

An idea of continuous thermographic monitoring of machinery

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Abstract

Thermographic measurements find broad application in maintenance and technical state assessment of machinery and apparatus, industrial processes, as well as manufacturing [1],[4]. Thermographic inspections of technical objects are realized as a single or cyclic inspection and consist in controlling of a current technical state of an object or identification of a pre-failure state and assessment of damage size. Technological progress and price decrease of industrial thermovision cameras make the application of such apparatus possible to continuous monitor and assess a state of machines and devices.

In case of continuous thermographic diagnostics of machinery a monitoring system can be proposed (Fig. 1). System consists of server, IR and vision cameras as well as sensors for observation of measurement path parameters. System should allow observation of additional signals from sensors if such are installed (e.g. vibration). Main part of monitoring system is server where data are stored, analyzed and diagnostics decisions are sent to machine operator. IR camera delivers images with information about thermal state changes of observed machine during its operation. Vision camera is installed for observation of object illumination. Images from this camera are used for evaluation of influence of daylight on changes of thermogram features. Measurement path sensors (e.g. ambient temperature) deliver information about changes of surroundings condition which can influence on content of thermovision images. If machine is equipped with additional sensors it would be useful to connect it to the system in order to correlate information and increase of system efficiency.

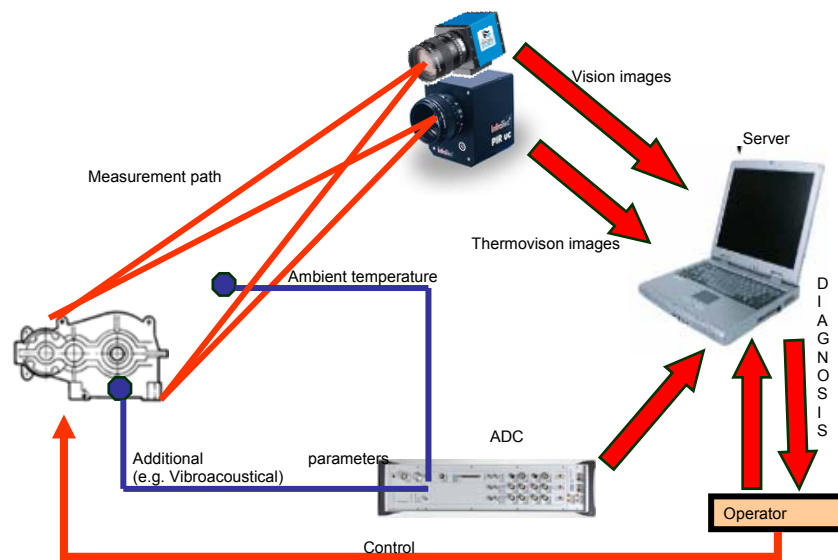


Fig. 1. Proposition of monitoring system for continuous thermographic monitoring

Continuous thermovision diagnostics of objects is connected with conduction of necessary and systematic actions consisting in acquiring of diagnostic data which is decoded in recorded thermographic images. In case of acquiring of relevant diagnostic information proper thermographic image processing methods [1],[6] should be applied.

A thermographic image can be treated as a digital image described by a discrete function of temperature values of two variables $T(x,y)$, where x and y are coordinates of coordinate system determining spatial resolution of the image.

During continuous object observation with the use of a thermovision device, a sequence of thermographic images in time t can be recorded. On the basis of acquired series of thermograms, a multidimensional thermographical signal $ST(T(x,y),t)$ can be defined. If we consider a concept **Błąd! Nie można odnaleźć źródła odwołania.** of conventional real time partition into “micro” (dynamic) and “macro” (operation) time, often applied in machine diagnostics, then the thermographic signal can be defined in these both domains.

Taking into account “micro” and “macro” time concepts, the process of analysis of thermographic signals can be divided into two stages. The first stage is connected with thermogram analysis and feature extraction. It enables us to determine diagnostic signals in “micro” and/or “macro” time (Fig. 2).

The second stage of analysis refers to the analysis of diagnostic signals which were determined at the first stage. For these purposes classical signal analysis methods can be applied.

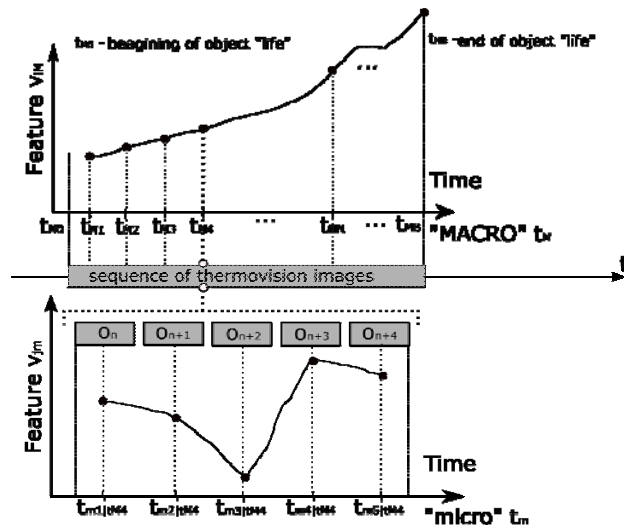


Fig. 2. Idea of analysis of thermographic signal in both "micro" and "macro" time domains

In order to verify proposed methods of analysis of thermogram series, an active diagnostic experiment was carried out. The aim of the experiment was acquisition of thermographic signals. An investigated object was a laboratory model of rotating machine. As a result of diagnostic experiments series of thermograms recorded during object operation in different technical states (S1-S5) have been obtained.

Recorded thermovision images have been analyzed with the use of selected statistical texture analysis methods. In this case specialized software MaZda dedicated to calculation of texture parameters (features) in digitized images has been applied. MaZda was originally developed in 1996 at the Institute of Electronics, Technical University of Lodz (TUL), Poland for texture analysis of mammograms [5].

In case of thermogram analysis it was necessary to separate regions of interest (ROI) in the images.

Fig. 3 presents an exemplary plot of a diagnostic signal of mean temperature estimated for selected ROI's. Values of selected feature are functions of numbers of consecutive recorded images. In the plot limits of technical states have been indicated. It can be observed that in some cases e.g. ROI 5 identification of changes of technical state is possible.

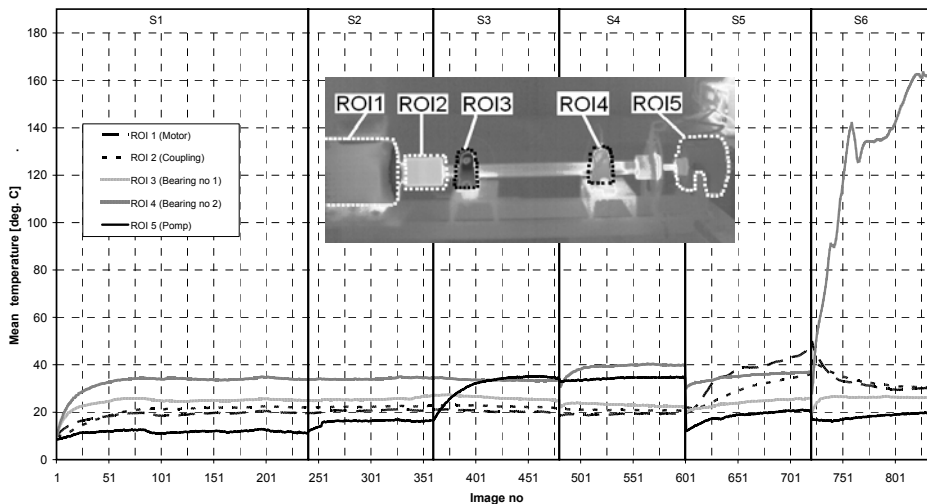


Fig. 2. Plot of diagnostic signal of mean value

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