Design & Analysis of Decanter Centrifuge Rotor using Ansys

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Abstract— A decanter centrifuge separates solid materials from liquids in slurry and therefore plays an important role in wastewater treatment, chemical, oil and food processing industries. By gravity separation, within matter of seconds the solid liquid gets separated. At high RPM of vane drum of centrifuge decanter, life of it very critical parameter. Almost 2000 rpm is the maximum ever found in decanter. But if industry eager to develop a decanter whose rpm is very high enough to separate almost most of the liquid from slurry then high rpm must be required and at high rpm damage must be verified. In this research paper, it is attempted to review how this can be done and its effect on the rotor design.

Key words: Decanter Centrifuge Machine, solid liquid separation, Rotor speed rpm

I. INTRODUCTION

A centrifuge is a device, which employs a high rotational speed to separate components of different densities. This is for industrial jobs where solids, liquids and gases are merged into a single mixture and the separation of these different phases is necessary. Since it is gravity separation, naturally, a component with a higher density would fall to the bottom of a mixture, while the less dense component would be suspended above it. Separation takes place in a horizontal cylindrical bowl equipped with a screw conveyor The feed enters the bowl through a stationary inlet tube and is accelerated smoothly by an inlet distributor. The centrifugal force that results from the rotation then causes sedimentation of the solids on the wall of the bowl. The conveyor rotates in the same direction as the bowl, but slightly slower, thus moving the solids towards the conical end of the bowl. The cake leaves the bowl through the solids discharge openings into the casing. Separation takes place throughout the entire length of the cylindrical part of the bowl, and the clarified liquid leaves the bowl by flowing over adjustable plate dams into the casing.

The separation process in a decanter centrifuge relies on a few process characteristics such as centrifugal force or Gforce, sedimentation rate and separating factor, differential speed between the conveyor and bowl, and clarity of the liquid discharge.

Decanter centrifuges require a centrifugal force for the separation of the solids from the liquid. This characteristic is dependent on the radius of the centrifuge and its angular rotational speed. Gforce is related to the gravitational acceleration and centrifugal acceleration inside the bowl. A decanter centrifuge applies a gravitational force of several thousand G, which reduces the settling time of the particles.

II. RELATED STUDIES ON DECANTER CENTRIFUGE MACHINE

Antonia Tamborrino , Alessandro Leone , Roberto Romaniello Pasquale Catalano , Biagio Bianchi (2014)[1] their work deals with a correlation between the mass flow rate, water ring levels and conveyor-bowl differential speed with respect to extracted efficiency, husk fat content and pulp water fat content. The decanter studied was found to maintain high values of extraction efficiency upto 86.5%.

Alessandro Leone , Roberto Romaniello , Riccardo Zagaria , Antonia Tamborrino, (2015)[2] developed mathematical models to predict the extraction efficiency and the oil content in the husk, wastewater and pâté as a function of the olive paste mass flow rate.

Giuseppe Altieri, Giovanni Carlo Di Renzo, Francesco Genovese (2003)[3] conducted trials for optimization of oil/water levels and differential speed during olive oil extraction.They conducted set of trials, using constant quality olives and an on-line system was built in order to control the olive paste mass flow rate fed to a decanter centrifuge.

H.B. Moller*, I. Lund, S.G. Sommer(2000)[4] their work deals with the comparison of mechanical screen separators and decanter centrifuges. They found that in comparison, decanting centrifuges were very efficient in removing Dry matter (DM) and Total Phosphorous (TP).

Bart Peeters & Stefan Weis(2004)[5] work shows that in Humbolt centrifuge machine there is an optimum pool depth at which the displacement of the mother liquid by washing liquid is highest, indicating that the efficiency of the displacement wash on the beach is very sensitive to the saturation profile of the cake.

George R.A.Bell , Digby D.Symons, John R.Pearse (2014)[6] developed mathematical model for solids transport power in a decanter centrifuge.The models were developed to calculate the power, torque and axial force required for the scroll to transport the solids along the bowl.

Giuseppe Altieri (2010)[7] compared two decanter centrifuges and based on experimental data, identified an empirical model of the decanter centrifuge suitable for use both as a comparison between two or more machines and as automatic control of the machine in order to adapt it to the olive paste.

Hongbin Liu, Pingying Li*, Huina Xiao, Weitao Mu (2015)[8] obtained pressure distribution under working conditions from CFX evaluation and gained equivalent stress and deformation under several load conditions by using the ANSYS Workbench platform to check the strength of conveyor. The results showed that the influence of centrifugal hydraulic pressure was less than that of centrifugal force on the strength and deformation of conveyor.

P. Catalano1; F. Pipitone2; A. Calafatello2; A. Leone3(2003) [9] conducted experimental trials carried out on third-generation, variable dynamic pressure cone decanters to assess machine performance and adjust the process parameters for optimum extraction yield. The results obtained led to the conclusions like: the regulation of the differential velocity screw/bowl allows a better performance

of the decanter at low dilutions of the olive paste; it is possible to obtain high efficiency at a low dilution of the olive paste achieving a higher minor compounds content and the more advanced system of regulation leads to better results according to the variations of the ratio between liquid and solid phases, thus optimizing operational performances in relation to the rheological features of olive pastes.

E.P. Giannoutsou, C. Meintanis, A.D. Karagouni,(2004)[10] investigated on the identification of yeast strains isolated from a two-phase decanter system olive oil waste and investigation of their ability for its fermentation.

Wallace W.-F. Leung, Ascher H, Shapiro. (1996)[11] worked upon the Improved Design of Conical Accelerators for Decanter and Pusher Centrifuges. More effective cone accelerator was described which has forward-curved vanes that produce over speeding and a final unvaned section of cone - called a smoothener – which smears out the jets from the vanes into a nearly uniform conical sheet. Model tests in the laboratory were used for developing the new accelerator technology.

Articleno.	Auther(s)	Decanter Used	Ingredients Separated	Research Methodology	Database
1	Antonia Tamborrino, Alessandro Leone, Roberto Romaniello Pasquale Catalano, Biagio Bianchi (2014)	Horizontal Centrifuge Decanter	Olive oil extraction and separation	A correlation between the mass flow rate, water ring levels and conveyor-bowl differential speed with respect to the extracted efficiency, husk fat content and pulp water fat content was evaluated.	Elsevier
2	Alessandro Leone, Roberto Romaniello , Riccardo Zagaria, Antonia Tamborrino, (2015)	Eureka - with water and without water configuration.	Olive oil extraction and separation	Mathematical models were developed to predict the extraction efficiency. The decanter was also demonstrated to be able to switch from one configuration to the other without stopping operation	Elsevier
3	Giuseppe Altieri, Giovanni Carlo Di Renzo, Francesco Genovese (2003)	Horizontal centrifuge with a screw conveyor.	Olive oil extraction and separation	an automatic system was setup to control the olive paste mass flow rate fed to a decanter centrifuge during olive oil extraction. Also a feedback control system was tested in the laboratory and built in-line in an industrial processing plant.	Elsevier
4	H.B. Moller*, I. Lund, S.G. Sommer (2000)	Decanter centrifuge and mechanical separator screens compared.	Solid±liquid separation of livestock slurry	Calculation of separation efficiency of both decanter centrifuge and mechanical screen separators.	Elsevier
5	Bart Peeters & Stefan Weis (2004)	Humboldt VS 900 x 1800 solid bowl decanter	Recover acetates from polymer slurry	Pool depth optimization and its effect on amount of separation was calculated.	Elsevier
6	George R.A.Bell , Digby D.Symons, John R.Pearse (2014)	Decanter centrifuge with the four zones within the bowl.	Transport of sedimented solids within a decanter centrifuge	Mathematical model was developed to calculate torque and axial force required for the scroll to transport the solids along the bowl. A relationship for the axial force on the scroll is also derived.	Elsevier
7	Giuseppe Altieri (2010)	Two decanter centrifuges were compared and based on our experimental data	Oil extraction	Empirical model was formed suitable for use both as a comparison between two or more machines and as automatic control of the machine in order to adapt it to the olive paste.	Elsevier

8	Hongbin Liu, Pingying Li*, Huina Xiao, Weitao Mu (2015)	M-2301-type horizontal screw decanter centrifuge	To push and separate the sediment.	Applied FLUENT software to simulate the fluid flow situation in the centrifuge drum and obtain the solid concentration distribution.	KeAI Advance Research Involving science - Petroleum Journal
9	P. Catalano1; F. Pipitone2; A. Calafatello2; A. Leone3 (2003)	Third-generation, variable dynamic pressure cone decanters	Oil extraction	Experimental trials carried out to assess machine performance and adjust the process parameters for optimum extraction yield.	Elsevier
10	E.P. Giannoutsou, C. Meintanis, A.D. Karagouni, (2004)	A two-phase decanter system	Olive oil extraction	A dynamic fed-batch microcosm system developed to measure the effects of the growth of yeast strains upon the chemical composition of Alpeorujo- the waste of a two-phase decanter system used for the extraction of olive oil.	Elsevier
11	Wallace W.-F. Leung, Ascher H, Shapiro. (1996)	Conical Accelerators for Decanter and Pusher Centrifuges	Solid liquid slurry	Model tests in the laboratory were used for developing the new accelerator technology.	Paper presented at the American Filtration & Separations (AFS) Society Annual Conference in USA

Table 1. Articles included in the literature review

III. Conclusion

Literature review indicates that the analysis of decanter centrifuge machine is attempted by various investigations for various conditions. Literature survey shows that there are so many analyses observed with decanter centrifuge rotor, vane drum, etc but there is no attempt made with analysis and optimization of rotor speed specifically. Hence Design and Analysis of centrifuge rotor using ANSYS is an interesting area for investigation.

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References

[1] Antonia Tamborrino, Alessandro Leone, Roberto Romaniello Pasquale Catalano, Biagio Bianchi, (2015) Comparative experiments to assess the performance of an innovative horizontal centrifuge working in a continuous olive oil plant. Biosystems Engineering Journal, ISSN - 15375110, 129, pp-160-168.

[2] Alessandro Leone, Roberto Romaniello, Riccardo Zagaria, Antonia Tamborrino (2015) Mathematical modelling of the performance parameters of a new decanter centrifuge generation. Journal of Food Engineering, ISSN - 0260-8774, 166, pp-10-20.

[3] Giuseppe Altieri, Giovanni Carlo Di Renzo, Francesco Genovese, (2013) Horizontal centrifuge with screw conveyor (decanter): Optimization of oil/water levels and differential speed during olive oil extraction.. Journal of Food Engineering, ISSN 0260-8774, 119, pp-561 – 572.

[4] H.B. Moller*, I. Lund, S.G. Sommer (2000) Solid-liquid separation of livestock slurry: efficiency and cost. Bioresource Technology,ISSN 0960-8524/00, 74, pp 223 – 229.

[5] Bart Peeters & Stefan Weis (2004) Relationship between pool depth and internal washing on the beach of a solid bowl decanter centrifuge. Research Article, July 2004, ISSN 0015-1882/04, pp 36 – 40 .

[6] George R.A.Bell , Digby D.Symons, John R.Pearse (2014) Mathematical model for solids transport power in a decanter centrifuge.Chemical Engineering Science Journal 107, ISSN-0009-2509, pp - 114 - 122.

[7] Giuseppe Altieri (2010). Comparative trials and an empirical model to assess throughput indices in olive oil extraction by decanter centrifuge. Journal of Food Engineering 97 (2010), ISSN - 0260-8774, pp - 46 -56.

[8] Hongbin Liu, Pingying Li*, Huina Xiao, Weitao Mu (2015) The fluidesolid coupling analysis of screw conveyor in drilling fluid centrifuge based on ANSYS. Petroleum Journal xxx (2015), ISSN - 2405-6561, pp-1-6.

[9] P. Catalano1; F. Pipitone2; A. Calafatello2; A. Leone3 (2003) Productive Efficiency of Decanters with Short and Variable Dynamic Pressure Cones. Biosystems Engineering (2003) 86 (4), ISSN: 1537-5110, pp-459–464

[10] E.P. Giannoutsou, C. Meintanis, A.D. Karagouni, (2004). Identification of yeast strains isolated from a two-phase decanter system olive oil waste and investigation of their ability for its fermentation .Bioresource Technology 93, ISSN- 0960-8524, pp - 301-306.

[11] Wallace W.-F. Leung, Ascher H, Shapiro. (1996) Improved design of conical accelerators for Decanter and Pusher Centrifuges, Research paper presentation at American Filtration & Separations (AFS) Society Annual Conference in Valley Forge, Pennsylvania, USA on 21-24 April 1996. Pp 735 - 738.

