Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 177 (2017) 303 – 306

Procedia Engineering

www.elsevier.com/locate/procedia

XXI International Polish-Slovak Conference "Machine Modeling and Simulations 2016"

Application of artificial intelligence methods to modeling of injector needle movement in diesel engine

Michał Kekez[a]*, Leszek Radziszewski[a], Alžbeta Sapietova[b]

[a]*Kielce University of Technology, Faculty of Mechatronics and Mechanical Engineering, Tysiąclecia Państwa Polskiego 7, 25314 Kielce Poland*
[b]*University of Žilina, Faculty of Mechanical Engineering, Univerzitná 8215/1, 01026 Žilina Slovakia*

Abstract

The paper presents analysis of injector needle movement in diesel engine. A methodology for obtaining models of this movements was described. The values of injector needle lift were recorded for the engine running at full load, powered by diesel fuel. The models were built using two computational intelligence methods: genetic-fuzzy system and regression trees. The analysis of transparency and accuracy of the obtained models was conducted. The proposed models can be applied to estimation of amount of fuel injected during the engine work cycle.

Peer-review under responsibility of the organizing committee of MMS 2016

Keywords: diesel engine; injector needle; computational intelligence;

1. Introduction

The amount of fuel burnt in one engine cycle (when the engine is working with constant load and rotational speed) can be measured in laboratory conditions. However, it is possible to calculate this value by using the area below the curve of injector needle lift as a function of time. The model of injector needle lift in diesel engine, common for all possible rotational speeds can be used for these calculations. The authors proposed two approaches to building such a model; both of them use algorithms from the field of computational intelligence. The accuracy of one of them (regression tree model) can be improved by the application of particle swarm optimization.

* Corresponding author. Tel.: +48 41 3424 420; fax: +48 41 34 48 698.
E-mail address: m.kekez@tu.kielce.pl

Peer-review under responsibility of the organizing committee of MMS 2016
doi:10.1016/j.proeng.2017.02.229

Nomenclature

°CA	degrees of crankshaft angle
n	rotational speed of the engine
rpm	revolutions per minute

2. Model of injector needle lift built by genetic-fuzzy system

The Fig. 1a shows the values of injector needle lift as a function of crankshaft rotational angle in the range of 330 to 370 °CA, recorded for various rotational speeds, when the engine was fuelled by diesel fuel. Each value shown in Fig. 1a is averaged from 50 consecutive engine cycles. The test bench used in the experiments was described in details in [1, 2].

The model of injector needle movement was built by the genetic-fuzzy system GFSm [2] (belonging to the group of genetic-fuzzy [3] and fuzzy systems [4]) based on the training dataset. The training dataset was prepared using experimental courses of injector needle lift in AD3.152 UR engine fuelled by diesel fuel, and running at rotational speeds of n=1200 and n=1800 rpm (revolutions per minute). Dataset consisted of 58 records. Each of them described the value of injector needle lift recorded at rotational speed of 1200 or 1800 rpm, in the range of 330 to 370 °CA, with a step of 1.4 °CA. The range of crankshaft rotational angle was selected in such a way that the values of injector needle lift were bigger than zero. Each record in dataset had the form [x_1, x_2, y], where:

x_1 is *alpha*, a degree of crankshaft angle, expressed in °CA,

x_2 is *time* left since the moment when *alpha* was 340 °CA (or 0 when x_1<340), expressed in milliseconds,

y is the value of injector needle lift, corresponding to the pair of values [x_1, x_2].

The GFSm system was started with the following configuration options: "maximum number of fuzzy sets describing one input = 30" and "models with high accuracy are preferred (the number of rules is irrelevant)". When running with these options, GFSm produced the model containing 18 rules (Fig. 2). The courses of injector needle movement calculated by this model are shown in Fig. 1b.

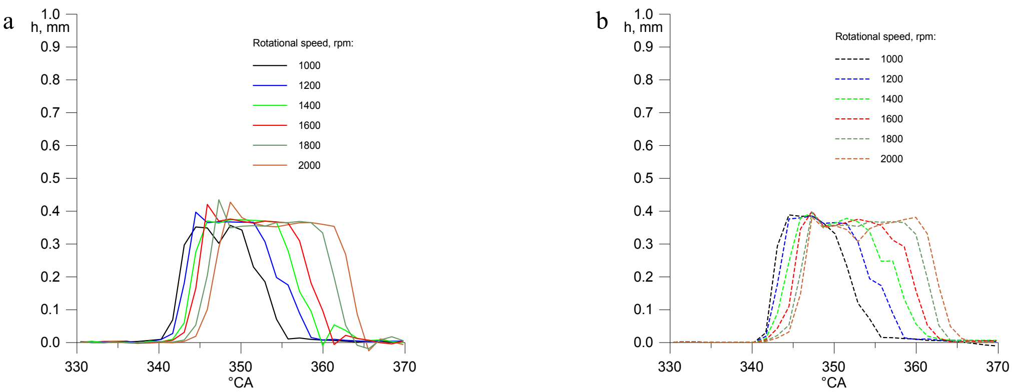

Fig. 1. Injector needle lift *h* in diesel engine fueled by diesel fuel, as a function of crankshaft rotational angle in the range of 330 to 370 °CA, for various crankshaft rotational speeds: (a) experimental; (b) modeled by GFSm.

The model shown in Fig. 2 uses several types of membership functions of fuzzy sets: the notion M(a,b) means Gaussian membership function with parameters a and b, described by (1); the notion L(a,b) means sigmoidal membership function with parameters a and b, described by (2), and the notion T(a,b) means triangular membership function with parameters a and b, described by (3):