

Effect of changes in bowl speed on TSS: By varying the rotational speed of the bowl, the G-force can be adjusted to suit the application. The higher speed, the better separation. This is can be observed in our trial by increasing the bowl speed lower TSS Observed. (Mannual Of alfa laval decanter 3.**5).**

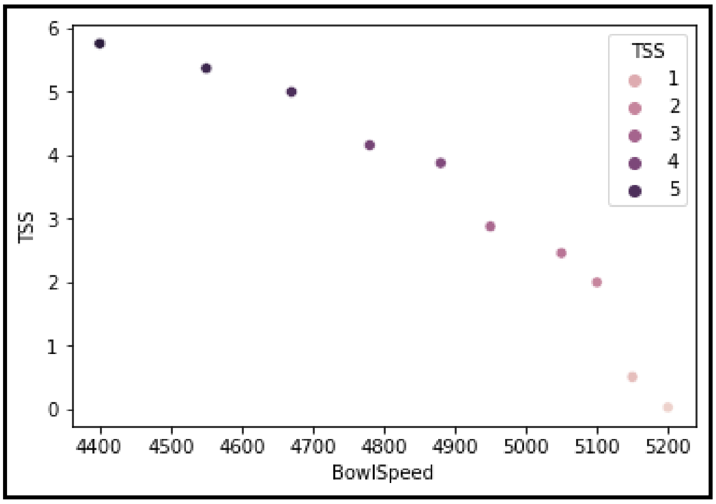

Figure 7.3 Effect of changes in Bowl Speed on TSS

Effect of changes in differential speed on TSS: The dryness of the cake can be expanded while working with a lower differential speed, yet the isolated fluid will be less clear as well as the other way around. The force increments with the lower Δn (the distinction in speed among bowl and screw transport. The differential speed can be managed naturally to make up for fluctuating substance of solids in the feed. Scroll speed (transport speed): The screw transport (scroll) turns at an unexpected speed in comparison to the bowl. The parchment scratches the solids from the sides of the bowl and afterward passes them the other way onto the dry region of the bowl. Bringing down the differential speed will increment the home season of the strong, consequently expanding the dryness of the slop cake. By the diminishing differential RPM less TSS was Observed.[10]

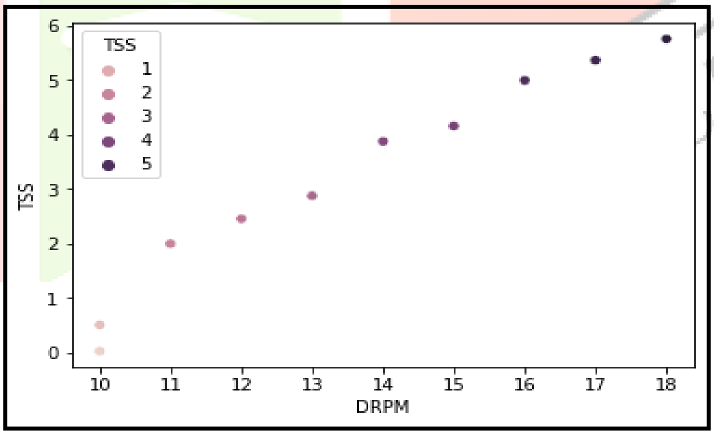

Figure 7.4 Effect of changes in Differential RPM on TSS

8. CONCLUSIONS

1. After all the experiments, it was found that there was good separation at the low flow rate, low differential speed, and high bowl speed. At 150 LPH, Differential speed 10 and 5200 RPM was the optimized parameter, But this parameter was only for Soya Protein for other Proteins it depends on the Viscosity of feed material, the particle size of feed material, feed and water ratio and other parameters

2. After performing all the experiments, it was found that trial no. 10 had less TSS. So that there will be no problem in performing the next unit operation. And We will not need one more unit operation and the overall cost of the process will be reduced

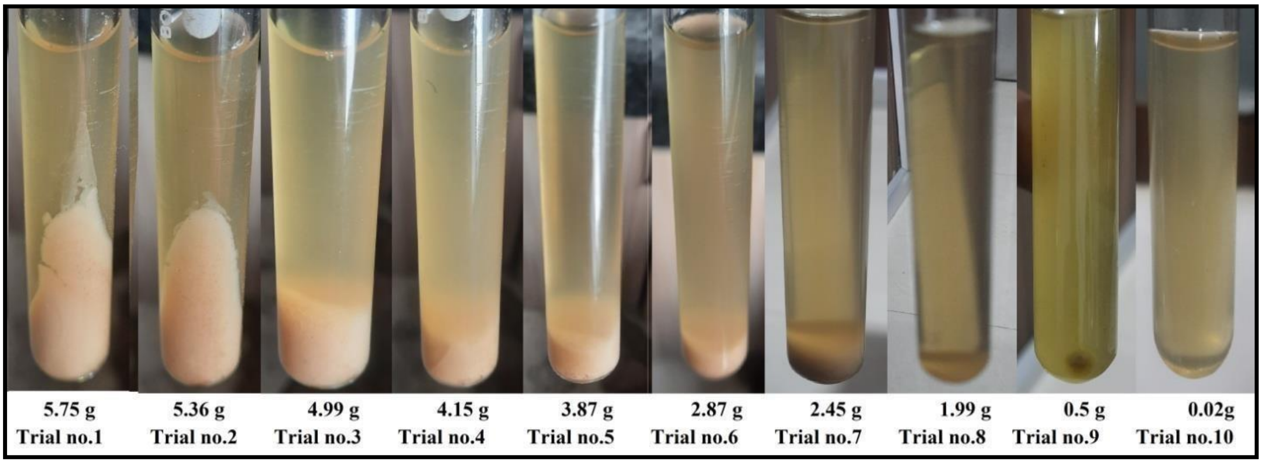

Figure 8.2 all Experiments

3. After getting very low TSS and clear Liquid it is an advantage for a further unit operation like UF, NF, and RO because less TSS and Clear liquid are required for the Membrane separation because if higher TSS and Unclear liquid is there then

1. It will reduce the life & performance of membrane unit
2. Yield reduction and undesired product.
3. High pressure required which is notrecommended
4. Operation time will be increased.
5. Need for one more separation unit.

4. With the help of Python it is very to interpret the data and make some conclusions so it was so helpful for further analysis.

5.After getting the data, all the data was analyzed with Python, from which Correlation data , Graph, and Plot were obtained which so helpful to optimize the process. the python data & Machine Learning can help in predicting the scale up and to optimized parameters

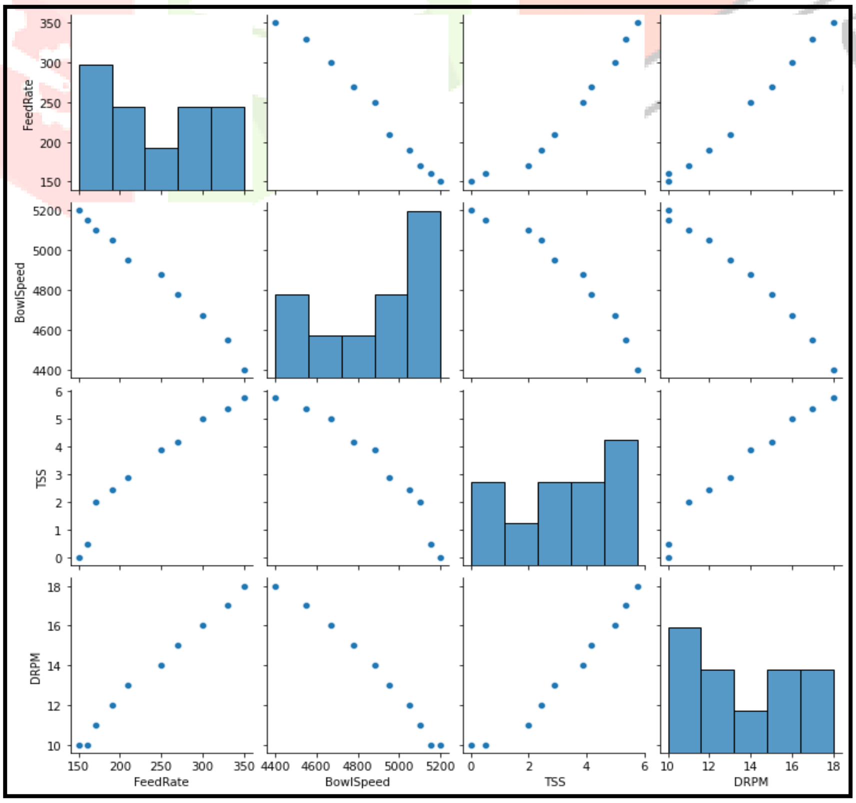

Figure 8.5 Pair plot for all the parameter

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