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# Optimize the Power of Stirrer Mixing in Lab Scale Enzymatic Degumming Process to Scale-Up

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## ABSTRACT

*Generally crude oil is obtained by solvent extraction and requires a series of operation known as refining before it is suitable for human consumption. Refining, which removes the free fatty acid (FFA) and reduce phosphatide (Gum) content in crude oil is used to produce edible oil. Refining of crude oil includes neutralization and degumming. Degumming is an important step in oil refining process and removes phosphatide along with some other unwanted minor compounds without destroying the beneficial ones. The degumming process is hydrolyzes the non-hydratable phosphatide converting it to hydratable phosphatide; this facilitates removal of gum with water phase by centrifugation. High phosphatide containing oil like soybean oil (700ppm) water alone is not satisfactorily to reduce the phosphatide content below 10ppm. Therefore degumming process is used together with enzyme with stirrer mixing which speedup the reaction. The power consumed by stirrer (Kw) was fitted with diameter ratio of vessel and stirrer (χ) which yield effective relationship of y = 72.357 χ -0.3357 (R2 = 0.9855), where the dimensionless number χ is always greater than one. This result could be used for scale-up condition of industrial mixing processes because the variable factor assigned as dimensionless number. The optimum power was achieved as 50.79 Kw/Lit where the diameter ratio of three (3.00) at the constant parameters of crude oil 1litre, enzyme 4000 LEU, mixing speed 1000 rpm, peddle type stirrer (Φ = 40mm), viscosity of 0.0322 Kg/m.s, density of 930 kg/m3, with constant temperature at 40 0 C in water bath.*

**Keywords:** *Refining, Phosphatide (Gum), free fatty acid (FFA), Neutralization and Degumming,*

## INTRODUCTION

Degumming is an important step in oil refining process and removes phosphatide (gum) along with some other unwanted minor compounds without destroying the beneficial ones. Gums tend to produce high refining losses, foaming, settling and discoloration of oil in processing and storage Degumming achieve this level and required to remove the non-hydratable phospholipids. Later refining process however requires phosphatide content to be less than 10 ppm as they affect the vacuum distillation process at higher level.

By removing these undesirable components the stability of soybean oil is increased. (P. Eickhoff, 2000). High phosphatide containing oil like soybean oil (700ppm) water degumming alone is not satisfactorily to reduce the phosphatide content below 10ppm. Therefore enzymatic process is used together with water degumming. Here target level of gum removal was attempted by using microbial enzyme (Lecitase Novo) secreted by Aspergillus orizae combine with water degumming under optimum condition with mixing (Novo Nordisk (2000).The power supplied to a mixer is usually in the form of electricity to operate the stirrer. Measuring amperes (A) or watts (W) at the motor is not a good way to determine power drawn by the impeller. The most practical way to estimate power is to use a Reynolds number verses power number curve for the impeller involved and measuring the viscosity and density.

Two different impellers yield the same minimum power at different diameter ratio of vessels and stirrer (D/T) for a given process. Diameter ratio of vessels and stirrer variation was responsible for the mixing time variation, which variables contribute mixing nature.

Power is proportional to impeller diameter to some exponent x. Power is proportional to Dx (P α Dx), x can have a value from 0 to –3 and Dv/Ds ratio of approximately three (3) is most effective. (Oldshue, 1983)

### The Specific Objective of This Work

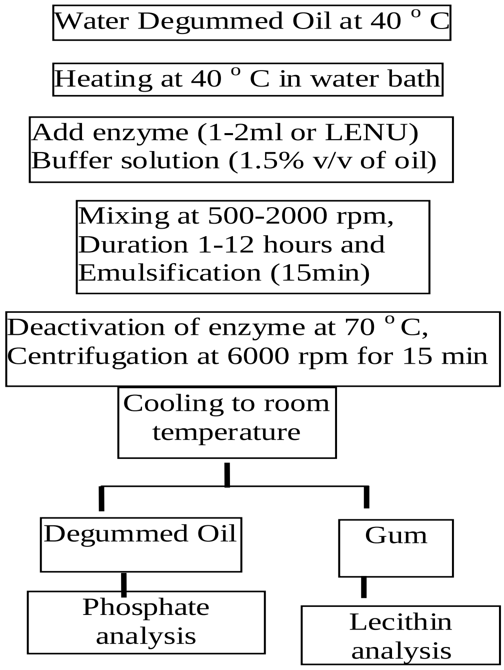
- To fit a mixing power consumption modal for the scale up enzymatic degumming of Soybean oil.

## METHOD AND MATERIALS

### Enzymatic Degumming of Crude Soybean Oil

In this experiment the optimum power consumption of stirrer involved mixing was investigated from power consumption at various diameter ratios of mixing vessel and stirrer. Power consumption per unit volume (Kw/Lit) of oil was calculated by calculating power number through Renold's number in particular mixing condition and stirrer.

Total mixing power was calibrated by multiplying unit power into time consuming to the level of phosphatide content less than 10 ppm. Renold's number was calculated at constant set of conditions of stirrer involved mixing. Explained in Flow chart1




**Flow Chart1.** *Enzymatic degumming process*

Degumming time was calculated in particular speed of mixing, diameter ratio, and buffer solution at constant temperature. Total power consumption was calculated by multiplying unit power by time consumed by mixing.

In the enzymatic Degumming process, all these constant conditions are Crude soybean oil 0.5 liters, 1.5% of water, 1.5% Buffer and Lecitase Novo with neutral pH, temperature 40oC, and mixing speed of 1000 rpm with various Dv/Ds ratio vessels, the mixing time is measured at achievable level of phosphatide (< 10 ppm).

Series of viscosity are measured under constant temperature (40oC) at various rotational speeds (rpm) in brook field viscometer density. Calculation was based on same amount of (10ml) of oil at same temperature divided by same amount of water (10ml), in specific gravity bottle, which gives density of oil at various stages.

### Mixing Power Consumption Calibration in Degumming

In this experiment diameter of vessels over stirrer ratios are plotted against power per unit volume. In the power calculation Reynolds number (NRe) was calculated by the constant parameters of diameter of stirrer (Di), rotational speed (Ni), density of oil (ρ) and viscosity of oil (η). Power number (Np) was calculated by using the NRe – Np graph for the particular paddle type stirrer.

Total power consumption was calculated by the power per unit time multiply by time requirement for the degumming (Phosphate level blow 10 ppm).The mixing power required depends on the impeller type and size, and on properties of the fluid. These are usually grouped into the dimensionless parameter called the power number, Np. is expressed as Np = P / ρ* Ni3 *Di5. The relationship between Rei and Np has been determined for a number of mixing impeller as displayed in Figure I.

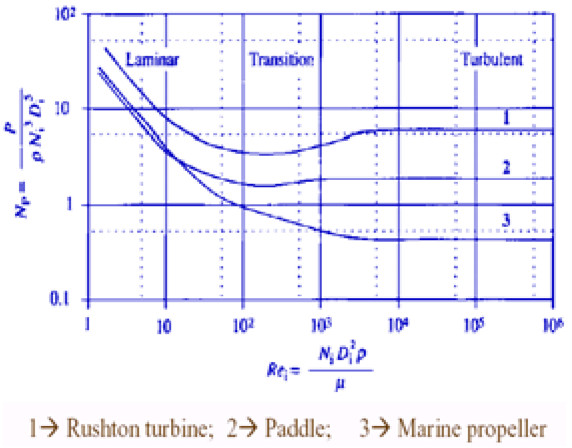



**Figure1.** *Mixing power for un-gassed Newtonian fluids*

## RESULT AND DISCUSSION

Power requirement per unit time (Watts) is calculated in the table 1.Power relationship was found to be most effective to fit in the graph of power modal presented in figure II, where its slope and power was calculated to be 72.357 χ – 0.3357 with regression of 0.9855. Power was proportional to impeller diameter to exponent x.

**Table1.** *Power requirement calculation*

| $N_{Re}$ = (N * $Ds^2$ * Den) / Viscosity Where | |
|---|---|
| Rotational speed (N) | 1000 rpm |
| Diameter of stirrer (Ds) | 0.04 M |
| Density (DEN) | 930 Kg/m3 |
| Viscosity of oil (VIS) | 0.0322 Kg/M.s |
| Re | 770.18 |
| Np (From Np-$N_{RE}$ figure ) | 3.00 |
| Unit power calculation P = Np * DEN * $N^3$ * $Ds^5$= 1.32 Watts | |

The optimum power was achieved as 50.79 Kw/Lit where the diameter ratio of 3.00 at the constant parameters at table 3. Power is proportional to diameter ratio Dx (P α Dx) and x can have a value from -0.3357. In this experiment Dv/Ds ratio was changed from 1.25 to 3 shown in table 2. Above this ratio limit proper mixing was not possible (Spill effects). A Dv/Dt ratio of approximately 3 was more effective than other ratios.

**Table2.** *Diameter ratio of vessel and stirrer*

| Diameter of vessels (mm) | 50 | 60 | 80 | 90 | 100 | 120 |
|---|---|---|---|---|---|---|
| Demeter of stirrer (mm) | 40 | 40 | 40 | 40 | 40 | 40 |
| Ratio (Dv / Ds) | 1.25 | 1.50 | 2.00 | 2.25 | 2.50 | 3.00 |

**Table3.** *Total power consumption of degumming oil*

| **Unit power** | **1.32 Watts** | | | | | |
|---|---|---|---|---|---|---|
| Vessel Diameter | 50MM | 60MM | 80MM | 90MM | 100MM | 120MM |
| Time (sec) | 25200 | 24300 | 21600 | 20700 | 19800 | 19200 |
| Power (KW) / Lit | 66.66 | 64.28 | 57.13 | 54.75 | 52.37 | 50.79 |

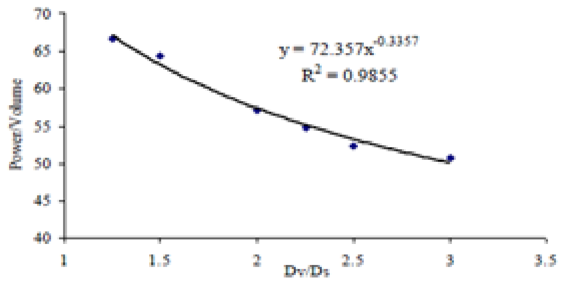



**Figure2.** *Power unit volume (KW/Lit) diameter ratio (Dv/Ds) relationship*

## Conclusion

This experiment expressed the power consumed by stirrer was fitted with dimensionless number of diameter ratio of vessel and stirrer (Dv/Ds) which yield effective relationship of Y = 72.357 χ -0.3357 (R2 = 0.9855). The optimum power was achieved as 50.79 Kw/Lit where the diameter ratio of three (3.00) at the constant parameters of crude oil 1Litre, mixing speed1000 rpm, viscosity of oil , density of oil, peddle type stirrer with constant temperature at 400C in water bath. The result of the experiments could be used for scale-up condition in industrial processing.

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