



UNIVERSITI PUTRA MALAYSIA

EMPIRICAL MODELING, SIMULATION AND CONTROL OF SPRAY DRYING PROCESS USING NOZZLE AT OMIZER SPRAY DRYER

TAN LEE WOUN

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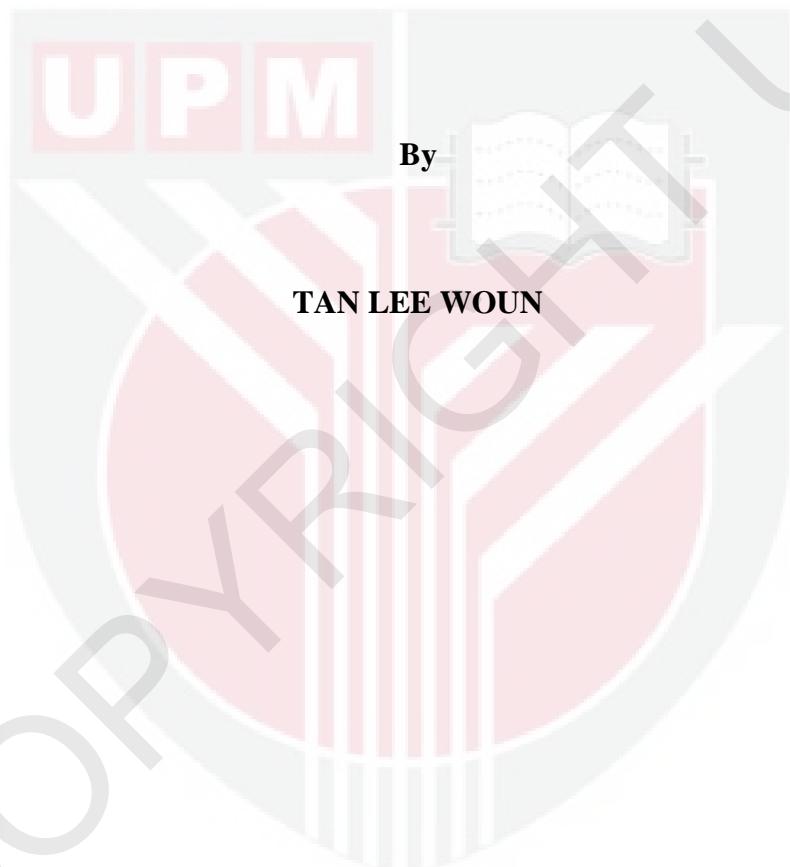
**EMPIRICAL MODELING, SIMULATION AND
CONTROL OF SPRAY DRYING PROCESS
USING NOZZLE ATOMIZER SPRAY DRYER**



**MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA**

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**EMPIRICAL MODELING, SIMULATION AND CONTROL OF SPRAY
DRYING PROCESS USING NOZZLE ATOMIZER SPRAY DRYER**



**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in fulfillment of the Requirement for the Degree of Master of Science**

December 2011

Specially dedicated to...

My loving parents...

My wonderful sister...

My friends...

for their supports and encouragements...



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment
of the requirements for the degree of Master of Science

**EMPRICAL MODELING, SIMULATION AND CONTROL OF SPRAY
DRYING PROCESS USING NOZZLE ATOMIZER SPRAY DRYER**

By

TAN LEE WOUN

December 2011

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Spray drying is a convenient dehydration technique in producing food powders. The characteristics of product depend on the drying parameters and characteristics of the liquid feed. Controlling the spray dryer is vital to ensure that the product meets the quality specifications, even when disturbance occurs. In order to control the spray dryer, the development of dynamic model is required. The main objective of this study is to investigate the dynamic behavior of the spray drying process and suggest the suitable control strategy using proportional-integral (PI) controller. Before developing the dynamic model, a preliminary study was conducted and the outlet air temperature was identified as the controlled variable and inlet air temperature as the manipulated variable. Dynamic models that gave the best prediction of the dynamic response of nozzle atomizer spray dryer for orange juice powder (with maltodextrin) and whole milk powder (without maltodextrin) were developed empirically. In addition, the models that show the effect of selected disturbance on the dynamic response of spray dryer was also developed. All models were represented as first

order plus time delay (FOPTD) and valid because $R^2 > 0.6$. Furthermore, the control of the spray dryer in this study engages a PI controller for the set point change and disturbance change. High overshoot is a problem in many processes, thus a lambda, λ guideline for direct synthesis tuning method was proposed to enable users to define the specified overshoot, and its performance and robustness were found to be satisfactory. When this method was applied in this process, it provided good performance in the set point change, more robust and less sensitive to the error but demonstrated slow performance (2-5 minutes) in disturbance change.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai
memenuhi keperluan untuk Ijazah Master Sains

**PEMODELAN EMPIRIK, SIMULASI DAN KAWALAN PROSES
PENGERINGAN SEMBURAN MENGGUNAKAN PENGERING SEMBURAN
NOZEL PENGATOMAN**

Oleh

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Pengeringan semburan ialah teknik penyuhidratan yang mudah dalam menghasilkan serbuk makanan. Ciri-ciri produk bergantung kepada parameter pengeringan dan ciri-ciri cecair yang dimasukkan. Mengawal pengering semburan adalah penting untuk memastikan produk memenuhi spesifikasi kualiti, walaupun gangguan berlaku. Dalam usaha untuk mengawal pengering semburan, pembagunan model dinamik diperlukan. Objektif utama kajian ini adalah untuk menyiasat kelakuan dinamik proses pengeringan semburan dan mencadangkan strategi kawalan yang sesuai menggunakan pengawal berkadar terus dan kamiran (PI). Sebelum membangunkan model dinamik, kajian awal telah dijalankan dan suhu udara keluar telah dikenal pasti sebagai pembolehubah dikawal dan suhu udara masuk sebagai pembolehubah dimanipulasi. Model dinamik yang memberi ramalan dinamik reaksi yang terbaik untuk pengering semburan nozel pengatoman bagi serbuk jus oren (dengan maltodekstrin) dan tepung susu penuh krim (tanpa maltodekstrin) masing-masing

telah dibangunkan secara empirik. Di samping itu, model yang menunjukkan kesan gangguan yang dipilih pada pengering semburan juga telah dibangunkan. Semua model telah diwakilkan oleh tertib pertama dengan waktu tunda (FOPTD) dan sah kerana $R^2 > 0.6$. Tambahan pula, kajian ke atas pengering semburan di dalam kajian ini menggunakan pengawal PI apabila titik tetap dan gangguan berubah. Lajakan yang melampu merupakan satu masalah dalam banyak proses, oleh itu satu panduan lambda, λ untuk kaedah penalaan sintesis langsung telah dicadangkan untuk membenarkan pengguna memilih lajakan tertentu, dan didapati prestasi dan keteguhan adalah memuaskan. Apabila kaedah ini digunakan dalam proses ini, ia telah menunjukkan prestasi yang baik dalam keadaan perubahan titik tetap, lebih teguh dan kurang sensitif terhadap ralat tetapi menunjukkan prestasi yang lambat (2-5 minit) dalam keadaan perubahan gangguan.

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I certify that a Thesis Examination Committee has met on 13 December 2011 to conduct the final examination of Tan Lee Woun on her thesis entitled "**Empirical Modeling, Simulation and Control of Spray Drying Process Using Nozzle Atomizer Spray Dryer**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the students be awarded the Master of Science.

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DECLARATION

I declare that the thesis is my original work except for the quotations and citations which have been duly acknowledge. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

TAN LEE WOUN

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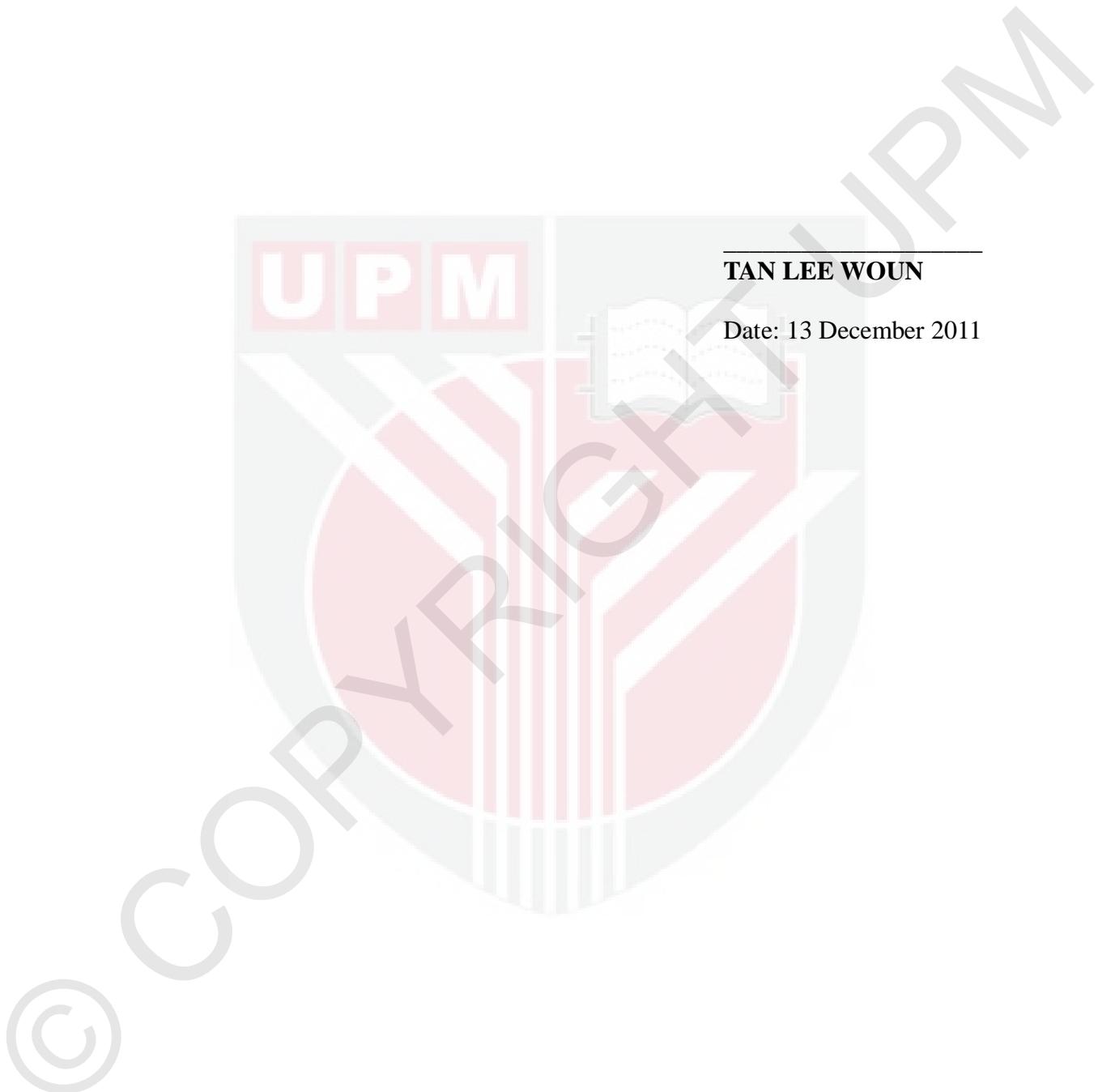


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