A real time simulation model of production system of Glycerol Esterification with self optimization

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2 AUTHORS:


Iwan Aang Soenandi
Bogor Agricultural University, Universitas K…


Taufik Djatna
Bogor Agricultural University

A REAL TIME SIMULATION MODEL OF PRODUCTION SYSTEM OF GLYCEROL ESTER WITH SELF OPTIMIZATION

Iwan Aang Soenandi[1], Taufik Djatna[2]

[1,2]Post Graduate Program of Agroindustrial Technology, Bogor Agricultural University

Darmaga, Bogor, West Java, Indonesia

[1]Email : iwansoenandi@gmail.com

[2]Email : taufikdjatna@ipb.ac.id

Abstract— ***This paper present a new approach for using a real time simulation model of production system for Glycerol Ester (GE) with self optimization. The quality and capacity of production GE are factors that need to monitor and control. In recent years industry sector have tried to satisfy their customer need for best quality product by developing the production system .With these construct model we deployed BPMN and using data acquisition with real time simulation. To collect the real time data we are using sensors that related to quality parameter selected. The model of self optimization for quality is being developed from Wagels (2011). By experiments we can evaluate the performance of the new system and find the optimization range for esterification parameter like temperature, reactor rotation speed and volume production for each batch optimization .As a result we find the range of optimization for the temperature between 240-260 ^{o}C, reactor rotation speed between 300-400 RPM and volume production 20-25 L for each batch.***

Keyword: Real time simulation, glycerol ester, self optimization

I. INTRODUCTION

The integration of advanced data acquisition for optimization and simulation offers considerable potential for innovations in the field of conventional production system. To increasing performance of system affected by many internal or external factors. An increase in the quality of the production system, which will secure sustained production for manufacturing companies, can thus be achieved [1]. On process level, self-optimization for example can be used to calculate machine and process parameters online according to changing outer conditions [2]. In process production GE there exist many possible scenarios how to solve these problems, but which of these scenarios is the best (optimal)? Is it possible to imagine how a change in the subsystem affects the entire system? , As one a product of agriindustrial sector, Glycerol Ester as by product of biodiesel. The product of Biodiesel is still increase , as the result from the goverment policy that use it for mixed material for solar. Glycerol ester is an oil soluble food additive It is also used as an ingredient in the production of chewing gum and ice cream [3]. To produce GE that came from Crude Glycerol ,there is small medium manufacturing .In all production system , optimization of quality and capacity production is important factor that can satisfy of customer needs and increase the efficiency of system.

With computer development in speed and capability with programmning, in recent years, optimization method will processed with computer as using for the simulation that can modeled the production system by real time for monitoring the flow of production and found the best parameter that we can used it in production system combined with self optimization.

The objective of these paper is to construct the model that applied the real time simulation method with self optimization process .This method can be explained with BPMN diagrams, using sensors and data acquisition system and find the parameter of production that closely related to the quality of product and the volume target of production Glycerol Ester. In these paper for Section II we briefly explain description of problem. In Section III we briefly review the concept of self optimization in production system of GE. In Section IV we present analysis and design production system of GE. For Section V we make an experiment to compare the performance of system of the proposed method with the existing method and the conclusion are discussed in Section VI.

II. DESCRIPTION OF PROBLEM

System is an integrated set of interoperable elements that working synergistically to perform value-added processing and to satisfy the user with a specified outcome [4]. Every system consists of its inputs, entities, outputs, stakeholders, roles, constrains, etc that need to be identified. The quality and capacity of production are the problem that involve in production system in GE because of their variously characteristic in end product that sometimes in a part of the product that not satisfy the customer . In this research we focus on production and quality control that dynamically changes by the factors like: material condition and capacity flow process for the process reaction . To optimize all that division we are using computer simulation in real time , and to find the best configuration of production system with self optimization . In these paper we explained how collect the input data by acquisition with sensors and the flow measurement of the process by using BPMN diagrams and using discrete and continuous (hybrid) modelling simulation computer software ARENA.

III. SELF OPTIMIZATION CONCEPTS IN PRODUCTION SYSTEM

A.Production System GE

The complexity of production system on production Glycerol Ester that we can analyze by using Business Processing Modelling Diagram. With this analysis , we can explain clearly the low level tasking in the production system that can improve the efficiency and effectiveness in the system [5] especially in order to produce the GE. As the product of raw material from Glycerol is a valuable byproduct in biodiesel production by transesterification, soap manufacturing by saponification as well as hydrolysis reaction. The purity of glycerol obtained is low due to the presence of impurities such as remaining catalyst, water, soaps, salts and esters formed during the reaction [6] Purification of glycerol as well as the conversion of glycerol into valuable products has attained growing interest in recent years due to the dramatic growth of the biodiesel industry. The process of production GE by reaction of Esterification that involving many parameter affected quality.

B. Quality Control

The simultaneous GC and FTIR analysis of total esters, acylglycerides and glycerol was developed. The method provides separation of acylglycerides, methyl and ethyl esters peaks. It was used C23:0 as internal standard. The method developed is faster and allows the elution of long-chain triacylglycerides [7]. But in this research we are setup QC system using Mid IR source and detector for identification ethyl ester peaks to meet the quality needed for the customer.

C. Self Optimization

To design production system with using the optimum parameter we are using self optimization and simulation with real time data acquisition method .The behavior of optimization algorithms is random, so we had to perform many optimization experiments to identify the pure nature of the optimization algorithms doing it by automatically as diagram in Fig. 1. Considering the number of simulation experiments we can divide the number of simulation experiments as follows:Simulation experiment –simulation run of simulation model.

- Optimization experiment –performed with concrete optimization method setting to find optimum of objective function.
- Series –replication of optimization experiments with concrete optimization method setting.

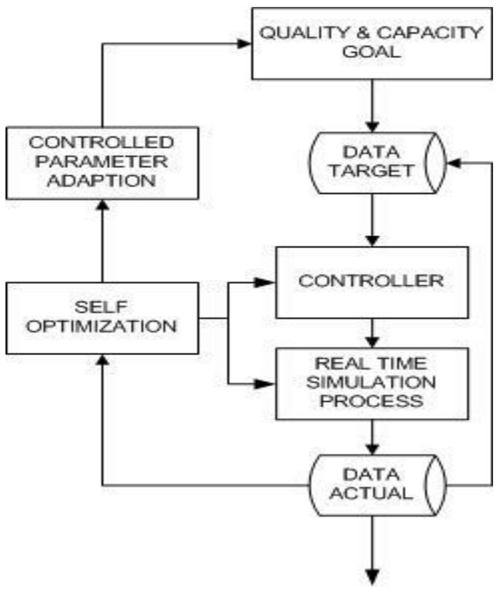

Fig.1. Real Time Simulation and Self Optimization Process

We specified the same conditions which had to be satisfied for each optimization method, e.g. the same termination criteria, the same search space where the optimization method can search for the global optimum. optimization method has the same parameters as another optimization method, we set up both parameters with the same boundaries (same step, low and high boundaries). Self-optimizing systems are defined by the interaction of contained elements and the recurring execution of the actions: [8]

1.continuous analysis of the current situation, in this case is parameter selected of pure gliserol

2.determination of quality targets of GE , production capacity , and

3.adaptation of the system's behavior to achieve these targets like temperature setting and rotational speed of reactor.In this paper we concerned to compare data from each sampling. We have

$$f_{min}=f_t-f_{(t-1)} \quad (1)$$

and for the object optimizing is O_i, the self optimizing object ,can be formulated as

$$O_{i\,avg}\ opt(P)\leftrightarrow(A) \quad (2)$$

P is process, and A is atribute.In this case we can analysis P as $\{p_1,p_2,\ldots p_k\}$ and attribute as $\{a_1,a_2,\ldots,a_m\}$.

The development of a simulation of an actual system involves the creation of a conceptual model of the actual system to be simulated), which may be based on a set of rules, or a set of mathematical equations, or some other method of defining the state of the simulation and and the way in which it changes with time. A simulation based on a discrete model establishes an initial state of the system and a future event queue with event timings. Event-based simulation in which time advances from event to event in a single software thread has been the basis of many popular discrete simulation languages, but, as parallel computing options increase, process based simulation using parallel processors and multiple software threads has become the more popular approach.

D.Real Time Simulation

Real-time systems differ from traditional data processing systems in that they are constrained by certain nonfunctional requirements (e.g. dependability and timing constraints or requirements). An efficient simulation of real-time system requires a model that satisfies both simulation objectives and timing constraints [9]. There is one research developed a structure and architecture for automatic simulation model generation for very detailed simulation models intended to be used for real-time simulation based shop floor control [10]. They identified two essential stages to be automated for automatic simulation model generation: System specification and the associated model construction. In this work, proposed a methodology for generating an Arena simulation model from a resource model as seen in Figure 2. This was made possible because the Arena simulation software supports Visual Basic Application (VBA), which enables application integration and automation. undertook the development of a modeling methodology to efficiently model real-time systems to satisfy given simulation objectives and to achieve arbitrary timing requirements.

In these paper we build the simulation of Manufacturing Systems is performed using Real Time Simulation concept with Discrete and Continuous Event (Hybrid) Computer Simulation Program [11]. The Software for simulation we using ARENA Version 12 with the schema in Fig.2 and real time data acquisition system with using flow sensor. The data was collected after the system of process has steady state condition.

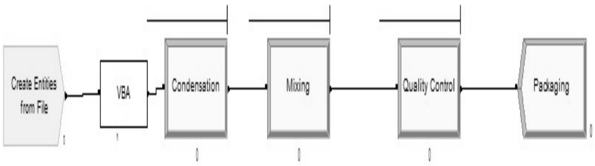

Fig.2 . Real Time Simulation of Production Glycerol Esterification with ARENA

E. Quality Control Factor Analysis

To analysis the factor that are related to quality control and for select the parameter we used RELIEF classification (generalisable to polynomial classification by decomposition into a number of binary problems) proposed by [12] Its strengths are that it is not dependent on heuristics, requires only linear time in the number of given features and training instances, and is noise-tolerant and robust to feature interactions, as well as being applicable for binary or continuous data; however, it does not discriminate between redundant features, and low numbers of training instances fool the algorithm. proposed some updates to the algorithm (RELIEF) in order to improve the reliability of the probability approximation, make it robust to incomplete data, and generalising it to two-class quality problems which is pass and not pass as in Fig. 3 and the selection attribute weighted as in Fig.4. In RELIEF classification we have collected 30 data being tested by the customer of GE.

%Water	Viscosity (poise)	%FFA	pH	Purity	Rel.Density	Quality Pass
50	0.0514	30	7	70	0.95	NO
40	0.0500	50	7	80	0.98	YES
70	0.0456	20	6	50	0.96	NO
30	0.0514	60	7	90	1	YES
50	0.0534	70	8	70	1.020	YES
40	0.0512	40	7	80	1.005	YES
80	0.0511	50	8	40	1.045	NO

Fig. 3. Sample Data Parameter for Quality Control

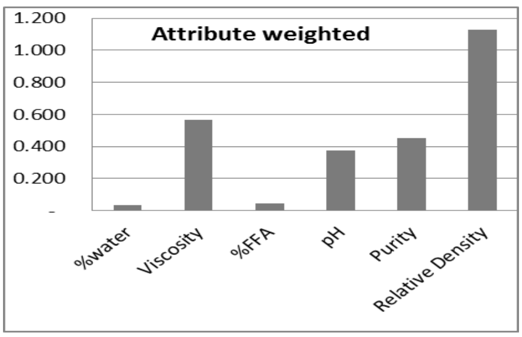

Fig. 4. Attribute Weighted Quality of Glycerol Ester

With RELIEF method we can found the parameter that close related to quality is Relative Density, Purity,pH and Viscosity as the algorithm properties to explain this method as in Fig. 5. So to identify quality parameter we are using sensors like :pH meter, viscometer, water content and densito meter. And for the sequence of flow mixing as a process of production Glycerol Ester and Task properties for setting temperature was in Fig. 6 and Fig. 7.

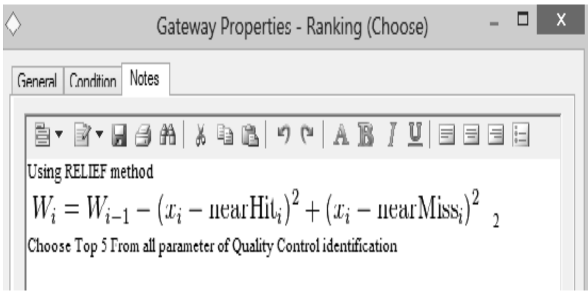

Fig. 5. Properties for RELIEF Method

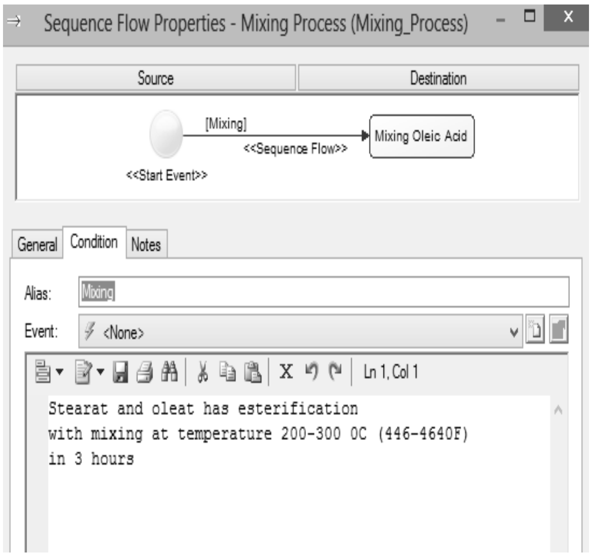

Fig. 6. Sequence Flow Mixing Oleic Acid

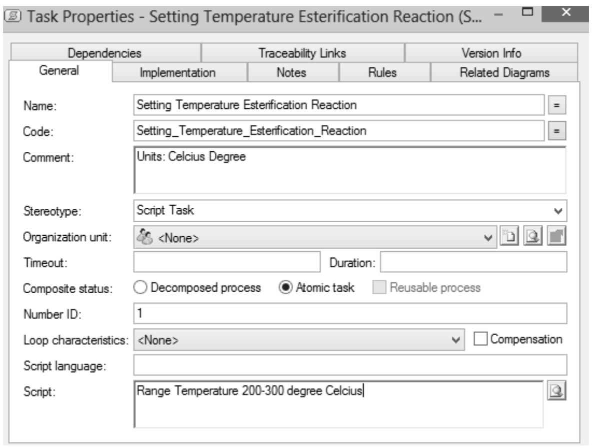

Fig. 7. Task Properties Setting Temperature

IV. Analysis and Design Production System of Glycerol Ester

A. BPM and Process Modelling

We refer to a Business Process (BP) as "a collection of related and structured activities undertaken by one or more organizations in order to pursue some particular goal. Within an organization a BP results in the provisioning of services or in the production of goods for internal or external stakeholders. Moreover BPs are often interrelated since the execution of a BP often results in the activation of related BPs within the same or other organizations [13] .BPM supports BP experts providing methods, techniques, and software to model, implement, execute and optimize BPs which involve humans, software applications, documents and other sources of information ,in this case we build PHD diagram.

From the real system we have build model with PHD diagram in first (Fig. 8.) and next we build the BPM diagrams. The component that involve in production system are: Logistic (material preferences), production , Quality Control and Production Capacity. In these paper focus on Production, Quality Control and Production Capacity using real time simulation.

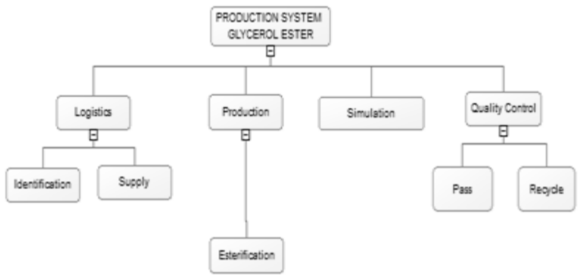

Fig. 8. PHD Diagram

Recent work has shown that BP modeling has been identified as a fundamental phase in BPM. The quality of BPs resulting from the BP modeling phase is critical for the success of an organization.. Techniques which can help organizations to implement high-quality BPs,and to increase process modeling efficiency, has become an highly attractive topic both for industries and for the academy, to the best of our knowledge none of them introduces and supports formal verification techniques., such as the BPMN 2.0 [14] . Business Process Model and Notation (BPMN) is a standard for business process modeling that provides a graphical notation for specifying business processes in a Business Process Diagram (BPD), based on a flowcharting technique very similar to activity diagrams from Unified Modeling Language (UML). The primary goal of BPMN is to provide a standard notation readily understandable by all business stakeholders [15].. BPMN serves as a common language, bridging the communication gap that frequently occurs between business process design and implementation. Currently there are several competing standards for business process modeling languages used by modeling tools and processes.

Widespread adoption of the BPMN will help unify the expression of basic business process concepts [16], as well as advanced process concepts (e.g., exception handling, transaction compensation). In this paper we can found that production process at the first time is purification of raw material Glycerol , it is mix with acid and keep in high temperature tank until the layer seperate clearly. The second step is filtering to make uniform viscosity of Glycerol, according the purification process that used filter to pass by. And the last step is to react the Glycerol with the reaction of esterification to get final product as BPMN diagram in Fig.9. For the simulation we can explain the process with Event Generator as BPMN diagram in Fig 10.

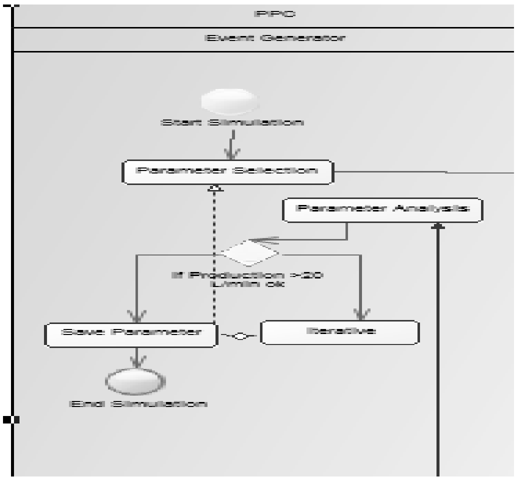

Fig. 9. BPMN Event Generator for Simulation

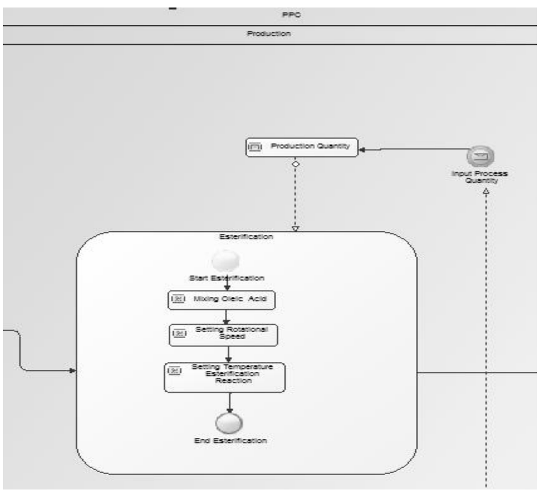

Fig. 10. BPMN Esterification Process

V. COMPUTATIONAL EXPERIMENT

A.Result and Discussion

From the real time simulation that collected after steady state condition in process production. We compared the performance of the system between existing process and using self optimization, we get lower average waiting time in process condensation and quality control as in Fig. 11 and Fig. 12.

Glycerol MonoOleat Existing System

Replications: 1 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Condensation.Queue	3.2168	(Insufficient)	1.6981	5.2704
Mixing.Queue	2.5495	(Insufficient)	2.5495	2.5495
Quality Control.Queue	4.6514	(Insufficient)	4.6514	4.6514

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Condensation.Queue	6.7977	(Insufficient)	2.0000	12.0000
Mixing.Queue	2.3919	(Insufficient)	1.0000	4.0000
Quality Control.Queue	1.2061	(Insufficient)	0.00	2.0000

Fig. 11.Output Existing Process

10:35:45PM **Category Overview** June 9, 2014

Glycerol MonoOleat Optimize System

Replications: 1 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Condensation.Queue	3.2066	(Insufficient)	1.5314	5.2914
Mixing.Queue	3.6000	(Insufficient)	2.3829	4.8172
Quality Control.Queue	4.4847	(Insufficient)	4.4847	4.4847

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Condensation.Queue	6.4628	(Insufficient)	2.0000	11.0000
Mixing.Queue	2.5110	(Insufficient)	1.0000	4.0000
Quality Control.Queue	1.2598	(Insufficient)	0.00	2.0000

Fig. 12. Output Optimized Process

To identify the effect of controlled parameter ,consist of: temperature, rotation speed and volume production for this research we have collected 100 data from production process as the sample of data in Table. 1 to find the range of self optimization for that parameter in production system to fulfill the quality of customer needed.

Table 1. Sample of Production Data

Temperature (C)	Rotation Speed (RPM)	Volume Production(L)	Quality
240	300	25	Good
230	300	23	Not Good
270	250	23	Not Good
250	400	28	Good

B.VERIFICATION AND VALIDATION

Computerized model verification ensures that the computer programming and implementation of the conceptual like modelling the production system Glycerol using Power Designer. The major factor affecting verification is whether a simulation language or a higher level programming language is used. When a simulation language is used, verification is primarily concerned with ensuring that an error free simulation language has been used, that the simulation language has been properly implemented on the computer that a tested (for correctness) pseudo random number event generator has been properly implemented and building diagram of BPMN , and the model has been programmed correctly in the simulation language [17]. The primary techniques used to determine that the model has been programmed correctly are structured walk-throughs and traces. In this case verification is primarily concerned with determining that the simulation real time functions (e.g., the time-flow mechanism, pseudo random number generator, and random variate generators) and the computer model have been programmed and implemented correctly[18]. With Power Designer we can doing the step of verification with error checking as captured in Fig. 13. If the result has shown 0 error and 0 warning, it means the flow of the sequence and interaction of data flow between all swimlane is correct.

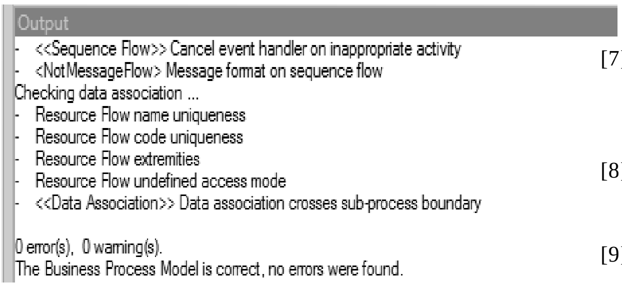

Fig. 13.Error Checking Report in Power Designer

VI. CONCLUSION

The quality and capacity of GE production can be optimized with integration of advanced data acquisition for self optimization and real time simulation. The analysis as explained in PHD diagram, and describe low level process detailed in BPMN 2.0 diagram. With those diagram we can find the relation or interaction between stakeholder and clearly to used for the simulation method to optimized the system including analysis factor (RELIEF) at quality control division. By experiments we can find the optimization quality process time and mixing process with temperature between 240 ^{o}C - 260^{o}C , 300-400 RPM and volume production between 25-30L. Verification model doing with computerized model that ensures computer programming and implementation of the conceptual model in Power Designer are correct as the result of error checking and the real time simulation run as well.

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