An Experimental Study on Gear Diagnosis by Using Acoustic Emission Technique

Şaban Ulus and Selçuk Erkaya

Erciyes University, Engineering Faculty, Mechatronic Engineering Department, 38039, Kayseri, Turkey

(Received 24 June 2014; accepted 1 January 2015)

Acoustic Emission (AE) is one of the condition monitoring and diagnosing techniques of rotating machine elements such as gears, bearings, etc. So far, many studies about fault diagnosis on gearboxes have been implemented for vibration monitoring. In addition, a great deal of research on spur gears has been done for understanding the possible gear faults by considering their acoustic characteristics. In this study, possible faults in gears were analysed by the AE technique. A single-stage gearbox system comprising both helical and spur gears was used to identify the existence of possible gear faults, such as pitting and cracking at the tooth root. Noise signal in time-domain is converted to frequency-domain by using Fast Fourier Transform (FFT). In the experimental stage, artificial faults were implemented, and some mathematical parameters such as Root Mean Square error (RMS), Crest Factor (CF), and maximum value of noise level were considered to identify the fault occurrence at the meshing gear. The results show that the AE technique is very effective in diagnosing the defects in a gear system by a contactless measurement. Also, compared to the other diagnostic approaches, it is clear that the gear defects can be determined at an earlier stage by the AE technique.

NOMENCLATURE

AE	Acoustic emission
FFT	Fast Fourier transform
RMS	Root mean square
CF	Crest factor
FCM	Fault condition monitoring
EI	Energy Index
f_{R1}	Rotation frequency of 300 rpm
f_{R2}	Rotation frequency of 500 rpm
f_{R3}	Rotation frequency of 700 rpm
dB	Decibel
SPL	Sound pressure level
BPF	Band pass filter
$P(t)$	Instantaneous sound pressure
T	Time interval averaging
x_{peak}	Maximum peak value of the signal
P_{RMS}	Root mean square value of the sound pressure level
CF0	Crest factor for no loaded condition
CF1	Crest factor for 1 Nm loaded condition
CF3	Crest factor for 3 Nm loaded condition
RMS0	Root mean square value for no loaded condition
RMS1	Root mean square value for 1 Nm loaded condition
RMS3	Root mean square value for 3 Nm loaded condition

1. INTRODUCTION

In the industry today, in order to meet consumer needs, continuity of the production and safety of the processes are of crucial importance. Continuous Fault Condition Monitoring (FCM) can reduce downtime and the total cost of products. In spite of the fact that the initial capital investment cost is high for setting the FCM system, monitoring the health of the structures has a great importance, and FCM requirements in the industry are increasing day by day. Providing a method of early detection of structural, mechanical, or electrical problems allows operators to predict where faults occurred and suggest an approximate time that the system will break down. Unexpected machine failure causes both hitches of the production schedule and increases in cost with financial loss. For this reason, Predictive Maintenance methods are very important. One of them is the Acoustic Emission (AE) technique. It requires a contactless measurement, which is an advantage for mechanical systems and their parts. Any abnormalities or defects in the machinery or equipment must be detected and analysed at an early stage to avoid major problems. Therefore, FCM of rotating machinery, such as at gears and bearings, has a crucial role in the industry, as it keeps the system in a healthy condition for maximum productivity, while detecting and diagnosing faults at an early stage. As a result, it is possible to prevent serious problems, damages, and more cost.[1]

It is difficult to diagnose possible gear faults such as micro-cracks and pitting because of their minimal effect on the system, and these kinds of faults can lead to a rapid destruction of the teeth in meshing gears. Micro-cracks and pitting in gear teeth can be a catastrophic problem resulting in tooth breakage while the system is running. Nowadays, fault diagnosis techniques for rotating machinery, such as vibration monitoring and temperature detection analysis, need a measurement technique with contact. Although vibration monitoring techniques are quite common for detecting and diagnosing faulty conditions of rotating machinery, the AE technique provides early detection of faults.[2]

In the last two decades, a new method for early fault diagnosis, the AE technique, has been researched and gained increasing attention. AE is defined as a matter that results in the generation of structure- or fluid-borne waves due to the rapid release of energy from localised sources within or on the surface of a material. The application of the AE technique is