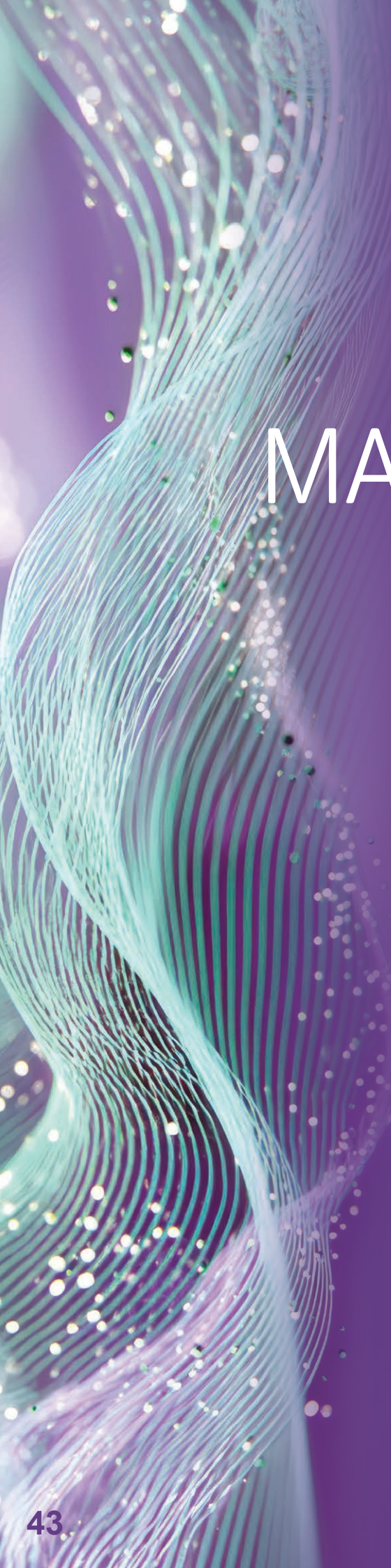


GENERATIVE DESIGN IN MANUFACTURING

HOW CAN YOU BENEFIT?

Generative design is a trend that makes me feel like a kid in front of a new toy: “It looks so cool - I want it!”. Other people’s responses seem to fit two categories. Either you don’t know what it is; in which case, don’t worry about it and continue your life and work as is. Or you have some, or a lot of, an idea of what generative design can do, which can be exciting and worrying. Either way, you are probably curious about what generative design can do for you. This article will give you a quick breakdown of some popular generative design techniques, with emphasis on their applicability in the manufacturing industry.

You have probably heard of the generative abilities of OpenAI’s ChatGPT and maybe used it to request an image of a chicken dancing on a table while wearing a hat (or whatever your creative mind conceived). This is generative design. In slightly more technical terms, generative design is a subfield of design automation that aims to produce a design solution through a defined mathematical process and computer software. While the term “generative design” sounds new, it essentially represents a reframing of existing methodologies for design automation, along with some arguably novel approaches. In this article, I use the term generative design loosely to encompass any form of computer-based design automation. **This may include automations such as parametric design, rule-based design, topology optimization, generative autoencoders, and neural networks.**

As I already mentioned, large language models such as OpenAI’s ChatGPT shifted generative design from amazing to pure magic. The ability to generate virtually anything is what one could describe as artificial general intelligence. However, this comes with hefty performance requirements and an expensive electricity bill. And this is only

the tip of the iceberg, as it overlooks the hours, efforts, and data needed to train such a model. This raises the question: *is this the type of solution that is viable for an SME, and is it sustainable and agile enough to adapt to an SME's requirements?*

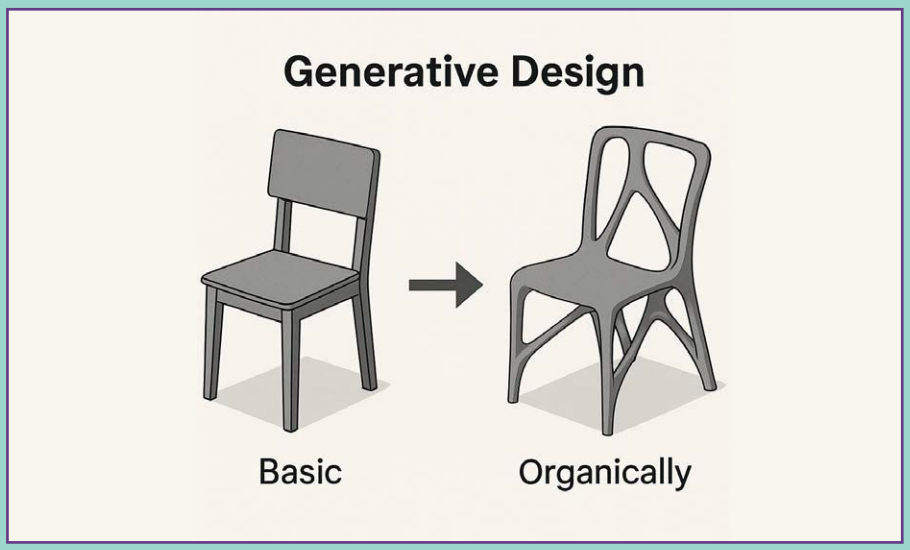
For me, generative design immediately makes me think of variational autoencoders (VAEs) and generative adversarial neural networks (GANs). While the two are not the same, similar requirements come into making them. In simple terms, if we have enough images or other data from a product category, both VAEs and GANs can be used to create a model that can generate new designs fitting the product category. From my experience, when it comes to SMEs, the number of products per category is not high enough to allow for such a solution to be deployed. And while there might be exceptions, it is common for designs within a product category to differ due to regulations, restrictions, or client requirements. Therefore, VAEs and GANs are not very attractive solutions for such products.

The second technology that comes to mind is that of topology optimization. As part of an engineering SME, you may have already seen a demonstration of what topology optimization can do or already be using it. Well, good news, this is considered a generative design approach! Topology optimization can be found as part of most computer-aided-design software nowadays. To generate a new design, you simply define some geometrical constraints, material properties, and a design objective (stress loading, bending, etc.), and the software will use an optimization algorithm to remove or add material until it satisfies the requirements. This works extremely well for single-part designs, but, from personal experience, this is not the solution for more complex mechanisms where the design requirements go beyond some stress and strain performance metrics.

Maybe the issue is that I started talking about technology, rather than a design problem. Identifying the problem can lead to better-fitted automation solutions. The number one issue for an SME, when it comes to design automation, is the **lead time required for new products and the need to stay competitive in an ever-evolving market.** Therefore, the first step to finding where generative design can improve lead times in design development is to identify tasks that are repeatable and time-consuming. From there, one can choose the right technology to address a specific problem. For example, parametric design can be an inexpensive version of topology optimization, where a product already consists of other product blocks. Pattern recognition and data analysis can become a computationally cheaper alternative to a complete design generation, with integration in the existing design process alongside the design engineer. And reinforcement learning can substitute classical design optimization and improve computational times when it comes to recurring but slightly varied designs. And these are only a few examples of how generative design can aid the development process.

If you have reached the end of this article, that means that you are at least a little interested in generative design. So let me end with some words of encouragement. **Design automation is likely feasible at this point for most SMEs.** With constant developments in technologies, computational power, and cloud integration, high-performance solutions become more and more accessible. I would urge you to explore further where generative design is applicable in your case. Either as an end-to-end solution or within a design phase, generative design will improve production time. In the end, automation in the design field is inevitable side-effect of the progressing technology. ■

▼ *OpenAI ChatGPT prompt: generate a figure for generative design using a chair as a product. Keep it conceptual.*



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