Taking additive manufacturing one step closer to the aviation industry goals

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The aviation industry is working intensively to reduce the environmental impact of flying, and additive manufacturing (AM) is a key enabler in this effort. However, for the technology to meet the industry's extremely high safety and quality standards, a thorough understanding of the process is required. New research by Karthikeyan Thalavai Pandian, University West, Sweden, contributes important pieces to this puzzle.

Today's aircraft already contain engine components produced with additive manufacturing, but for less critical applications. Given the numerous advantages of the technology, the aircraft engine manufacturer GKN Aerospace aims to produce even more components in more materials using AM for critical applications. Achieving this goal requires extensive research and testing.

Pandian presented his doctoral dissertation at the end of May, focusing on one of the AM technologies called electron beam powder bed fusion (PFB-EB) for titanium alloys.

AM has many advantages

"This manufacturing technology is highly interesting for certain components. It enables reduced material consumption, lowers costs, and in the long term, decreases environmental impact. Additionally, the technology opens new possibilities for manufacturing more complex geometries than what is possible with conventional methods like casting and forging," explains Pandian.

His research has primarily focused on the microstructure and mechanical properties of the titanium alloy Ti-6Al-4V. This alloy is used for components in the low-temperature sections of aircraft engines due to its very high specific strength.

"My focus has been on improving the fatigue properties of the PBF-EB-built Ti-6Al-4V material. When using this AM technology, surface quality and defects can affect the fatigue properties. If the surface layer becomes too rough and uneven, the fatigue performance of the components can be reduced. Several PBF-EB process parameters can make the surfaces too rough and uneven. In my research, I have explored the effect of a few of these process parameters on surface roughness and how the PBF-EB built surfaces influence the fatigue properties," he says.

"Similar to the surface roughness, the defects in the bulk of the AM components can be detrimental to fatigue life."

New post-build-heat treatment

The AM-built components are typically subjected to post-build-heat treatments (hot isostatic pressing). The current post-build-heat treatment method is developed for conventional manufacturing techniques. The method is not optimal for AM manufacturing as it negatively affects the static strength.

Pandian continues, "I have investigated a new method tailored for AM manufacturing. This method uses a lower temperature, providing several advantages: the titanium alloy does not lose static strength, and the fatigue properties are comparable to the standard post-build-heat treatment method."

For the aviation industry to use the new method after AM manufacturing, it must be standardized according to the industry's safety and quality criteria.

"Once a standard is in place, the industry can more efficiently use AM technology to manufacture more components. The technology is also interesting for other applications, such as the medical technology industry that produces implants," Pandian notes.

Aims to reduce the need for post-processing

One of Pandian's overarching goals in his research has been to develop AM technology to reduce post-build-machining while meeting quality requirements, which can be achieved by improving the surface quality of AM-built components.

"By reducing post-build-machining depth from about 2 mm to 1 mm, material and time are saved in manufacturing. If components can also be built fully finished in an AM process without requiring post-processing, then we can truly claim to have created a sustainable manufacturing method. Today we talk about achieving 'near-net-shape,' but the goal should be to achieve 'net-shape,'" says Pandian.

As a newly minted doctor in production technology, Pandian is now taking his research further in his role as a senior lecturer at University West.

"In addition to teaching, I look forward to working with more AM processes and more materials with a focus on the fatigue properties of materials and how we ensure quality with the help of AI.

"After eleven years as a product developer at Volvo Construction Equipment in India, I needed to understand how the properties of materials affect the final product. Now, after completing my doctoral studies, I am convinced that more research in materials science can make a big difference," Pandian concludes.

More information: Karthikeyan Thalavai Pandian, Microstructure and mechanical properties of Ti-6Al-4V manufactured by electron beam powder bed fusion. www.diva-portal.org/smash/get/ …