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Service knowledge capture and reuse

R. Roy*, J. Mehnen, S. Addepalli, L. Redding, L. Tinsley, C. Okoh

EPSRC Centre for Innovative Manufacturing in Through-life Engineering Services
Manufacturing and Materials department, Cranfiled University, MK43 0AL, UK

* Corresponding author. Tel.: +44 (0)1234 758555; Fax: +44 (0)1234 758292. *E-mail address:* r.roy@cranfield.ac.uk

Abstract

The keynote will start with the need for service knowledge capture and reuse for industrial product-service systems. A novel approach to capture the service damage knowledge about individual component will be presented with experimental results. The technique uses active thermography and image processing approaches for the assessment. The paper will also give an overview of other non-destructive inspection techniques for service damage assessment. A robotic system will be described to automate the damage image capture. The keynote will then propose ways to reuse the knowledge to predict remaining life of the component and feedback to design and manufacturing.

Keywords: Service damage identification; degradation analysis; pulsed thermography; non-destructive inspection

1. Introduction

Industrial product-service systems aim to shift through-life engineering services [1] responsibility and risks to the manufacturers. Manufacturers of long life and complex engineering systems are looking to improve the design and manufacturing of their products to reduce the service cost, in order to improve their profitability. The design and manufacturing for service is becoming essential for the industrial product-service systems [2]. The most common approach is to utilize the service knowledge from similar products to improve the design and manufacture of the new products and associated services, such as maintenance. Service knowledge is defined as the processed information and experiences of the service personnel gained through their service related activities. The knowledge will include assessment of the current health of a component or system in service and the operational and service history. This paper presents an outline of the service knowledge capture approach developed within the EPSRC Centre at Cranfield University and ideas to reuse the knowledge for design and manufacturing of aerospace components.

Service knowledge capture and reuse is of significant importance especially with high-value components within the aerospace industry due to the associated high maintenance cost relating to component replacement and/or refurbishment. Thus there is constant need to collect service information to critically assess component degradation during maintenance. This keynote paper presents a novel approach to capture service damage knowledge of an individual component using thermographic inspection, automated robotic thermographic inspection and image processing which will perform root-cause analysis for the degradation identified thereby identifying new relationships between component degradation, initial system design, and manufacturing process used. The research will produce new knowledge on dependencies and will capture design and manufacturing rules to extend the life of the component.

Infrared thermography has become the condition monitoring tool gathering additional interest in the field of advanced NDT methods [3]. With faster inspection, data

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processing and lower equipment costs, thermography has found its way into traditional NDT methods, however has not been fully incorporated to inspect high-value components. Currently thermography is being used to detect subsurface damages such as cracks, delaminations, disbonds, voids, inclusions or water ingress in advanced materials mainly in composites [4].

The EPSRC Centre for Through-life Engineering Services at Cranfield University is currently developing automated NDT techniques to quantify service damages occurring in high-value components that will predict the remaining life of the component. This paper presents the automatic thermography inspection using a robotic arm.

The EPSRC Centre:

The £11.15 million National EPSRC Centre (including £5.7 million from EPSRC) for Innovative Manufacturing in Through-life Engineering Services provides world-class capability in the UK to enable industry to deliver high value products with outstanding availability, predictability and reliability with the lowest life cycle cost. The EPSRC Centre vision is to provide thought leadership in through-life engineering services and be the first choice for UK manufacturing companies as a source of technological solutions, R and D capability, knowledge, skill and advice.

As a part of the center's activities, the following are the major projects being taken up by the center:

- Characterization of **in-service component feedback** for system design and manufacturing
- Reduction of **no-fault found** (NFF) through system design
- Improvement of **system design** process for whole life cost reduction
- **Self-healing technologies** for electronic and mechanical components and subsystems
- **Collaborative Autonomous Robotics for Maintenance**

2. Service knowledge capture and reuse: current research and industry practice

The role of service knowledge for product-service systems is recognized by Baxter et al. [5], Goh and McMahon [6]. Baxter et al. presented a framework to inform design with service requirements purely based on human expert assessment. Goh and McMahon argue that continuous improvement for product-service systems depend crucially upon the implementation of effective knowledge and information management systems within a dynamic learning environment across the product lifecycle. The paper does not address any automatic knowledge capture approaches for effective knowledge capture. There are other authors who focused on intelligent monitoring and algorithmic approaches for the service knowledge capture [7][8]. The knowledge obtained through the monitoring was used to optimise maintenance schedules, but did not feedback to improve the design or manufacturing.

Through a recent study at the EPSRC Centre in Through-life Engineering Services, it was observed that the interfaces between the design and service and manufacturing and service are still not well developed in industry. It was observed that the communication between the functions is very much dependent on occasional meetings and individual initiatives. Figure 1 shows high-level communication between design, manufacturing and service functions.

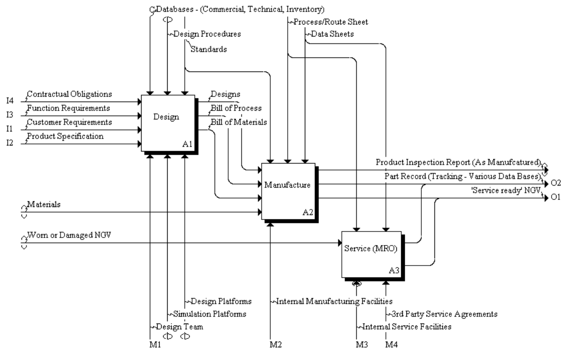

Figure 1: First Level Decomposition of IDEF0 Process Model for Design, Manufacture, & Service of an Aerospace Component

This paper presents approaches to automate the service knowledge capture using a quantitative approach and discusses opportunities to reuse the knowledge. The research is based on detailed case studies with aerospace and railway components.

3. The automated knowledge capture approach

The automated knowledge capture approach analyses the thermal images of service damage on a component and verifies the results with other non-destructive testing techniques if appropriate. An integrated system to automate the service damage capture is also developed using a robot. For inaccessible areas, a borescope is designed for railway axle internal service damage examination. From literature it has been noticed that the most common degradation mechanisms for aerospace components are wear, cracking, fatigue, and corrosion (Figure 2).

Figure 2: Image of aero-engine component exhibiting typical damage.

This project will capture component failure, damage and degradation using 3D surface scanner to identify surface