Digital Lifecycle Management (DLM)

RLW Process Monitoring for Quality & Productivity Improvement

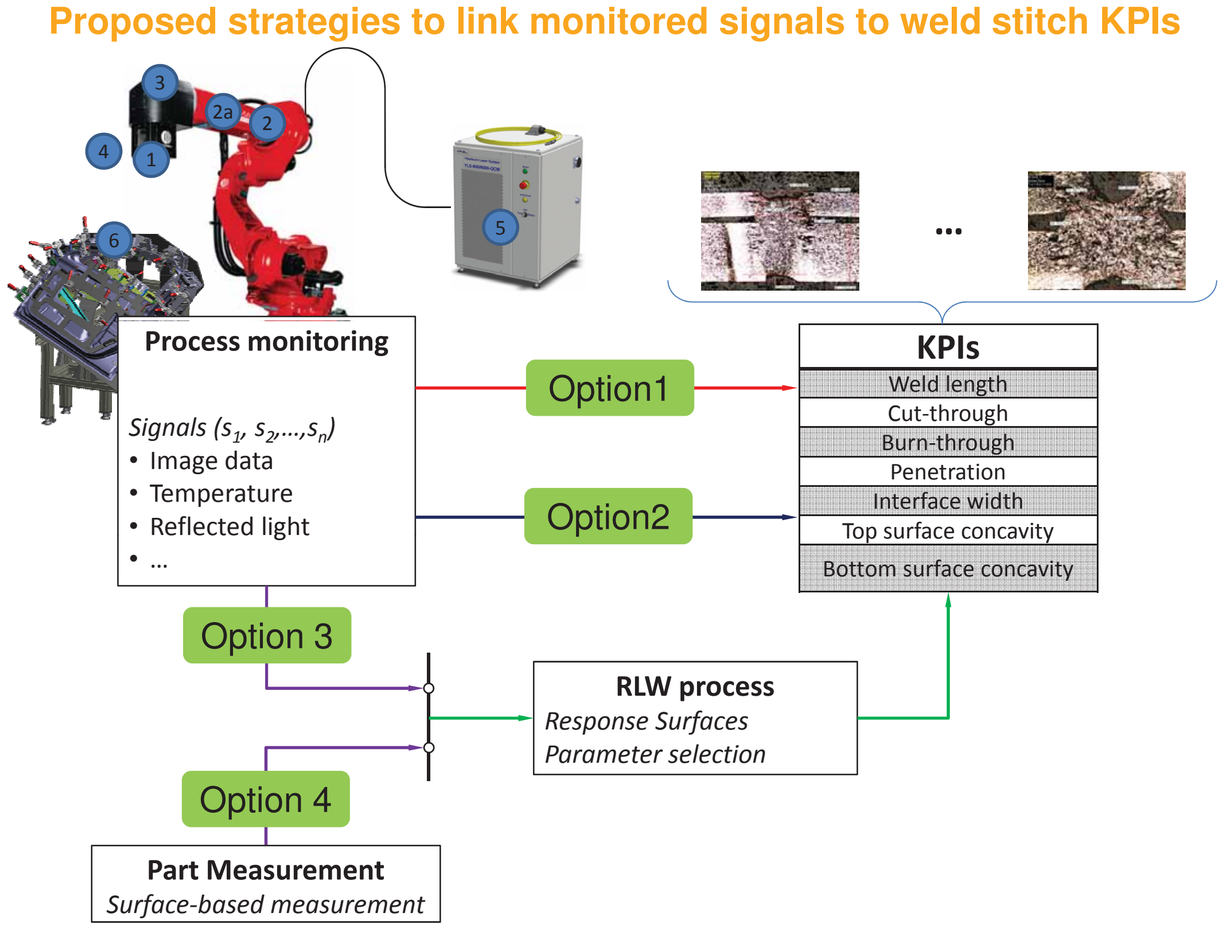
Dr PKS Prakash, Dr Pasquale Franciosa, Prof. Darek Ceglarek

The research aims to develop methodologies to link the process signals with the process Key Product Indicators (KPI's) to enhance the process monitoring capability for quality and productivity improvement in the Remote Laser Welding (RLW) process.

Introduction

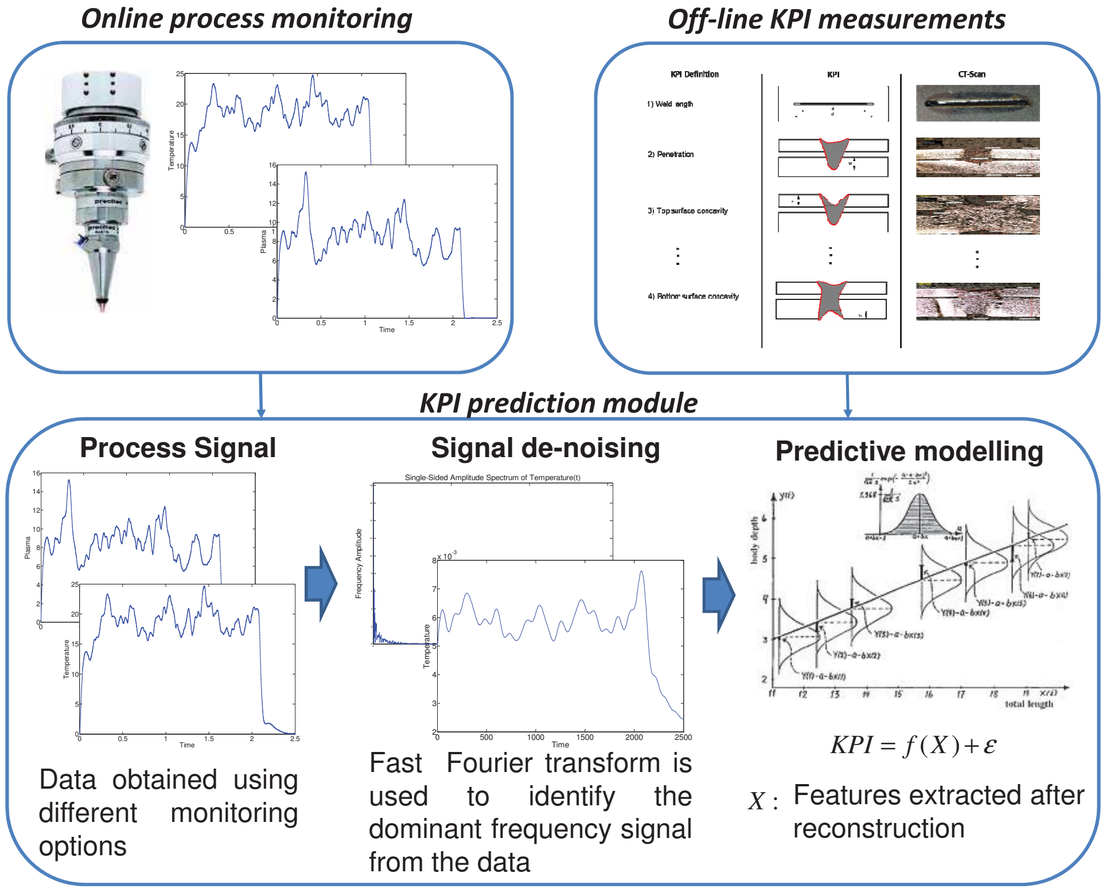
Process-induced variation has significant impact on product quality and productivity. The complexity of products coupled with increasing flexibility and responsiveness in processes enhances the challenges of process control. For example, in the Remote Laser Welding (RLW) process several Key Process Indicators (KPI's) such as penetration, interface width, top-surface concavity and bottom surface concavity are used to evaluate the product quality. The efficient detection of any variation in the KPI's needs to be captured in real time to improve the quality and productivity of the process. The current research explores 4 options to link process monitoring with weld KPI's.

Proposed strategies to link monitored signals to weld stitch KPIs



Option 1: SIGNAL to KPI

This option links the in-line measurement information captured using a camera and photodiode to link with KPI's.



Data obtained using different monitoring options

Fast Fourier transform is used to identify the dominant frequency signal from the data

$KPI = f(X) + \varepsilon$

X : Features extracted after reconstruction

Option 2: Signal to KPIs (analytical-based)

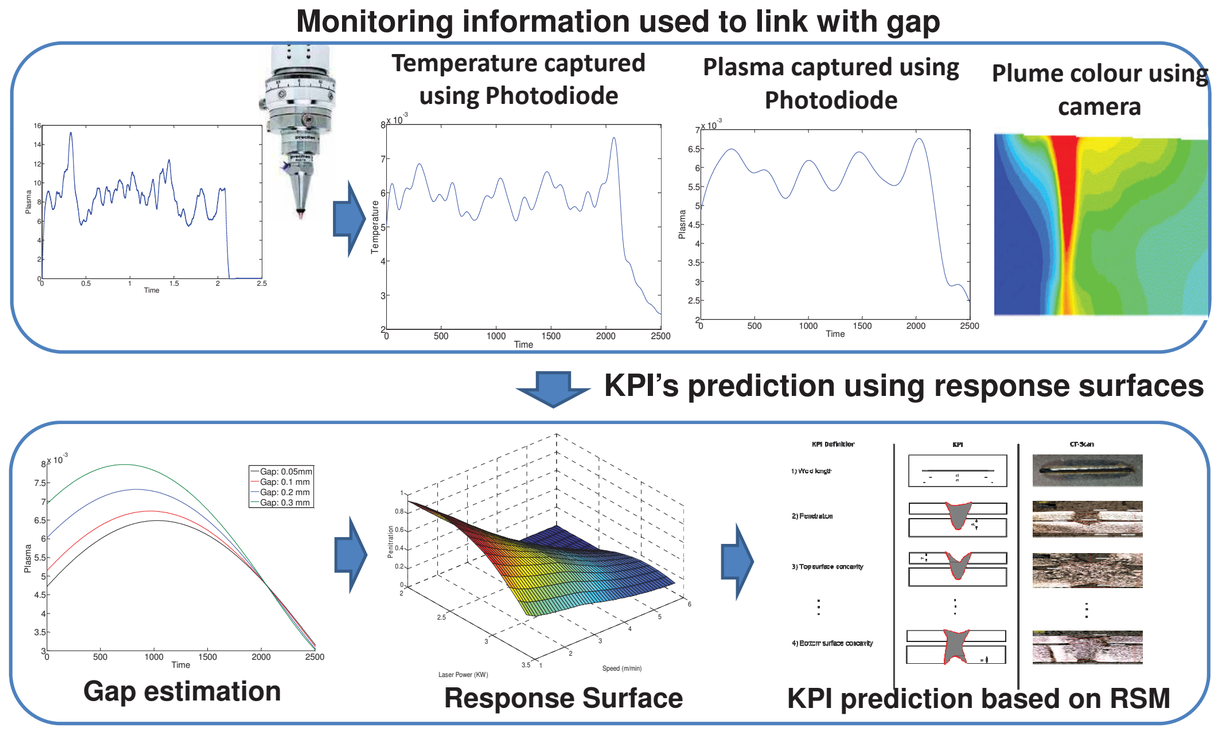
This option allows us to analytically correlate measured temperature and stitch penetration (this could also include interface width).

The preliminary model will be based on a 1-dimensional assumption. This means that only the variation along the thickness axis is modelled.

The two main phases occurring during the RLW joining process are considered: (i) melting phase (Stefan problem); (ii) vaporisation (plasma generation due to high power/temperature field). If the analysis fails to predict KPI's with a satisfactory confidence level, then FEM-based model will be developed.

Option 3: RSM (Response Surface Method) to KPIs (on-line gap measurement)

This option links the on-line signals with part-to-part gap. The methodology exploits spectroscopic tests to evaluate the optical radiation from the welding plasma/plume. Acquired spectra are then analysed using a multivariate data analysis approach in order to ensure gap monitoring.



Option 4: RSM to KPIs (off-line gap measurement)

This option links the off-line measurement data to KPI's. Gap distribution can be estimated by combining off-line measurement gauges and simulation tools: (i) measurement of single part before assembly; (ii) generation of variation in sheet-metal parts, based on 3D-DCT approach; (iii) generation of simulation assembly stack-up (including locators, clamps, dimples), based on VRM (Variation Response Method) approach; (iv) estimation of part-to-part gap.

It may be possible to obtain KPI's using the response surface models. These models define the KPIs in terms of: power, speed, material stack-up and gap. This option offers the possibility of using the gap distribution data for fixture Root Cause Analysis (RCA).

For more information please contact Prof. Darek Ceglarek (d.j.ceglarek@warwick.ac.uk). Also visit http://www.rlwnavigator.eu/