Grey Wolf Optimization of Fractional PID controller in Gas Metal Arc Welding process.

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***Abstract*— Gas metal arc welding (GMAW) plays the great importance in the welding industry. This paper presents a grey wolf optimization (GWO) of fractional PID controller in order to optimize arc length and arc current in the GMAW process. Firstly, fractional PID control of gas metal arc welding system is proposed, wherein the arc length and current of welding process are controlled, then the Grey Wolf Optimization is introduced to solve multi-objectives functions of GMAW in order to find the optimal parameters of fractional PID controller. The obtained results are compared with those given by fractional PID controller in which our proposed method can ensure a better dynamic behavior of the GMAW process.**

***Keywords*— GMAW, MIMO system, GWO, Fractional PID controller**

I. Introduction

Welding is an assembly technique used in the most industrial sectors. It is a multidisciplinary technique mobilizing a large number of phenomena [1]. Several welding processes can be classified in the industrial manufacturing. The GMAW process proved to be faster, especially on thicker materials. Today this welding process is indispensable in the production industry in series of components in particular robotized [2]. There are many advantages in the welding by gas metal arc welding process, such as the high productivity, high welding speed, wide range of thickness and both manual and automatic process[3].

In order to evaluate and ensure the weld quality in the GMAW process, arc length and current are important controlled variables. These two variables of welding is determined by several characteristics such as the transfer mode of melting droplets and the weld geometry [4], in this reason the control of the GMAW process can be separated into weld pool control and arc control [5]. Previous studies for the GMAW process have been implemented to control the arc length and current; in [6, 7, and 8] a controller design has already been combined with feedback linearisation technique using an additional feedback signal where non linearities are cancelled and the linearised strategy is managed by (PI) controller. A similar strategy with sliding mode control has been applied to ensure robustness in [9]. Thomsen proposed a control system for manual pulsed gas metal arc welding. The particular arc length controller is dependent on a non-linear SISO model of the arc length process and uses feedback linearization approach [10].

Khatamianfar et al are proposed a novel application of sliding control in the manual gas metal arc welding process; Arc length is controlled successfully by the robust control system with combined the feedback linearization technique and sliding mode control [11].Golob. M [12] combined a full-bridge inverter circuit together with the GMAW model.

Recently, a fractional order controller $PI^{\lambda}D^{\mu}$ which is a generalization of the classical PID controller have received great attention technique of robust controllers for complex nonlinear dynamic systems operating under uncertain conditions [13, 14].

In the past decade there has been an increasing research to developing tuning methods for $PI^{\lambda}/PI^{\lambda}D^{\mu}$ controllers [15, 16 and 17].

In order to control the GMAW process, the control objective can be formulated as an optimization problem, and there is a certain difficulty about the tuning methods for $PI^{\lambda}D^{\mu}$ controllers, concerning the definition of the controller parameters.

The optimization problems can be solved using meta-heuristic optimization methods. Some of these approaches include genetic algorithm (GA) [18], bacterial foraging (BF) [19], gravitational search algorithm (GSA) [20], and particle swarm optimization (PSO) [21].

Grey Wolf Optimization (GWO) is recently developed meta-heuristics algorithm simulates hunting mechanism of gray wolves in nature proposed by Mirjalili et al. [22].GWO has been successfully applied for solving the engineering optimization problems [23,24].

This paper studies the GMAW arc self-regulating process utilizing a nonlinear mathematical state space model of the process. In addition, a fractional order controller $PI^{\lambda}D^{\mu}$ is designed to control the wire feed speed and open circuit voltage.

This paper is organized as follows: First in section 1, the mathematical modeling of a GMAW process is presented and, then in section 2, the control objective is discussed. Subsequently, a fractional order controller $PI^{\lambda}D^{\mu}$ is designed. Applications of the fractional order control to the GMAW process and simulation results are given in the section 3.Finaly, the conclusions are drawn.

II. Modeling of the GMAW process