Non-destructive crack testing with induction thermography

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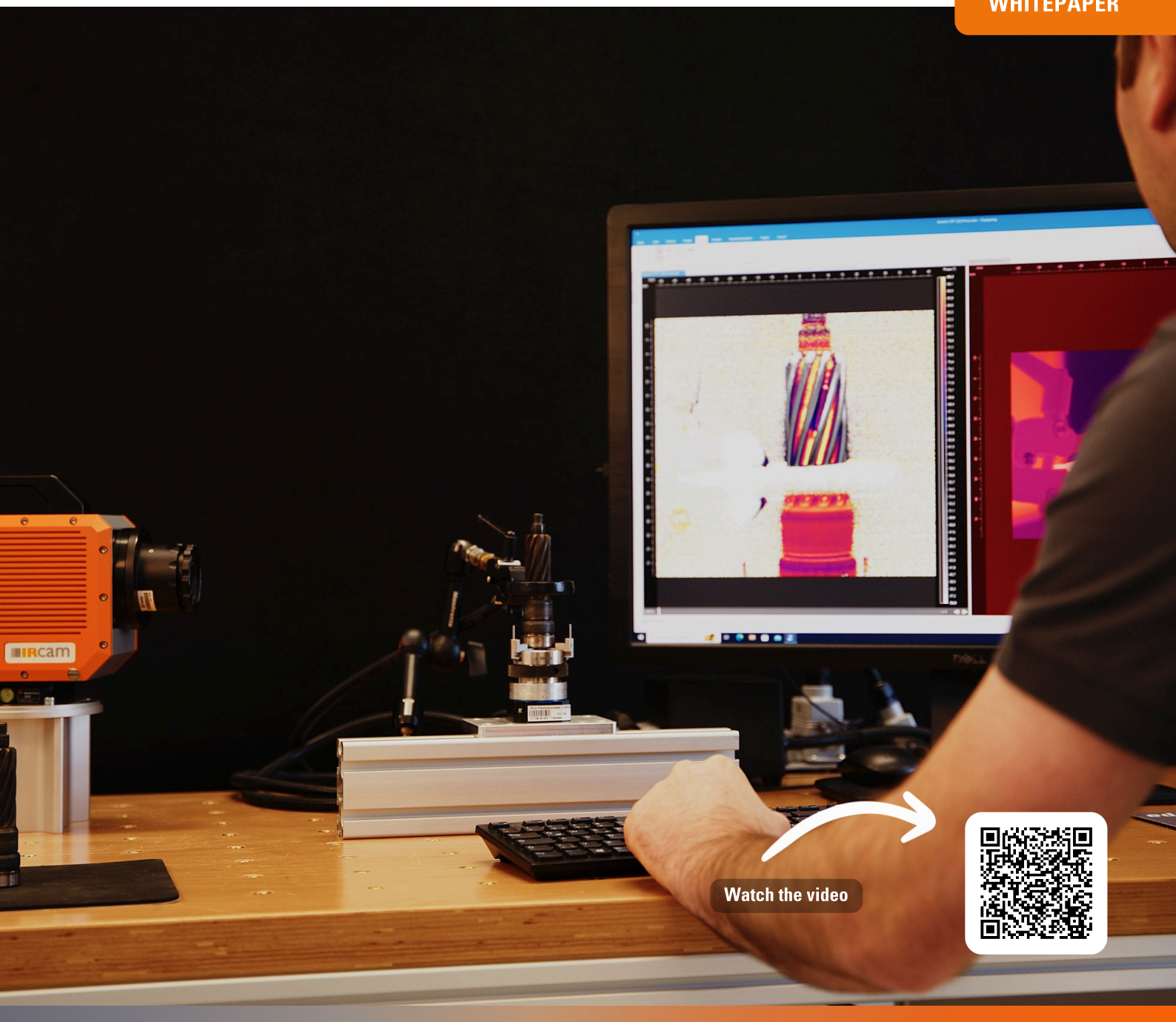
WHITEPAPER



Abstract

The non-destructive testing of cracks in metallic forged and case-hardened components is becoming increasingly important, particularly in the automotive and aerospace sectors. Cracks can significantly affect the mechanical strength and service life of these components and are therefore critical to product quality. The induction thermography technique developed by edevis offers a fast and precise solution for non-contact quality control by making cracks visible through heat flow analysis.

Introduction

In sectors such as the automotive industry, where the durability and reliability of components are of the utmost importance, testing metallic components for cracks and similar defects is becoming ever more important. Induction thermography makes it possible to detect even fine cracks and material defects non-destructively, which contributes decisively to quality assurance and to compliance with high safety standards.

Safety aspects: Cracks in safety-critical components such as drive shafts or gearbox components can lead to failure in operation, which could cause serious damage or even accidents. Inspecting these components considerably reduces this risk.

Performance optimisation: Flawless quality in metallic components supports their mechanical strength and extends their service life, which contributes to the performance of the overall system.

Regulatory requirements: Regulations in safety-critical industries call for complete documentation and verification of component quality. Reliable testing helps to meet these requirements efficiently.

Background

Crack testing on forged or case-hardened components is a challenge due to the high mechanical loads involved and the often complex geometries. Traditional testing methods, such as magnetic particle inspection, are costly and as a rule cannot readily be automated. Non-destructive testing across the full surface offers clear advantages here.

Induction thermography uses the heating generated by eddy currents, which are induced by an alternating magnetic field, in order to analyse the heat flow within a component. In areas containing material defects such as cracks, the heat flow changes markedly and can be made visible by an infrared camera. This method enables fast, precise and automatable testing of components and is particularly suitable for series inspection in production.

Concept

Principle of induction thermography

Induction thermography combines inductive heating with infrared thermography and belongs to the category of active thermography. In this method the component is exposed to an alternating magnetic field, which induces local eddy currents. The heat thereby generated travels through the material along the areas free of defects. At points where cracks or other defects are present, an uneven heat distribution occurs, which is captured by a high-resolution infrared camera.

Analysing the temperature distribution enables detailed testing and identification of cracks as well as further structural defects in the material (e.g. porosity and inclusions). The image processing software displays the defects as thermal anomalies, so that even the smallest irregularities can be reliably detected.

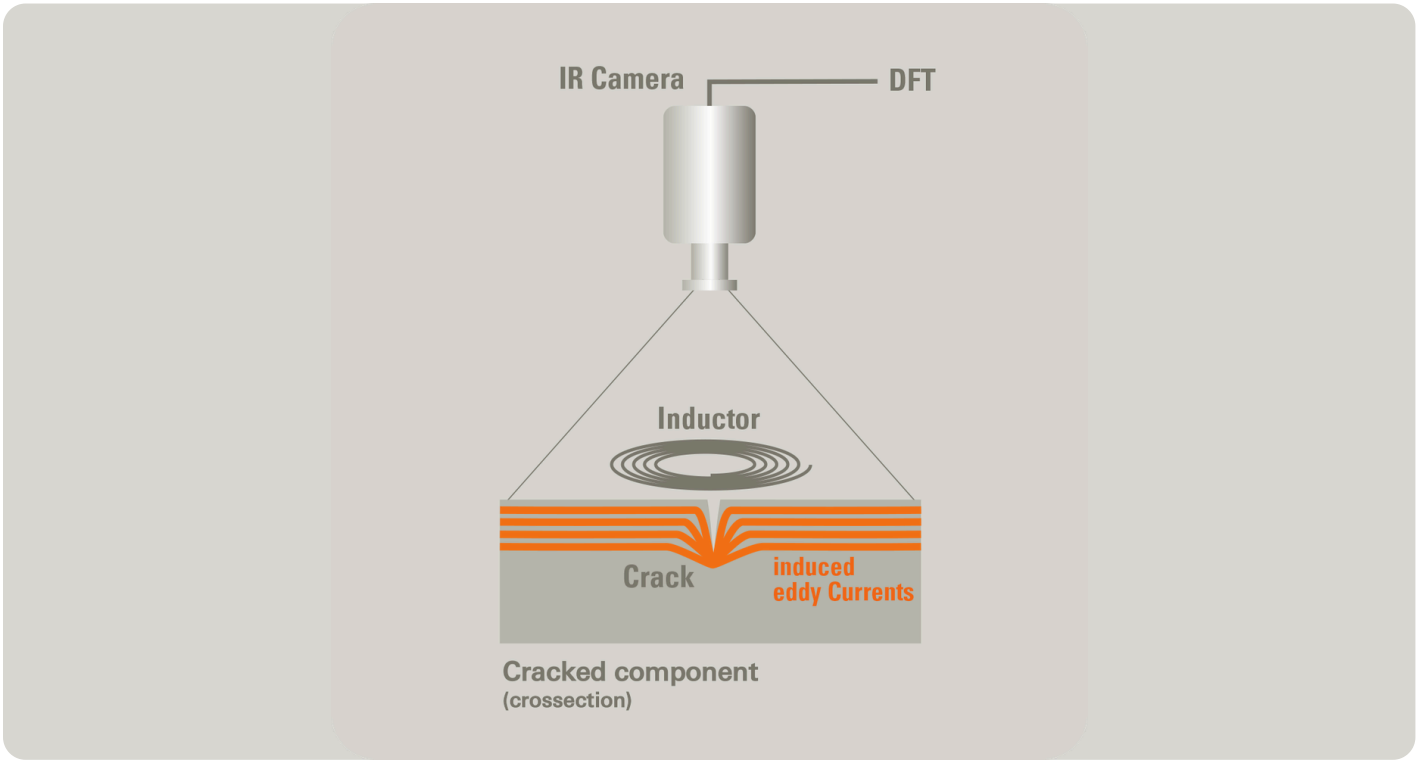


Fig. 1 Principle of induction thermography

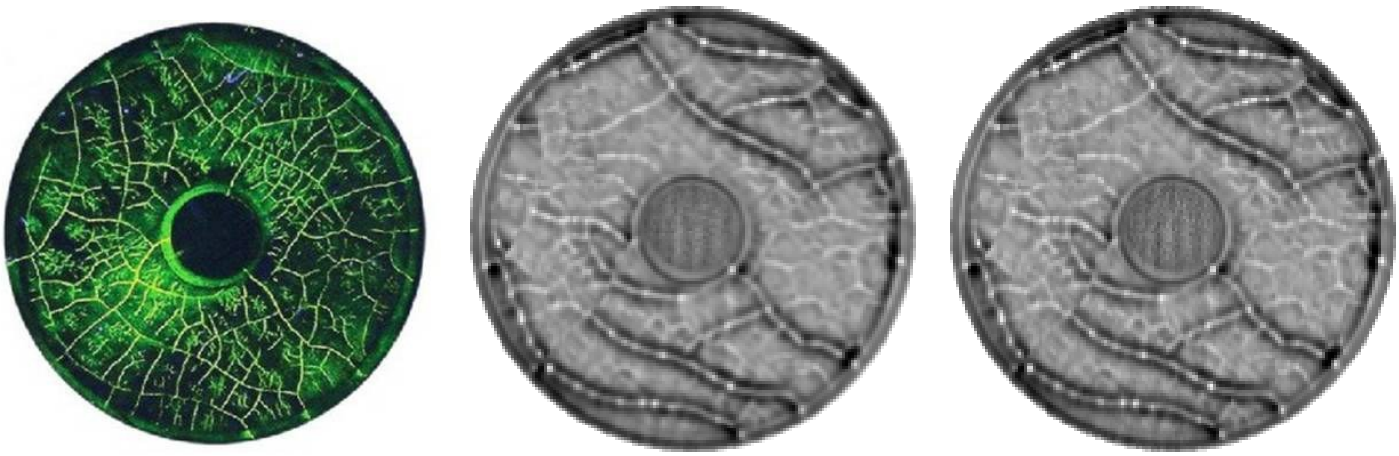


Fig. 2 Images of a reference specimen for crack testing. Left: magnetic particle inspection. Centre/right: induction thermography with different excitation directions.

Example images and phase representation

Figure 2 shows a typical example of an induction thermography image. Left: magnetic particle inspection of the surface; centre: induction thermography with the identified crack structures in the vertical direction; right: induction thermography with the identified crack structures in the horizontal direction.

Solution

The ITvis system from edevis combines a powerful inductor with a precise infrared camera designed specifically to detect thermal changes in the vicinity of cracks and material irregularities. Its modular design allows it to be adapted to different component sizes and geometries, from small forged parts through to larger hardened components.

Inductor: A high-frequency inductor whose power and penetration depth are matched to the specific component geometry and material.

Infrared camera: A high-performance camera captures thermal changes with a thermal resolution of less than 20 mK and a high frame rate for real-time analysis.

Software: DisplayIMG enables automated image processing and defect detection. Phase images and specific algorithms for crack analysis allow a clear and reproducible assessment of component quality.

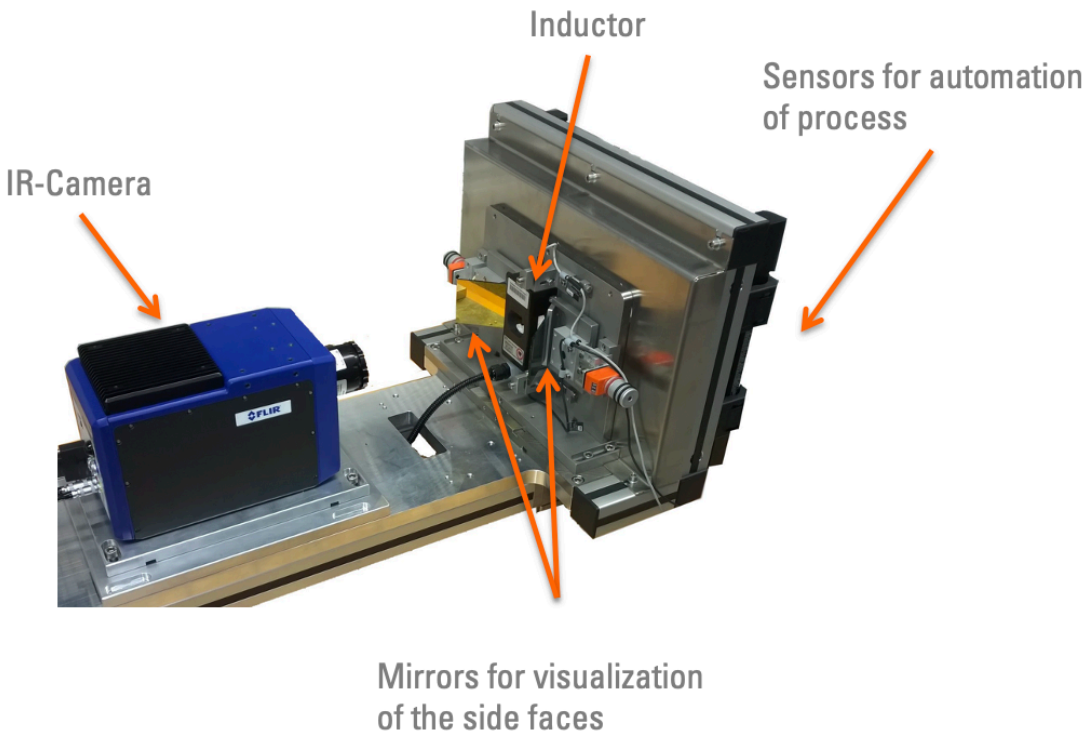


Fig. 3 Images of an open inspection head for crack testing on forged components.

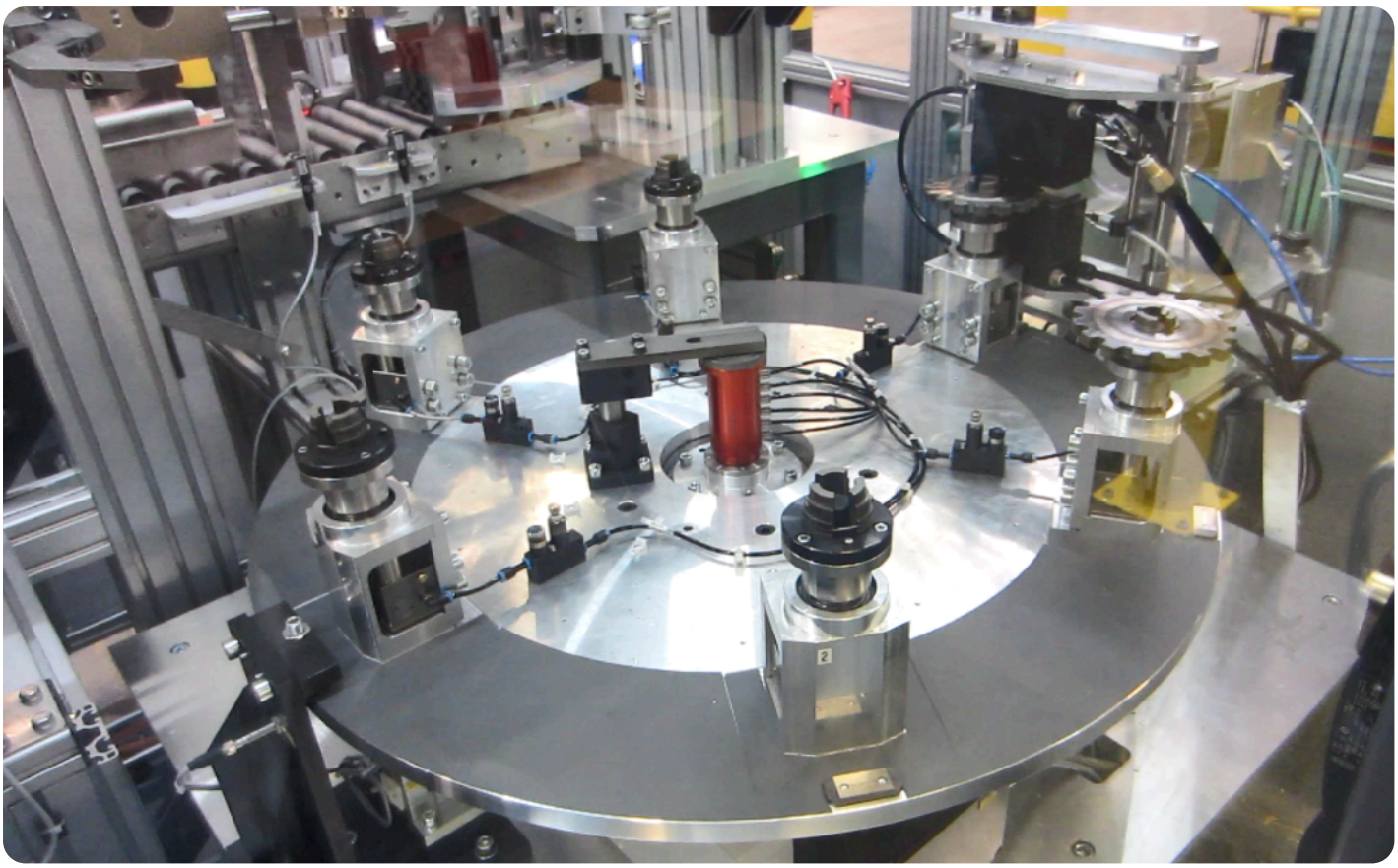


Fig. 4 ITvis inspection system with rotary table

Automation capability and inline integration

The ITvis system is fully automatable and can be integrated into existing production lines. Communication via PROFINET, OPC-UA and TCP/IP simplifies the connection to PLC-based systems and enables seamless integration into industrial inspection processes.

Advantages of induction thermography

- Non-contact and non-destructive
- Fast and precise (≤ 1 second per measurement)
- High repeatability and sensitivity
- Automatable and inline-capable
- High defect detection sensitivity (comparable to magnetic particle inspection)
- No need for elaborate pre- and post-treatment or washing of the parts

Conclusion

Induction thermography offers an effective and non-destructive method for the quality control of forged and case-hardened components. It ensures fast and reliable detection of cracks and other material irregularities and thus makes a substantial contribution to safeguarding safety and quality in the production of metallic components.

Technical specifications

Induction	
Induction type	Medium-frequency induction
Inductor frequency	10 kHz – 60 kHz
Cooling	Water or air cooling
Measurement area	Variable (up to approx. 60 mm x 60 mm)
Power	3 kW to 5 kW
Infrared camera	
Maximum frame rate	100 frames per second
Camera field of view	10 degrees
Thermal resolution	20 mK
Sensor resolution	640 x 512 pixels
Spectral range	MWIR (2 – 5 µm)
Operating parameters	
Typical measurement duration	< 0.1 second per measurement area
Possible test surfaces	Shiny, matt, oiled if applicable (cleaned, free of scale)
Possible materials	Steel, stainless steel, aluminium
Maximum cable feed length	20 metres between control cabinet and inspection head
Cable and light guide	Suitable for robots / drag chains
Data transmission	Standard CAT-6 cable, Gigabit Ethernet
Interface to automation	Profi.NET, OPC-UA, TCP/IP

edevis – enhanced defect visualization

Based in Leinfelden-Echterdingen, edevis GmbH has specialised in imaging-based, non-destructive testing using active thermography since 2004. The company develops and supplies testing systems for the inspection of materials and components – from feasibility studies through to fully integrated production-scale systems.

The fields of application include the testing of fibre-reinforced structures, crack testing on metallic components and the inspection of welded and joined joints.

In the company's own test laboratories, customers can evaluate technologies with minimal effort before proceeding to series testing. In addition, edevis offers training on systems and procedures – both in-house and on-site at the customer's premises.

The testing systems are currently in use in the automotive, aerospace, medical technology, plant engineering and research and development sectors.

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