

Evolutionary Algorithm Based Corrective Process Control System in Glass Melting Process

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Abstract. This paper presents the corrective process control system for achieving a target quality level in glass melting processes. Since automated data collection devices would monitor and log process attributes that are assumed to correlate to a quality level in the glass melting process, appropriate process control logics utilizing the collected data are definitely needed. In this paper, an evolutionary algorithm based search logic is newly proposed. The objective of the proposed logic is to find the best process condition composed of the process attributes which can generate the target quality level. The proposed logic tries to find the best process condition that needs to satisfy the following two criteria: 1) a process condition should require minimal changes from the current setting of the process attributes; and 2) a process condition can generate the exact or closest value against the target quality level. A case study and a developed process control system are presented.

Keywords: Evolutionary algorithm, corrective process control, glass melting process.

1 Introduction

One of the major activities for improving quality in manufacturing processes is to control the processes correctly. The product defects typically come from even small changes during manufacturing processes that cause big vibrations in the product that in turn result in out of the acceptable limits. This paper is concerned with finding the desirable process conditions that result in achieving a target quality in glass melting processes. Glass melting processes are composed of three parts: a furnace, a refinery, and a forehearth as shown in Fig. 1. Raw materials such as mostly sand and many kinds of chemicals are melted into glass at high temperature in the furnace. The refinery makes the temperature of the molten glass uniform at every spot. Then the temperature of the melted glass is adjusted to a suitable temperature through the forehearth for the glass forming process to follow. Due to flow dynamics, the flow of melted glass is not uniform, especially at the bottom of the furnace. As a matter of fact, each spot of the melted glass has a different temperature profile. In addition to temperature, other attributes also affect the thermal characteristics of melted glass.

Raw material composition, thermal conductivity, viscosity, fuel/air feed rate, glass color, and the amount of the glass in a furnace are some of the process attributes. Because there are so many – either known or unknown – attributes and the process is so dynamic, it is very difficult to control the behavior of molten glass.

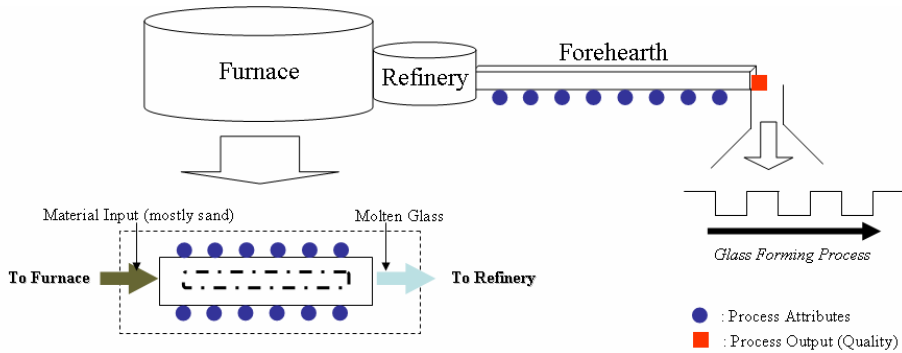


Fig. 1. Glass melting process

In real glass melting processes, there exists the automated data collection devices to monitor and log the process attributes on the assumption that they might be related to the quality level of the process.

In this paper, we propose the corrective process control system for achieving a target quality level in glass melting processes. The proposed corrective process control system has the evolutionary algorithm based search logic (EASL) as a main engine in order to utilize the past data collected from the automated data collection device. The main objective of the EASL is to find the best process condition composed of the process attributes which can generate the target quality level. The proposed EASL tries to find the best process condition that needs to satisfy the following two criteria: 1) a process condition should require minimal changes from the current setting of the process attributes; and 2) a process condition can generate the exact or closest value against the target quality level.

This paper is organized as follows. Section 2 describes data collection procedure, and in Section 3, the EASL is explained in detail. Section 4 presents the implementation of the proposed corrective process control system with a real glass melting process case. Finally, conclusions and future research directions are discussed in Section 5.

2 Data Collection

In glass melting processes, one of the most difficult jobs is to control the process attributes. The automated data collection devices constantly monitor operating parameters (i.e., process attributes) and the quality level throughout the individual facilities. When the quality level becomes out of tolerance, these systems will either respond with an alarm to notify the operation personnel that an unexpected quality