UNIVERSITI TEKNOLOGI MARA

MODELLING AND OPTIMISING THE NEXUS BETWEEN OPERATING PARAMETERS OF COMBINE HARVESTER AND GRAIN LOSS DURING HARVEST IN MALAYSIAN PADDY FIELD

NOR AZI ASMINDA BINTI JOHARI

Thesis submitted in fulfillment
of the requirements for the degree of
Doctorate of Philosophy

Faculty of Plantation and Agrotechnology

November 2022

ABSTRACT

Paddy cultivation is one of the largest contributors to feeding Malaysian since it serves as a staple food. Harvesting is the most critical factor that should be given big attention in paddy cultivation since it directly affects the grain loss in the field. During the operation, improper management of some operating parameters, such as combine harvester handling and crop physiological factors, may lead to excessive grain loss. Five operating parameters usually affect the grain loss (GL), namely field speed (FS), grain moisture content (GMC), soil moisture content (SMC), soil compaction (SC), and cutting height (CH). However, the relationship between grain loss and these operating parameters of mechanized rice harvesting in Malaysia is rarely studied. Thus, the study was conducted to investigate the effect of these operating parameters on grain loss during the mechanized rice harvesting operation. Modelling and optimizing the significant operating parameters for predicting grain loss were also developed. Besides that, the simulation of the control system using MATLAB was designed based on the developed predictive empirical model for minimizing grain loss and evaluating the field performance of the rice combine harvester during harvesting operations. Lastly, the spatial variability maps towards the significant operating parameters and grain loss were also visualized. To collect the data, daily paddy harvesting operations with New Holland Clayson 8080 combine harvester were observed at rice granaries in the Sekinchan district of Selangor state of Malaysia through a field observation measurement method on December 2017. The total grain loss was measured based on the header loss test and processing loss test. Results from statistical analysis proved that operating parameters have highly significant effects on grain loss. A new predictive empirical model of grain loss with related operating parameters was successfully developed with a high correlation between the involved parameter using regression analysis of $GL=3.941+0.547FS-0.041GMC+0.01SC-0.018SMC+0.022CH$ ($R^2=0.986$). The optimization was also successfully made by developing a control system and then transforming it into a block diagram with the help of Simulink tools in MATLAB software. The findings also found that the best FS operating in the damp soil condition of 55% moisture content and 469 kPa compaction was 2.23 km/h at 45 cm cutting height. With the best operating field conditions during harvesting operations, the grain loss contributes 4.59%, which equals RM421.66/ha (USD 93.69/ha) income loss. The dispersal of the spatial variability of yield maps displayed the grain loss and other related operating parameters. The developed control system, which is transformed into the block diagram with the help of Simulink tools in MATLAB software, has successfully demonstrated a conceptual model-based design with real-time system execution. Conclusively, this study would be beneficial in assisting rice farmers in predicting grain loss during mechanized harvesting by considering the parameters mentioned earlier. Indirectly, it may also help increase paddy yields by reducing excessive losses during harvesting.

ACKNOWLEDGEMENT

Firstly, I thank Allah for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My deep sense of gratitude, sincere appreciation, and high indebtedness to my supervisor Dr. Darius El Pebrian, Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, for the invaluable guidance, untiring assistant, constant encouragement and constructive advice throughout the study. His supervision has carried me to complete both my Master's and PhD studies with flying colors.

My appreciation goes to the undergraduate student, Miss Rohaida Mohamed, who has contributed indirectly during the data collection. A special thanks to the villagers in Sungai Besar, Selangor, including the farmers, field supervisor, brokers and harvester operators, for permitting us to conduct the data collection in their area. The experience was memorable!

I would like to profound gratitude and deepest appreciation to my beloved family, especially to my mother, Maznah Binti Mamat, and father, Johari bin Daud for the vision and determination to educate me. Not to forget my beloved siblings, who never stopped for their unfailing prayers, encouragement, and dedicated efforts to educate me up to this level. Since I am the eldest, I need to prove that nothing is impossible!

Last but not least, thanks to those not mentioned here for their contribution to completing this study.

Finally, this piece of victory is dedicated to my beloved family. Alhamdulilah!

TABLE OF CONTENTS