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Project title: ARP²: Automatic production of repair patches for fibre composite materials
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Abstract

Fiber-reinforced composites (FRP) have become increasingly popular in recent years in many branches of industry, such as the automotive and aerospace industries. Due to their increased use, there is an increasing number of damage to components made of FRP. However, the replacement of these parts is not economical, because of their high manufacturing costs. For this reason, the aim is to repair the damaged components.

Standardized repair concepts are currently mostly found in the aerospace industry and are used there for structural components. The process can be divided into four stages. Firstly, a 3D damage detection is carried out, which is completed by an analysis of the resulting damage. This allows to determine the exact strategy for repairing the damaged area. Subsequently, the so-called patch, which is required for the repair, is produced and applied to the damaged component. In order to repair the damaged area, different strategies can be distinguished, which are listed below:

- The cured patch is glued onto the damaged area
- Dry patch is applied as a textile to the damaged area and connected to the component by infusion
- Pre-impregnated patch (prepreg) is applied during the co-bonding process under the influence of heat

Depending on the strategy used, the mechanical properties of the repaired part can be reduced by more than 20% compared to an undamaged part. This loss of mechanical properties is the consequence of insufficient adhesive bonding between the patch and the component. In order to improve the adhesive bond between patch and component, it is necessary to use nanoparticles, which is to be carried out in the present application.

Due to the dimensions of components made of FRP, such as those used in the aerospace industry (Airbus A350 XWB wings), it is clear that the actual repair process of the component must take place in the assembled state and

on site. Because of the high demand for FRP components in the aerospace and automotive industries, individual repair patches cannot be produced locally. Therefore, it makes sense to outsource the production of patches, as shown in Fig. 1.1, like it is currently used for the sheet metal repair of car body components.

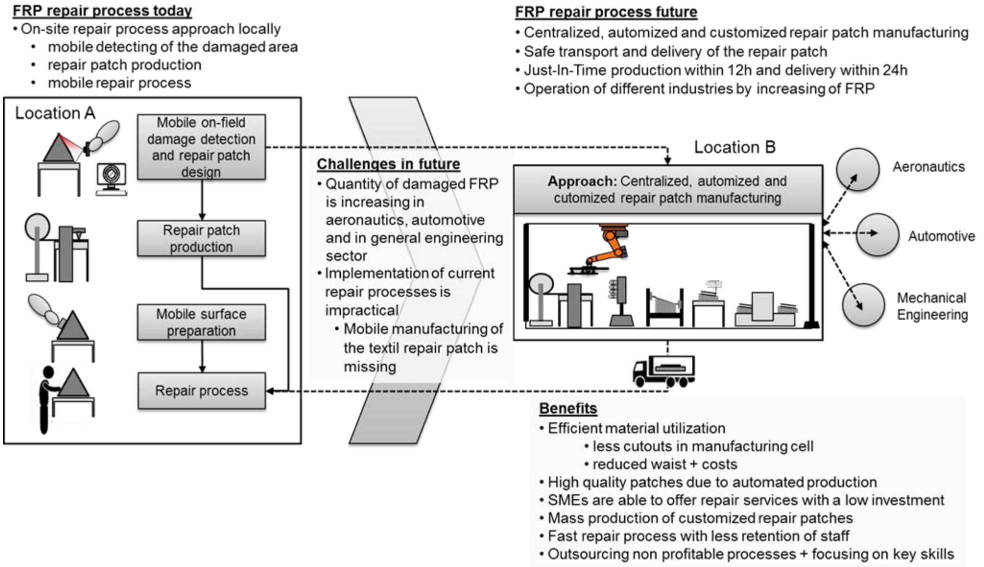

Fig. 1.1: Goal and approach for the automated production of repair patches

Repair concepts with the requirement for safe and fast transport aspects are not yet in focus, but are becoming more important in case of the increasing number of FRP components.

The aim of this project is to guarantee a safe delivery of tailor-made repair patches to the European demand location within 24 hours and to increase the residual carrying capacity of the repaired area to 90 %.

In order to be able to implement this project, the focus will be on just-in-time production, whereby the repair patches will be centralized and produced automatically. In combination with a new transport approach, the patches can be delivered safely and quickly to the place of repair, thus keeping investment costs low (cf. Fig. 1.2). Due to increase the residual carrying capacity to 90%, as already mentioned, the repair patches are provided with functional nanoparticles. These cause covalent interactions between matrix and reinforcement and thus improve the connection of the patch to the area, which is going to be repaired.

Fig. 1.2 shows the process chain envisaged in the project. The figure also shows the responsibility of the project partners for the various parts of the process chain.

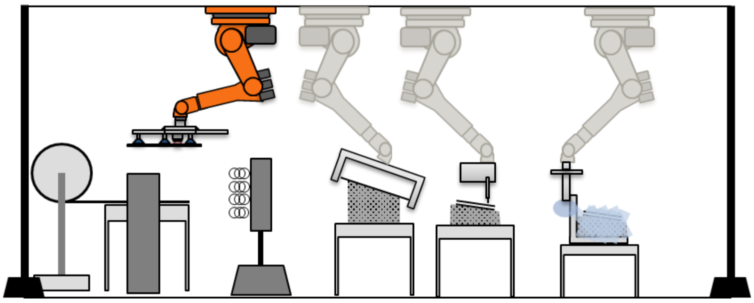

Fig. 1.2: Desired process chain of the repair concept

As shown in Fig. 1.2, the damaged area is first scanned by a mobile 3D laser system. Information such as cutting geometry, draping information and nanoapplication location are generated. With this information the repair patch can be produced by the cutting unit. The patches can be produced as prepregs or dry textiles to carry out various repair processes up to a maximum size of 400 mm x 400 mm. The next step is the application of the nanoapplication to the patch. Parallel to the production of the textile, the Rapid-Tooling unit produces the foam carrier as an auxiliary tool and transport medium. On this foam the finished patches are combined to a preform. In addition, a tufting unit temporarily fixes the different layers on the foam to maintain the fibre orientation. The movement between the stations is ensured by a handling unit attached to a robot. For transport, a temperature and moisture indicator is enclosed with the patch before everything is prepared for shipment by a packing unit. At the receiving point, only the shipping film and tufting seam have to be removed in order to use the patch for repair. The foam carrier continues to serve as an auxiliary tool.

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