University of Science and Technology
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Conventional and Digital Control Systems of a CSTR

Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of M.Sc. In Chemical Engineering

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Abstract

In this research compare the conventional system control and digital control system of the production Ethyl acetate (CH3 CO2 C2 H5) from ethanol. The reaction is exothermic and needs to be cooled at the desired temperature. A control strategy was developed, the transfer functions were identified and the block diagram was drawn with each Transfer Function in its block. Stability and tuning was carried and analyzed, and it is observed that the ultimate gain Ku, and ultimate period Pu are equal on using the conventional methods, but there different when using digital method. The value of the conventional on averages is Ku=28.08, Pu=3.63 sec and digital Ku=12.06, Pu=5.78 sec for loop"1". For loop "2" the conventional on averages Ku=27.24, Pu=1.33 sec and digital Ku=5.78, Pu=3.61 sec

المستخلص

هذه الدراسه للمقارنه بين نظام التحكم التقليدي ونظام التحكم الرقمي لإنتاج(ايثيل الاستيت CH3 CO2 C2H5) من الايثانول. التفاعل هو طارد للحرارة ويحتاج إلى أن تبرد في درجة الحرارة المطلوبة. ووضعت استراتيجية السيطرة، وقد تم تحديد داله النقل ورسم المخططات مع كل تحويل الداله في المخطط. وقد أجريت استقرار وضبط وتحليلها، ويلاحظ أن (العائد النهائي P ،التردد النهائيKu) متساوية باستخدام الطرق التقليدية، ولكنها مختلفة عند استخدام الأسلوب u الرقمي.

Ku=28. :"1 القيم التقليدية المتوسطة للحلقة " ٠٨، Pu=3.63 sec

Ku=12.06, Pu=5.78 secوالرقمية :

Ku=27. :"2القيم التقليدية المتوسطة للحلقة " ٢٤، Pu=1.33 sec

Ku=5.78, Pu=3.6 والرقمية : ١ sec

Introduction

1-1. Background:

Continuous Stirred Tank Reactor (CSTR) is a typical chemical reactor system with complex nonlinear dynamic characteristics. There has been considerable interest in its real time control based on the mathematical modeling. However, the lack of understanding of the dynamics of the process, the highly sensitive and nonlinear behavior of the reactor, has made difficult to develop the precise mathematical modeling of the system. An efficient control of the product concentration in CSTR can be achieved only through accurate model. The best way to learn about control system is to design a controller , apply it to the system and then observe the system that use control theory is continuous stirred tank reactor system (CSTR).it can usually be found in most university process control labs used explain and leach control system engineering. The problem of controlling of CSTR is considered as an attractive and controversial issue, especially for control engineers, corresponding to its nonlinear dynamic. Most of the conventional controllers are restricted just for linear time invariant system applications. However, in real environment, the nonlinear characteristics of the systems and their functional parameters changes, due to wear and tear, cannot be neglected. Furthermore, dealing the systems with uncertainties in real applications, is the another subject which must be noticed. In this way, the role of the adaptive and intelligent controllers, by the capability of the overcoming the aforementioned points are of the importance. It is very important to control different parameters while operating with chemical process. The process may be exothermic or endothermic, while

2 designing a controller, it is better to understand the process very well. An important part of process industry is the control of chemical processes

by the help of various input variables classified as either manipulated or disturbance variables. A manipulated input is one that can be adjusted by the control system while a disturbance input is a variable that affects the process output. The major processes that needed to be controlled are level, thermal, gas etc. These are also, often the measured variables and are commonly the controlled variable. Different control loop demands different controllers, so the most important part of process control is to study the performance of the controller. The best way to learn about control systems is to design a controller, apply it to the system and then observe the system in operation. One example of systems that use control theory is Continuous stirred tank reactor system (CSTR). It is generally linked to real control problems such as chemical factories, preparing of the antidotes in medicine and food processing too. It is widely used because it is very simple to understand; yet the control techniques that can be studied cover many important classical and modern design methods. Continuous stirred tank reactor system (CSTR) is a typical chemical reactor system with complex nonlinear characteristics. A Continuous Stirred Tank Reactor (CSTR) is one of the most important unit operations in chemical industries and it exhibits highly nonlinear behavior and usually has wide operating ranges. Chemical reactions in a reactor are either exothermic or endothermic and therefore require that energy either to be removed or added to the reactor to maintain constant temperature. Most of the reactors dealt in the literature for control purposes have been modeled as ideal CSTRs. In an ideal CSTR, it is assumed that the reactor is well-mixed, meaning that the concentration at different positions of the CSTR is identical throughout the reactor. On the contrary, the mixing in the non-ideal CSTR is not uniform, resulting in bypass and stagnant regions (dead space). Due to bypass, the flow passing through the reactor will be less than the total volumetric flow rate and as a result, there will be slower decay of the transients in the concentration response in the reactor than in the case of perfect operation.

In the dead space where the fluid does not enter, there results a lesser reactor volume than in the case of perfect operation. Hence, the fluid will pass through the reactor more quickly and as a result the transients in the concentration in the reactor will decay more rapidly than in the case for the perfect operation. Normally CSTR process is very complicated in nature and deals with multiple aspects in industries it consists of more than one process are correlated ,any changes in the single variable lead the system to undesirable .Designing controller to this process is very complicated and big challenge for engineers ,Many process and chemical industries uses this CSTR process. There they have to use lots of controller for maintaining the process in closured condition, so we need to use more than one sensor for measuring each parameter from this process. The continuous stirred tank reactor system (CSTR) is complex nonlinear system due to its strong non liner behavior, the problem of identification and control of CSTR is always challenging take for control system engineer. Chemical reactors often have significant heat effects, so it is important to be able to add or remove heat from them. In a CSTR the head is add or removed by virtue of the temperature difference between a jacked fluid and the reactor fluid, often the heat transfer fluid is pumped through agitation nozzle that circulation that fluid through the jacked at a high velocity. The reactant conversing in chemical reaction is functioning of residence time r its inverse, the space velocity. For CSTR the product concentration can be controlled by manipulating the feed flow rate .which change the residence time for a constant chemical reactor. The CSTR reactor is usually used for liquid-phase or multiphase reactions that have fairly high reaction rates. Reactant streams are continuously fed into the vessel, and product streams are withdrawn. Cooling or heating is achieved by a number of different mechanisms. The two most common involve the use of a jacket surrounding the vessel or an internal coil. If high conversion is required, a single CSTR must be quite large Un less reaction rates are very fast.

1-2 Digital Control:

The digital control systems have been introduced in control system to improve the tracking Performance for complex systems. This is due to the price of devices that have been improved dramatically during past decade. Figure below shows a block diagram of a single-loop digital control system

Fig.1.1: Digital control The digital computer (or micro-Controller, microprocessor) receives the error or only the reference signal and performs calculations (program) in order to provide an output near or equals the desired signal. (2)

1-3 Objectives:

This research aimed to:

1/ Study and investigate the performance of conventional in a CSTR.

2/Study and investigate the performance of digital controller in a CSTR.

3/Compare between the conventional and digital controller in a CSTR.