A design of ANFIS controller through ES algorithm for disturbances rejection in Hot Rolling

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Abstract In this paper, we developed an ANFIS controller through ES algorithm for disturbances rejection in Hot Rolling. The looper of a Hot Rolling is installed between each pair of stands and plays key roles to enhance the product quality of the strip by controlling the tension and the width of the strip. At the same time, the AGC on top of the Mill produces a strip with the desired thickness through pressing its Mill. Between both, however, interactions are caused by coupling effects among strip tension, looper angle and strip thickness. In addition, in case disturbances, it is more difficult to keep strip quantities desirable. So we present an ANFIS controller through ES algorithm which is able to identify fuzzy rule with input/output data and update itself through output errors.

Keywords ES, ANFIS, PID, Looper and AGC, Hot Rolling

NOMENCLATURE

E	Young's Coefficient
σ	Strip Tension
θ	Looper angle
L	Length of stand
F2	Geometric length
F3	Load Torque
Crcc	Current Converting Coefficient
h	Exit thickness of strip
S	Roll Gap
J	Motor Inertia Coefficient
P	Rolling Force
M	Mill's Stiffness
Q	Plasticity Coefficient
D	Damping Coefficients
T_1	Motor time constant
T_h	Time constant of Servo valve

1. INTRODUCTION

In Hot Rolling, a reheated slab is rolled in a Roughing Mill and a Finishing Mill in sequence. The rolled strip is cooled down and finally coiled by a down coiler. In Finishing Mills, it is necessary to keep strip thickness, width and tension within desirable range of target values. To control strip tension and width, loopers are installed between the rolling stands and so far, mainly controlled by PID method. Also, AGC(Automatic Gauge Control) on the top of its mill runs a hydraulic actuator to roll strip and have a desirable thickness.

However, it is difficult to keep qualities of strip,i.e., tension and thickness uniform due to interactions existing between the looper and the AGC. For instance, in case of uncertain disturbances caused by uneven temperatures or different types of strips, AGC begins to change a hydraulic actuator to keep the strip thickness constant in spite of them, however, resulting in the fluctuation in the strip tension. On the other hand, both looper motor and main mill motor simultaneously start to vary their angles and to change their speed for constant strip tension, respectively. This creates the opposite effect of varying the strip thickness, leading to a variation in the AGC again.

The AGC, the main motor and the looper are coupled through the mechanics of the inter-stand system. Mutual interactions are considered to be the main problem in tension and thickness control of strip. Thus far, many multi-variable control strategies have been applied to this problem for interaction decoupling, but this leads to complicated controllers which are intuitively incomprehensible and hard to tune on site. Moreover, 6 or 7 stands in tandem make it difficult to analyze their mathematical structures and to understand accurate, reciprocal effects.

However, an ES(Evolutionary Strategy), [3] [4], a part of Evolutionary Algorithm, has advantages to find out the optimal solution in search problems without a complicated mathematical analysis. Using a given input/output data set, an ANFIS(Adaptive Network based Fuzzy Inference System) constructs a fuzzy inference system whose membership function parameters are ad-