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Vibration gear fault diagnostics technique using wavelet support vector machine

Widodo A.[a] ; Dewi Widowati D.P.[b] ; Satrijo D.[a] ; Haryanto I.[a]

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[a] Department of Mechanical Engineering, Diponegoro University, Semarang, Indonesia

[b] Department of Industrial Technology, Sultan Agung Islamic University, Semarang, Indonesia

Abstract

Intelligent diagnostics tool for detecting damaged bevel gears was developed based on wavelet support vector machine (WSVM). In this technique , the existing method of SVM was modified by introducing Haar wavelet function as kernel for mapping input data into feature space. The developed method was experimentally evaluated by vibration data measured from test rig machinery fault simulator (MFS). There were four conditions of gears namely normal, worn, teeth defect and one missing-teeth which has been experimented. Statistical features were then calculated from vibration signals and they were employed as input data for training WSVM. Fault diagnostics of bevel gear was performed by executing classification task in trained WSVM. The accuracy of fault diagnostics were evaluated by testing procedure through vibration data acquired from test rig. The results show that the proposed system gives plausible performance in fault diagnostics based on experimental work. © (2014) Trans Tech Publications, Switzerland.

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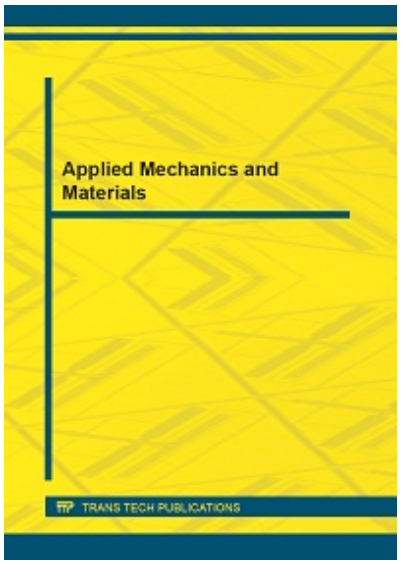

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Vibration Gear Fault Diagnostics Technique Using Wavelet Support Vector Machine

A. Widodo[1,a], D.P Dewi Widowati[2,b], D. Satrijo[1,c] and I. Haryanto[1,d]

[1]Department of Mechanical Engineering, Diponegoro University, Semarang, Indonesia
[2]Department of Industrial Technology, Sultan Agung Islamic University, Semarang, Indonesia
[a]awid@undip.ac.id , [b]dyah.queenaya@gmail.com, [c]djoeli_satrijo@yahoo.com,
[d]ismoyo2001@yahoo.de

Keywords: gearbox, fault diagnostics, support vector machine, wavelet function.

Abstract. Intelligent diagnostics tool for detecting damaged bevel gears was developed based on wavelet support vector machine (WSVM). In this technique, the existing method of SVM was modified by introducing Haar wavelet function as kernel for mapping input data into feature space. The developed method was experimentally evaluated by vibration data measured from test rig machinery fault simulator (MFS). There were four conditions of gears namely normal, worn, teeth defect and one missing-teeth which has been experimented. Statistical features were then calculated from vibration signals and they were employed as input data for training WSVM. Fault diagnostics of bevel gear was performed by executing classification task in trained WSVM. The accuracy of fault diagnostics were evaluated by testing procedure through vibration data acquired from test rig. The results show that the proposed system gives plausible performance in fault diagnostics based on experimental work.

Introduction

Gearboxes are important component in machinery due to their function to power trasnmission with high efficiency. The gearboxes are widely spreaded in use such as helicopter and airplane, ships, automobiles and manufacturing machineries. Since their function is very important, a gearbox monitoring system is needed as reliable tool for quality control of power transmission. Early detection and fault diagnostics of gear is critical for guarantee the functional availability of power transmission. In addition, this will be a maintenance tool that enables the establishsment of a maintenance program based on early warning and automated fault diagnostics.

Intelligent fault diagnostics of rotating machinery component such as gearboxes is sequential process involving three steps: 1) feature calculation for finding salient feature; 2) feature extraction that represents the symptom; and 3) pattern classification (for diagnostics task). Feature extraction refers to mapping process from iput space to feature space which usually employs special functions such as kernel functions. Salient features that represent charateristics features assicoated with the conditions of gearboxes are usually extracted using approriate signal processing technique.

Pattern classification or sometimes called pattern recognition is the process of classifying the features into different categories. This procedure is augmented by intelligent technique through a knowledge-based paradigms [1, 2]. This technique is adopted in this work due to existing of many difficulties when deriving mathematical model for very complex system such as gear. The great efforts has been reported in using knowledge-based diagnostics as intelligent tools for diagnostics such as neural network [3, 4], fuzzy logic [5, 6], sinergetic schemes [7] and support vector machine [8].

In this paper, a relatively new kernel trick using Haar wavelet function is proposed. In this method, wavelet function is performed as kernel function for mapping input data in SVM theory. The theoretical development of wavelet kernel are reported in references: reproducing wavelet kernel [9], construction of support wavelet network [10], application wavelet support vector to regression [11, 12], least square wavelet support vector [13]. However, the application is still rare in faults detection and classification of gearboxes. Therefore, this study is aimed to evaluate the performance of WSVM in diagnosing gearboxes.

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An experimental Study of Heat Transfer and Friction Factor Characteristics of Finned Flat Tube Banks with In-line Tubes Configurations

Tahseen Ahmad Tahseen[1,3,a], M. Ishak[1,2,b] and M.M. Rahman[1,2,c]

[1]Faculty of Mechanical Engineering, Universiti Malaysia Pahang

26600 Pekan, Pahang, Malaysia

[2]Automotive Engineering Centre, Universiti Malaysia Pahang,

26600 Pekan, Pahang, Malaysia

[3]Department of Mechanical Engineering, College of Engineering, University of Tikrit,

Tikrit, Iraq

[a]tahseen@tu.edu.iq, [b]mahadzir@ump.edu.my, [c]mustafizur@ump.edu.my

Keyword: Measurement; forced convection; friction factor; in-line finned flat tube.

Abstract. The experimental study has been made to investigate heat transfer and pressure drop for air flow around finned flat tube banks in-line configurations with laminar forced convection. Measurements were conducted for twelve tubes in the flow direction, four tubes in the row. Four air velocity (0.2, 0.5, 0.8 and 2.0 m/s) identical to the Reynolds number, Re_{Dh} based hydraulic diameter was varied between 124 and 1238. The total heat flux supplies in all tubes change four times from 473.2 to 3871.7 W/m^2. The study results indicate that the average heat transfer coefficient, $\overline{h}$ and the average Nusselt number, $\overline{Nu}$ of all tubes has increased 113.6%–150.3% with Re_{Dh} numbers varying from 124 to 1238 at the fixed heat flux. Likewise, the friction factor decreases 57.7% with a Re_{Dh} number range 124 – 1238.

Introduction

The heat transfer and fluid flow in tube bundles represent an idealization of many industrially important processes. Tube banks are openly employed in cross-flow heat exchangers the design still relies on empirical correlations of pressure drop and heat transfer. Heat exchangers with tube bundles in cross-flow are of a major operation interest in many chemicals and thermal engineering processes [1–7]. Flat tubes, despite, have not been achieved to the same extent, through the fact that they play a significant role in many technical applications, such as automotive radiators and modern heat exchangers. It is designs have recently been provided use air conditioning for automotive evaporators and condensers. The recent developments in automotive aluminium manufacturing technology have made the cost of the flat tube heat exchanger building more propitious [8]. In addition, the flat tube heat exchangers are expected to be the best airside heat transfer coefficients and minimum air side pressure drop compared with circular tube heat exchangers, the pressure drop in flat tube is expected to be less of circular tubes, due to a smaller wake area. For the same reason, noise and vibration are expected are less in flat tube heat exchangers compared to circular tube heat exchangers.

Tahseen et al. [9–11] have numerical studies incompressible, steady state flow and using the body fitted coordinate (BFC). The first study is about heat transfer over a series of the flat tube between two parallel plates. The second study heat transfer over a two flat tube staggered, and the third study is about the heat transfer over in-line banks of the circular tube. All studies show that the Nusselt number increases with an increase of Reynolds number.

In this paper, the cooling process was experimentally examined. The finned in-line flat tubes arrangement with the diameter ratio of tube D/d = 1.85. The Reynolds number of external air flow based on the outer hydraulic diameter the tube and the mean free stream air velocity. The Reynolds

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An Experimental Study on Double-Glazed Flat Plate Solar Water Heating System in Turkey

Ahmet OZSOY[1,a],Sabahattin DEMIRER[2,b] and N.M. Adam*[3,c]
[1]Suleyman Demirel University, Faculty of Technology, Isparta, TURKEY
[2]Suleyman Demirel University, Graduate School of Natural and Applied Science, Isparta, Turkey
[3]University Putra Malaysia, Faculty of Engineering,Serdang, Selangor, Malaysia.
[a]ahmetozsoy@sdu.edu.tr, [b]sa_de_32@hotmail.com, *[c]mariah@upm.edu.my

Keywords: Collector efficiency, Domestic water heating, Double-glazed solar collector, Turkey

Abstract.Domestic hot water preparation systems with flat plate solar collectors are widely used in Turkey. In this collector, the temperature difference between the required water temperature and the ambient air temperature increase causes a decrease in the efficiency of the collector. In this study, the use of double glass in order to increase the efficiency of the collector is studied experimentally.The location is in Isparta South West Turkey. Experimental study is conducted in May 2013 at the Suleyman Demirel University, Isparta. The system components are solar simulator, solar collector, tank, circulation pump, flowmeter, thermocouples, data acquisition device and solar sensor. Solar collector system's operating temperature is 50 ^{o}C for winter also summer. The difference between the collector temperature and the ambient air temperature exceeds 25 ^{o}C in many cases, were found to be more efficient double-glazed collectors. When the temperature difference is 40 ^{o}C, using double glazing collector is 24% more efficient than using single glazing collector.

Introduction

Utilization of solar energy, solar domestic hot water preparation is widely used in Turkey. The population of Turkey is 70 million. So, solar collector has very wide market.Turkey is between 26-45 north latitude and east longitude and 36 to 42 in terms of solar energy fortunate countries. Turkey experience the four seasons i.e. winter, spring, summer and autumn. Ambient air temperature varies according to the season. In summer temperature is generally around +30 ^{o}C, in winter it is around -10 ^{o}C. The desired water temperature for domestic hot water use is assumed to be 45 °C, difference between collector temperature and ambient air temperature is at least 50 ^{o}C in winter.

Flat plate solar collector heat losses can be classified as the upper surface and the lower and side surface heat losses. To reduce the upper surface heat loss, honeycomb or double transparent cover can be used. On the other hand, side and bottom surface heat loss can be reduced by increasing the thickness of heat insulation materials.The collector absorber plate, matte black color was chosen to reduce surface heat losses.Each transparent layer used in solar collector reduces both the permeability of the solar radiation and the heat losses from internal to external ambient.Especially in cases where the solar radiation is sufficient but the ambient air temperature is too low, to use more than one glass layer is more appropriate [1,2]. Inside the solar collector pipe, passive methods like twisted tape, wire coil etc. can be used in order to increase heat transfer from absorber plate to working fluid.Use of these passive methods not only increase heat transfer but also increases pressure drop[3,4].

Using single and double glazing to reduce heat losses from the top surface are investigated experimentally the effect of flat plate solar collector efficiency.The effect of the heat losses of the collector bottom and side surfaces are not taken into account.

Experimental Procedure

All experiments were performed in Isparta, SuleymanDemirel University, Faculty of Technology. TS EN12975-2 Turkish standardis used for testing performance of solar collector [5].