EXPLORING DESIGNING WITH COMPOSITES

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Currently the dominant manufacturing route for composites materials is a manual process, called hand lay up. This is problematic because it is an unstandardised process that is heavily reliant on tacit knowledge and poorly understood. Production has both low rates and capabilities, this is linked to the industry's ability to develop the supply chain and train a workforce with composites' skills. Overcoming both this challenges requires a knowledge base around the hand lay up process to be established. The industry is also experiencing problems with manufacturability, defects and scrap rates leading to increased costs (Chatzimichali, 2014).

The manufacturing route for composites is very different to metals. Hand lay up involves forming layers of glass or carbon reinforcements that have been pre impregnated with resin to a mould. The person who does this job is called a laminator. Ingrained in the process of lay up are handmade and personally owned hand held tools belonging to the laminators. These are used to aid forming the reinforcements to a mould. They are important because they represent the in-process knowledge that the laminators have. This knowledge is currently tacit.

Probing where the problems that the industry is seeing start and why we have them leads to the following observations (Chatzimichali, 2013):

- The problems start in design and manifest themselves in production
- Designers are not trained in how to work with composites materials, the sectors that use composites have a history built on metallic design
- The industry doesn't know how to digest new knowledge so within production craftsman develop as there are no standardised codes of practice

A theory for how new knowledge can be integrated into a learning cycle for new product development (NPD) has been developed by F. Smulders (Smulders, 2004). This is being used to explore where new knowledge gets generated and integrated within the composites industry. Interviews were conducted with laminators to understand a typical production process for a high performance product. The manufacturing tools are being used to elicit a laminator's tacit knowledge and contribute to building a knowledge base around hand layup. They represent where knowledge about how to handle the reinforcements is generated. As a paradigm art fabricators who have worked with carbon reinforcements were also interviewed. They were selected to understand the role that material explorations can play in NPD.

It was found that within a production environment there was an incomplete learning cycle. The manufacturing tools are not developed until an artefact is in production and their use is not communicated outside of the shop floor. A laminator's knowledge is remaining tacit. To explore how a craft can become a standardised industrially setup process it has been suggested to standardise these tools. It is thought that this will be beneficial by

- Introducing a consistent training approach for laminators
- Building a knowledge base that will facilitate developing the supply chain
- Integrating a laminator's knowledge in handling reinforcements at the conceptual stage in the design process to overcome manufacturability problems seen in production

By contrast it was found the art fabricators use material experiments to generate a knowledge base around handling materials that enables them to support the concept development stage of NPD. They had a complete learning cycle.

In conclusion the composites industry has an incomplete learning cycle. This has arisen from knowledge gaps in both design and its translated into production. Possible causes for these gaps are problems with design education and an inability to integrate new knowledge about how to handle a material. This develops a situation that allows laminators to work out how to handle reinforcements for themselves, and perpetuates their lack of formal training. Training requires a knowledge base that currently does not exist.

Overcoming these knowledge gaps requires generating new concepts with knowledge about how to handle the reinforcements. Currently this is generally not done and the industry is ignoring what is possible with the material. A suggested mechanism to integrate knowledge is to develop prototyping within a production environment. This means developing concepts and prototypes with production.

The challenge is it is not understood how best to integrate the knowledge to meet the industries development needs. Therefore the next steps are to conduct interviews in an attempt to understand them. The aim is to suggest physical mechanisms to integrate knowledge that can be tested.

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