Bachelor thesis (BT) on Additive Manufacturing (AM) processes

Comparison with CNC manufacturing

Before I describe and categorize basic AM processes, it is important to see the distinction between AM and conventional CNC manufacturing. The reason is that both approach the same problem – manufacturing – from completely different point of view. Conventional manufacturing processes are based on machining and processing block of raw material, thus it is subtractive process. This way, using modern equipment, one is able to achieve very high precisions of manufactured part, with good surface quality and roughness. Commonly, materials as steel and other metals, plastics, wood and many other materials can be processed. But in general, it is often the way that parts of complex shapes could be very tricky to make. With CNCs, it is simply impossible to create objects with inner cavities or other internal features by machining the inside of the object. Also, machining shapes like curved overhangs or crevasses can be problematic. Furthermore, we haven’t considered the amount of waste material. Because we simply need block of raw material, exceeding the dimensions of the part being made in all directions, it is not rare to machine away more than 80% of material, becoming waste. Although scrap material is recycled, the blocks of raw material are very expensive. Machining parts for use in aerospace industry might be a typical example. Often the parts are of very complex shape, and made out of lightweight metals such as titanium. But requiring big block of titanium might be unnecessarily expensive, when significant part of provided material in fact is unused and thrown away.

Another field of comparison of AM and conventional production processes is the scale and amount of produced parts. Conventional methods of machining are known for a long time, and are used for series production. The combination i.e. of CNC machining with mold casting is a fast and efficient process. Problems will occur, regarding these series-process chains, when we want to alter a few manufactured parts – it is often not suitable for making only few parts, because of long preparation time, prototyping phase, and expensive equipment specially only for one kind of a product.

Most of AM technologies are not limited by mentioned obstacles, such as manufacturing inner cavities or waste material. The main principle is that we don’t machine away unwanted material, but we only deposit material where we do want it. This incredibly simple idea results in fact of having almost no waste material (some technologies require material recycling, but recycled material is immediately ready for use – no need for re-melting and so…). Because AM machines are based on material deposition instead of removal, we could say that time of product manufacturing is almost independent of its shape. In other words, AM machines don’t care, if we print a box, small statue, of a scaled model of a flower. The build time depends only on the amount of material - but, different technologies vary in build-speed. This attribute comes very handy in production of single custom parts of complicated shapes. The example might be printing custom body-parts of implants, since they are always unique, person to person. Also, shape-free manufacturing comes very handy to designers, which used to be limited by capabilities of conventional machines, making production of complex shapes tricky.

For the comparison to be complete, it should also be mentioned that machining is often difficult for processing hard and brittle materials. On the other hand, machining from its principle works in an isotropic way, meaning there shouldn’t be differences in machined part related to the direction of CNC tool movement.

When we look at AM processes, we see the major difference. Simply said, waste material is no longer a problem. When we want to produce small number of customized parts or objects of complicated shape with curved 3D features, AM enables us to do so. The general process of object making (of course depending on specific technology) takes longer time. But, considered that i.e. complex parts can be manufactured simultaneously in one go, they don’t have to be moved from machine to machine. This can cause significant time saving, resulting in faster making process, even though the technology itself is not faster than CNC.