ANALYSIS OF MOISTURE REMOVAL EFFICIENCY AND PARTICLE SIZE DEVELOPMENT INSIDE FLUIDIZED BED DRYING PROCESS AT A FULL CREAM MILK POWDER MANUFACTURING PLANT IN SRI LANKA

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Sustainable Process Engineering

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August 2023

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ABSTRACT

Milk powder manufacturing can be identified as one of the leading industrial processes in the global dairy sector for cow milk preservation with nutrition purposes and processing as a raw material for many other food processing applications. The global milk powder market has already reached 11.2 million tonnes in 2020 and is expected to reach a volume of 14.1 million in 2026. Milk Powder is manufactured by dehydrating liquid milk by removing free moisture with some amount of bound moisture and leaving only milk solids by falling film evaporation and multi-stage drying processes. Milk powder has an extremely long shelf life when compared to raw milk and does not need refrigeration. This manufacturing process includes many chemical engineering unit operations, such as falling film evaporation, flash evaporation, direct steam injection, thermal vapor recompression, spray drying, fluidized bed drying, dehumidification, cyclone separation, screening, mixing, centrifugal separation, pasteurization, homogenization, etc. Drying processes play a significant role in the desired removal of moisture which will help particle size improvements as well as final milk powder quality parameter improvements.

Multi-stage drying processes are included in milk powder manufacturing for moisture removal. Three-stage dryers, as well as two-stage dryers are widely used in the process industry to achieve desired moisture removal with improved quality parameters. The two-stage drying process, which is a combination of spray drying and fluidized bed drying processes are widely used in Sri Lankan milk powder manufacturing plant operations. Among these two drying processes, the fluidized bed drying process will directly help to improve the particle diameter as well as desired final milk powder quality parameters like wettability, insolubility index, bulk density, etc.

In this study, the existing literature on the milk powder manufacturing process and fluidized bed dryer operations, including moisture removal were reviewed and analysed. In this study, the moisture removal process of a fluidized bed dryer is analysed with the aim of identifying the reason behind less solubility of produced full cream milk powder in hot water. Fluidized bed dryer operation can be identified as the main unit operation of the entire manufacturing process which directly helps to improve the final product quality parameters like particle diameter, insolubility index, wettability, bulk density, etc. To analyse the moisture removal process of full cream milk powder, samples were collected from the inlet of the fluidized bed dryer, from the heating section, and from the cooling section, as well as the full cream milk powder outlet. Moisture removal activity is compared with the design parameters of the equipment and reviewed the moisture removal gradient to predict the improvement of particle diameter which directly affect the solubility characteristics.

In addition, final milk powder product particle size improvement in each section of the fluidized bed dryer were analyzed and compared with the literature values to have a sound idea about quality improvements. This study shows that the moisture removal process is the key process operation, which determines the final product quality related to the solubility and particle size development of full cream milk powder. The study identifies a relationship between the moisture removal process as well as gradual particle size development along the fluidized bed that would support the related industries in Sri Lanka to improve the full-cream milk powder manufacturing process.

Keywords: Multi-effect Falling Film Evaporation, Spray Drying, Fluidized Bed Drying, Moisture Removal, Particle Development.

DEDICATION

This thesis is dedicated to my research supervisor Dr. Mahinsasa Rathnayake, who taught me that teachers go beyond textbooks and inspire from the heart.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my research supervisor Dr. Mahinsasa Rathnayake for the immense guidance, motivation and knowledge to steer me in the right direction whenever he thought I needed it.

I would also like to thank Prof. Mahinsasa Narayana, Dr. Ashok Fonseka, Prof. Padma Amarasinghe, Prof. P.G Rathnasiri, Prof. Shantha Amarasinghe and all the lecturers who have supported me throughout my MSc study. Without their passionate teachings and help, I could not have successfully completed my MSc degree.

Finally, I must express my very profound gratitude to my family for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CCP	Critical Control Point
DSI	Direct Steam Injection
FBD	Fluidized Bed Dryer
FCMP	Full Cream Milk Powder
SEM	Scanning Electron Microscope
SMP	Skim Milk Powder
SNF	Solid Non-Fat
TS	Total Solids
TVR	Thermal Vapor Recompression
VS	Vapor Separator
WMP	Whole Milk Powder