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ORIGINAL ARTICLE

An adaptive immune algorithm based gravimetric fluid dispensing machine

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KEYWORDS

Artificial immune system;
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Pulse width modulation;
Gravimetric;
Materials blending

Abstract A dispensing system is used in a materials-mixing plant to provide accurate blend ratios in producing the desired end-use product. The AIS-based (Artificial Immune Systems) fine tuning of dispensing parameters is proposed by optimizing the components of dispensing time and stopping time delay to obtain constant and accurate reading from the precision balance scale. Based on the new dispensing sequence, experimental tests had been carried out using different materials with varying viscosities. The results indicate that the combination of both PWM and AIS techniques would minimize overshoot while exhibiting lower steady-state error and faster response time. These are important in order to overcome the limitations of the conventional volumetric dispensing and manual parameter tuning presently applied in the dispensing system used in the coatings industry.

1. Introduction

Manufacturers in the coating industry encounter difficulties in corrugated carton printing as the number of coatings used can be as high as 30000. Thus, it is impossible and highly unlikely for the manufacturers to store 30000 types of coatings in separate containers. Moreover, the acquisition costs for these coatings would be astronomically high. A solution to this problem called blending was proposed and a typical range of 6–20 base ingredients can be blended to produce thousands of other types of coatings. Hence, the storage requirement can be reduced drastically which is dependent on the amount of base ingredients. In order to match the desired coatings, the printers must mix these base ingredients

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carefully and very accurately with regards to a formula or mixing scheme agreed by their customers.

The automatic fluid dispensing systems applied in the coatings industry are normally volumetric-based which operate by a measuring device (metering pump or other components) for each ingredient being dispensed. Volumetric system is susceptible to changes in temperature and air flow, which directly affect the end result in terms of accuracy, speed and quality.

In order to resolve this setback, reference has been studied on Microfluidic System, Inkjet Technology and other system (Steger et al., 2002; Pöschel and Engel, 1998) as well as Pulse Width Modulation (PWM) technique (Bowler, 1995; Foulds and Johnstone, 2005) to adapt the concept for a fast and accurate fluid dispensing technique suitable for coating industry. The result is a gravimetric and PWM based controlled fluid dispensing system (Sim et al., 2009) with Artificial Immune System (AIS) dispensing parameter fine tuning capability. The proposed closed-loop dispensing system would provide the set point weight, the actual weight of each ingredient and real dispensing data as input which are helpful for each dispensed batch in terms of quality control, audit trail and quality-related problems diagnosis. Ingredient usage, formulation usage and batch production are accurately logged as the output of the system and stored in the built-in database where tracking and monitoring of ingredients and formulations used are being carried out from time-to-time. In this active control system, information from one or more sensors in the flow, along with a flow model guides the actuation process.

The developed gravimetric fluid dispensing system is able:

a. to dispense batch by batch within accuracy of ± 2 g,
b. to complete the dispensing cycle with optimum performance in terms of faster speed,
c. to communicate with AIS dispensing parameter fine tuning technique,
d. to prevent settling of the pigment in the base ingredient,
e. to dispense via a manual control backup system in the event of PC breakdown,
f. to obtain optimum dispense parameters through an adaptive fine tuning system.

The flow chart of the proposed fluid dispensing system is shown in Fig. 1. There are three major parts of the system as follows:

i. Dispensing software.
ii. Hardware design of a single valve gravimetric fluid dispensing system.
iii. AIS-based dispensing parameter fine tuning.

2. Dispensing software architecture

The dispensing software architecture consists of three major components shown in Fig. 2.

The development of the dispensing software can be divided into control of dispensing sequence, control of PWM module and PLC and GUI module. The dispensing sequence of a liquid is pre-determined (as shown in Table 1). Initial flow of the liquid happens when the valve is fully opened. This is termed as Big Flow. Next, when approaching the amount of liquid needed to be dispensed, the valve would be slightly closed. This stage is called Small Flow. Subsequently, the

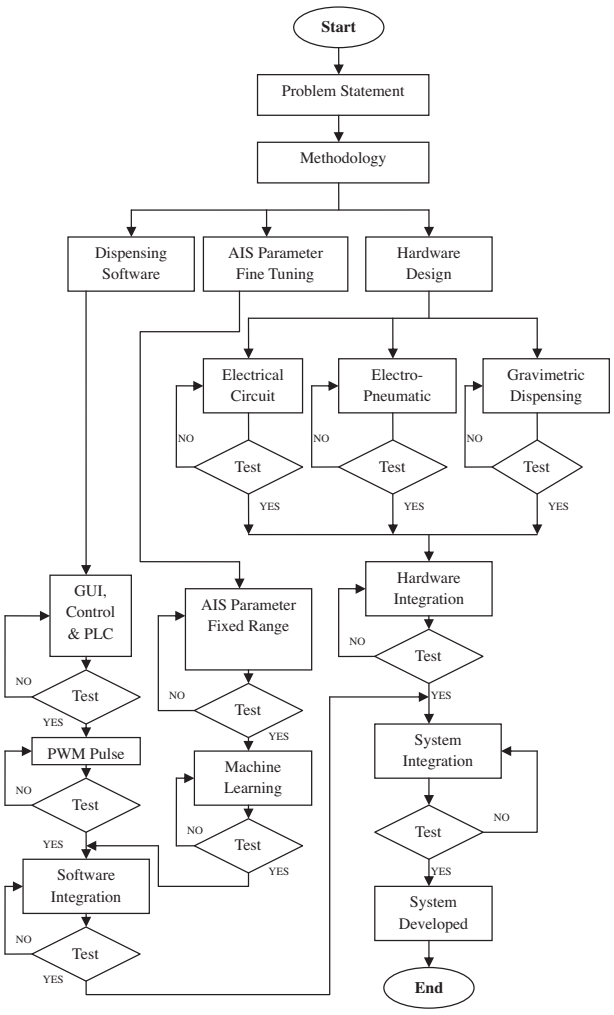

Figure 1 Flow chart of the proposed system development.

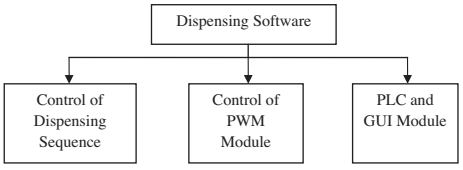

Figure 2 Dispensing software architecture.

Table 1 Dispensing parameters.

Description	Symbol
Set point for Big Flow to Small Flow	*a*
Set point for Small Flow to PWM Pulse	*b*
Set point for PWM Pulse to Spit Pulse	*c*
PWM coefficient	*d*
Spit coefficient	*e*