PERANCANGAN PENGENDALI PREDIKTIF BERBASIS MODEL UNTUK *FLUID CATALYTIC CRACKING* BERDASARKAN STANDAR IEC 61499

Oleh
M. Hafiezd Sidqy N.
16/394997/TK/44289

Diajukan kepada Departemen Teknik Nuklir dan Teknik Fisika Fakultas Teknik
Universitas Gadjah Mada pada tanggal 24 Juni 2021
untuk memenuhi Sebagian persyaratan untuk memperoleh derajat
Sarjana Program Studi Teknik Fisika

INTISARI

Seiring sistem kendali terdigitalisasi, perangkat fisik dan pengendali menjadi semakin saling berhubungan. Permintaan untuk mengembangkan sistem kendali terdistribusi untuk automasi industri yang independen dari vendor dan fleksibel sedang meningkat. Standar IEC 61499 menyediakan referensi untuk pengembangan aplikasi sistem kendali terdistribusi yang mendukung portabilitas, konfigurabilitas, dan interoperabilitas *software* dan *hardware* dari vendor yang berbeda. Tujuan penelitian ini adalah memperoleh blok fungsi (FB) IEC 61499 yang mengapsulkan *Model Predictive Control* (MPC) beralgoritma *single variable, unconstrained Dynamic Matrix Control* (DMC), serta memperoleh kinerja FB pengendali pada kasus pengendalian proses *Fluid Catalytic Cracking* (FCC).

FB DMC dibangun dengan mentransformasi komponen algoritma DMC menjadi *Basic FB*, dan menghubungkannya menjadi sebuah *Composite FB* (CFB) menggunakan *Framework for Distributed Industrial Automation and Control* (4DIAC). CFB DMC diimplementasikan sebagai pengendali *feedback* pada proses *First Order Plus Time Delay*, serta simulator unit FCC model IV yang mengendalikan variabel proses tekanan reaktor, perbedaan tekanan *regenerator*-reaktor, dan laju alir massa udara total ke *regenerator.*

CFB DMC mampu beroperasi pada 1 *resource* 4DIAC dengan kriteria rentang *control horizon* $1 \leq M \leq 6$, rentang *prediction horizon* $P \leq 100$, dengan $P \times M \leq 200$. CFB DMC menunjukkan kinerja yang baik dalam memenuhi *set point* dan menolak efek gangguan. Pengendali mampu menjaga 9 dari 9 batasan operasional FCC pada kondisi operasi normal dan kondisi operasi perubahan temperatur atmosfer. Pelanggaran batasan temperatur reaktor-*riser* didapati pada kondisi operasi perubahan temperatur umpan. Pelanggaran batasan temperatur reaktor-*riser* dan konsentrasi oksigen pada *stack gas* didapati pada kondisi operasi perubahan *coking factor.*

Kata kunci: *Dynamic Matrix Control*, *Fluid Catalytic Cracking*, IEC 61499, *Model Predictive Control.*

Pembimbing Utama : Dr. -Ing. Awang N.I. Wardana, S.T., M.T., M.Sc.

Pembimbing Pendamping : Ir. Ester Wijayanti, M.T.

DESIGN OF MODEL PREDICTIVE CONTROL CONTROLLER FOR FLUID CATALYTIC CRACKING BASED ON IEC 61499 STANDARD

By
M. Hafiezd Sidqy N.
16/394997/TK/44289

Submitted to the Departement of Nuclear Engineering and Engineering Physics
Faculty of Engineering Universitas Gadjah Mada on June 24th, 2021
in partial fullfillment of the requirement for the Degree of
Bachelor of Engineering in Engineering Physics

ABSTRACT

As control systems are digitalized, physical devices and controllers became more interconnected. The demand for developing flexible and vendor independent distributed control systems for industrial automation is rising. The IEC 61499 standard provides a reference for developing distributed control system applications which supports portability, configurability, and interoperability of software and hardware from different vendors. The purpose of this research is to obtain an IEC 61499 Function Block (FB) which encapsulates Model Predictive Control (MPC) with the single variable, unconstained Dynamic Matrix Control (DMC) algorithm, and to obtain the performance of the FB in the case of Fluid Catalytic Cracking (FCC) process control.

The DMC FB is constructed by transforming the components of the DMC algorithm into Basic FBs, and integrating them to form a Composite FB (CFB) using the IEC 61499 compliant software, *Framework for Distributed Industrial Automation and Control* (4DIAC). The DMC CFB is implemented as a feedback controller for the First Order Plus Time Delay process, and for the FCC model IV simulator that controls the reactor pressure, the regenerator-reactor pressure difference, and the total air flow rate to the regenerator.

The DMC CFB demonstrates an adequate performance in fulfilling set points and rejecting distrubance effects. It is able to operate at 1 4DIAC resource within a criteria where the control horizon is $1 \leq M \leq 6$, prediction horizon is $P \leq 100$, where $P \times M \leq 200$. The controller is able to maintain 9 out of 9 operational constraints of the FCC at normal operating condition and under ambient atmosphere temperature change. Reactor-riser temperature constraint violation is present under feed temperature change. Reactor-riser temperature and oxygen concentration at stack gas constraint violations is present under coking factor change.

Keywords: Dynamic Matrix Control, Fluid Catalytic Cracking, IEC 61499, Model Predictive Control.

Supervisor : Dr. -Ing. Awang N.I. Wardana, S.T., M.T., M.Sc.

Co-supervisor : Ir. Ester Wijayanti, M.T.