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MODERN APPROACH TO SUPPLY CHAIN INDEPENDANCE

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Abstract: *This paper describes modern approach to supply chain independance using 3D printing technology of composites based on chopped Carbon combined with continuous fibers (Fiberglass, Carbon fiber or Kevlar) or different metals. During an action, parts of equipment, vehicles and machinery could be broken or damaged, and disturbances in the supply chain could cause those equipment could not be used. New technologies in the field of 3D printing of composites and metals could be deployed to serve on the field to produce new parts quickly. 3D printed composite parts could be as strong as aluminium and could be strong enough to survive the harshest environments. Flame-retardant materials could be used for parts exposed to extreme heats and burning. For most demanding strength, metal parts based on different alloys (as 17-4 PH Stainless Steel, Inconel 625, D2 Tool Steel, H13 Tool Steel, A2 Tool Steel and even Copper) could be 3D printed. All these technologies are changing the way products are designed and maintained during their lifetime.*

Keywords: *supply chain, 3D printing, composites, metals.*

1. INTRODUCTION

More than ever, we live in the digital world. This world is powered by technology. Over the last decade, the way that we communicate, the way that we buy and sell, the way that we do our banking, how we navigate, how we take our pictures, how we watch a movie, have all changed to digital. Of course, the way how we design products using 3D CAD software is now also digital. Digitalization has further been accelerated with AI (Artificial Intelligence), Big Data, Data Mining, IoT (Internet of Things) and robotics.

Figure 1. Tesla fully robotized factory on the principles of Industry 4.0

Yet, the fundamental way how we make things has largely stay the same. If you think about from thousand of years we started taking a physical piece of raw material weather it's stone, wood or metal and we be working on this material to produce final product. Of course, we waste a lot of valuable material as we are working in a way of subtractive approach. Not only that, with traditional methods it comes a certain level of skillsets to make tools, parts and products that you need. And one of our biggest for manufactures is finding that skilled workforce. This put pressure on being able to deliver goods in a timely manner and ensuring that production remains constant. One you have your part, what do you do? Well, we ship this part across the world in many cases. This could take several weeks or even more than a month from good being shipped from China to Europe to arrive. And of course, as things are happening to day, there could be further delay. There could be challenges which include things like global pandemia or trade wars. And once this part arrive, what do we do? In many cases, it's stored in a warehouse. However, lots of the worlds spare parts are never used. Increasing inventory means less cash available for certain company or organization. At this point of time, companies around the world have billions of euros or dollars worth stock of spare parts in their warehouses. The costs are nor parts only, we need to include also cost of leasing the places, insurance, security, and similar.

On the other side, sometime it could happen that there are no spare parts available. The reason could be poor planning or some unmanageable situations as already mentioned pandemia, global or regional tensions, an earthquake, factory fire or port strike and similar. This could specially be an issue in the supply chains relying on just-in-time production and delivery. In many cases we are missing the robustness and predictability of on-demand delivery.

Figure 2. Keeping warehouse full, means lot of cash not available for business

With digitalization the way things are made is changing. We are moving from the traditional analog way of making part to digital inventory. Digital inventory is on demand is truly on-demand which means: anywhere, anytime and any shape. Imagine taking your design and optimizing it for 3D printing and pressing print to have you prototype, your product or your tools [1]. This would lead to better control, reduce the lead time and reduce costs. This shift is already taking place. It means that we could move from the offshore to local manufacturing, meaning that from logistics point of view from shipping globally to manufacture and deliver locally [2]. As development speed is accelerating, digitalization could and would support that. All those means lower cost for a product and also mean better predictability. This paradigm is already in place. Just watching the length of existence of average Fortune 500 companies are going from 55 years in 1963. to 20 years in 1990. and is predicted to go to 14 years in 2026. driven by the digital transformation.

2. WHO ARE THE SURVIVORS?

Well, that those companies and organizations which embrace new approach of digitalization representing Industry 4.0. One great example is US Military that's leading this trend with permanent reinventing global supply. Already general Dwight D. Eisenhower said that wars had been won or lost primarily because of logistics.

Figure 3. US Marine Corps understand the importance of digitalization of logistics

Having a digital part catalogue out in the field is extremely valuable for such kind of organization. When something broke like a door handle of vehicle in the mission or something similar, they have a possibility to manufacture a spare part in a day or two and replace the broken one. Important is that the person to perform that do not need to be an engineer or high skilled technician. Complete system operate as a 3D copy machine, operator could set up the 3D printer in less than 3 minutes.

3. UNDERSTANDING THE PROCESS OF 3D PRINTING FOR SUPPLY CHAIN INDEPENDANCE

To understand how to achieve that 3D printers could be so effective, we need to understand the process [3]. With 3D design in place and 3D printing, geometry of such parts could be in some cases such it could not be manufactured by the traditional methods or it could be very expensive. Then we need to select right material. For tough conditions composites and metal shall be considered.

Starting with composites, great material is Markforged Onyx which based on Nylon PA 6 with chopped Carbon fibers. Onyx has smooth surface finish with more strength, stiffness and chemical resistance than ABS or regular Nylon [4].

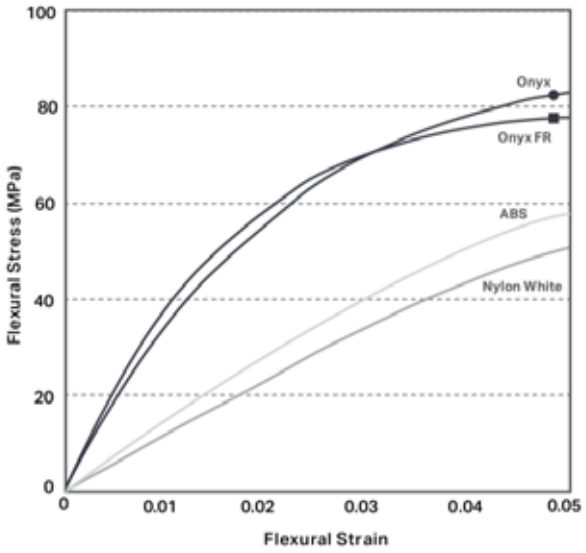

Figure 4. Flexural Stress/Strength comparison between Onyx, flame-retardant Onyx, ABS and Nylon [4]

Besides printing with Onyx only, Markforged printers could reinforce parts with continuous fibers (Fiberglass, Kevlar, HSHT Fiberglass and Carbon). Combining the materials during printing yields composite parts far stronger, stiffer, and more robust than conventional 3D printed plastics. Continuous Filament Fabrication (CFF) is proprietary technology that reinforces plastic printed parts with continuous fibers on each layer of a part. Users can control the layers reinforced, amount, orientation, and type of reinforcing fiber.

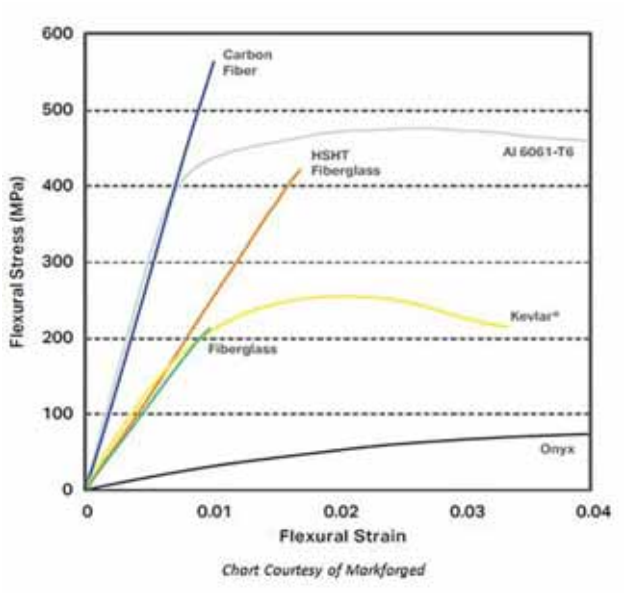

Figure 5. Flexural Stress/Strength comparison between Onyx and reinforced Onyx with Fiberglass, Kevlar, HSHT Fiberglass and Carbon [5]

As visible on the Figure 5., using Continuous Filament Fabrication (CFF) technology, such 3D printed parts can be designed to have the flexural strength of aluminum and tensile strength of steel [5].

Similar technology could be applied for metal 3D printing [6]. However, the process here is a bit more complex as there are several phases to get final metal product. First, the "green" parts need to be printed. Those parts need to be washed to dissolve most of the plastic binding material ("brown" parts). Washed "brown" parts are placed in a furnace, where they are heated with a material-specific profile to burn away remaining binder and solidify metal powder. Different materials could be used such as 17-4 PH Stainless Steel (combines high strength, corrosion resistance and hardness. Used in a wide variety of manufacturing applications), H13 Tool Steel (a hot-work tool steel with excellent toughness, wear resistance and heat resistance. Excels in high temperatures), A2 Tool Steel (can be air-hardened up to 58 HRC, excellent impact resistance. Used for forming tooling, punches and dies), D2 Tool Steel (can be air-hardened to 60 HRC, trades toughness for hardness and abrasion resistance. Great for cutting tools and dies), Inconel 625 (a proprietary nickel alloy that excels in high temperatures and corrosive environments. Used in automotive and aerospace), Copper (thermal and electrical conductivity. Print heat sinks, custom conductive elements and other geometrically complex parts).

Figure 6. 3D printed metal parts

4. CONCLUSION

Digitalization is changing our world and the way we manufacture. The digitization of the supply chain, or "Supply Chain 4.0", promises to reduce inefficiencies and lower costs while improving flexibility.

However, technology is a double-edged sword: It's driving significant opportunity, but it's also behind some of the biggest challenges in supply chain management [7]. Smart strategies need to be introduced to manage the challenges and fulfill the positive promises this approach contains.

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