The Use of Additive Manufacturing During the COVID-19 Pandemic

Evan Lam and Brennan Taylor, Office of Industry and Competitiveness Analysis

Additive manufacturing, the process of fabricating an object through the addition of materials, has traditionally been used primarily for prototyping and designing within the broader manufacturing process. However, in recent years, adoption of additive manufacturing has become more widespread in some important manufacturing industries in the form of "bridge production" and parts production. One such example occurred during the COVID-19 pandemic, when additive manufacturing helped meet heightened demand for ventilators and personal protective equipment.

Current Uses of Additive Manufacturing

The terms "additive manufacturing" and "3D printing" are often used as substitutes for one another but there is a clear and distinct difference between the two processes. Additive manufacturing refers to the entire process of creating an object through the addition of materials. This process can include modeling, 3D printing, material traceability, and post-processing. 3D printing only refers to the transformation of a computer-aided-design file into a precise, three-dimensional geometric shape and is an element in the additive manufacturing process. Additive manufacturing is primarily used in large-scale industrial manufacturing, while 3D printing is primarily smaller-scale in-home printing operations.

The adoption of additive manufacturing has been growing over time with the two most common uses of additive manufacturing being prototyping and designing. Prototyping is the most common use case, as additive manufacturing provides a low-cost technique that allows for testing and refining of a non-final version of a product. Additive manufacturing is also widely used in the design process since it allows for increased flexibility outside of digital modeling due to the ability to create custom parts. Outside of these two uses, additive manufacturing has seen limited large-scale usage, mainly due to high costs and availability concerns for both 3D printing materials and 3D printers. Despite these barriers to production, the use of additive manufacturing in bridge production[1] and parts production has been steadily increasing. Findings from a survey of 200 industry members involved in additive manufacturing processes indicate that since 2017, organizations that use additive manufacturing in bridge production and parts production have increased from 23 percent to 59 percent and from 27 percent to 67 percent, respectively (prototyping usage remains the highest at 97 percent).

In the aerospace industry parts such as fuel nozzles, brackets, door latches, and light fixtures are commonly manufactured with an additive process. Medical and dentistry implants are regularly produced using additive manufacturing since they need to be highly customized. Automotive manufacturers have started to produce roof brackets using additive manufacturing, making it the first mass produced additively manufactured automotive component. Perhaps the most unexpected use case of additive manufacturing to date, however, was spurred by the onset of the COVID-19 pandemic.

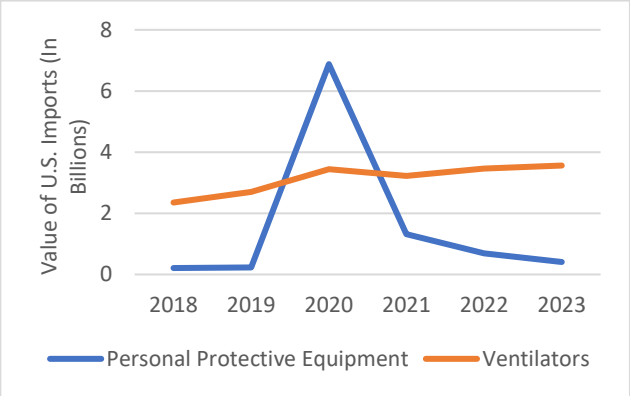
Shortage of Ventilators and Personal Protective Equipment During COVID-19

The U.S. demand for ventilators and personal protective equipment (PPE) increased dramatically in 2020 due to the onset of the COVID-19 pandemic. U.S. market growth and supply were unable to meet demand and the United States faced a severe shortage of medical equipment. There were several factors that

[1] Bridge production involves producing in low volumes for testing and marketing. Additive manufacturing is used because it bypasses inflexible supply chains and does not rely on injection molding, which is only cost effective with economies of scale.

contributed to this shortage: (1) the domestic market demand historically grew slowly before 2020 and thus domestic production was not prepared for the pandemic-induced demand; (2) U.S. based medical equipment manufacturers sourced from global suppliers and relied on "just-in-time manufacturing" to reduce storage costs; and (3) production facilities around the world shut down in early 2020, and countries enacted export restrictions which limited the supply of inputs for U.S. manufacturers.

Figure 1: U.S. Imports of PPE and Ventilators



Source: USITC DataWeb/USDOC, HTS 9019.20.00, 3926.90.9950, 6307.90.9845, 6307.90.9850, 6307.90.9870, 6307.90.9875, 9020.00.6000, 9020.00.9000 (accessed July 18, 2024).

Due to these factors, U.S. manufacturers were unable to meet the increase in demand, which led to increased imports of ventilators and PPE. From 2019 to 2020, U.S. imports containing ventilators increased from $2.7 billion to $3.4 billion (or by 31.1 percent) and imports of PPE increased from $229.2 million to $6.9 billion (or by 2,900 percent).[2] Imports of PPE ultimately peaked in 2020 then declined to levels only $200 million higher than 2019 before the pandemic began while imports containing ventilators continue to remain above pre-pandemic levels (figure 1).

Additive Manufacturing to Meet Demand

To further address the shortage of ventilators and PPE, the U.S. government utilized the Defense Production Act to spur domestic manufacturing. This allowed the U.S. government to forge partnerships between automotive manufacturers that did not specialize in producing medical equipment and firms that produced ventilators or PPE but were struggling to meet demand. For example, Ventec Life Systems partnered with General Motors, while Ford partnered with GE Healthcare and 3M. Using additive manufacturing due to lower capital costs than other methods, GM and Ford were able to deliver 80,000 ventilators to the U.S. government with Ford producing 50,000 and GM producing 30,000.

In addition to these government contracts, automotive manufacturers also delivered large amounts of PPE to the U.S. market, the majority of which was manufactured using an additive process. Ford donated over 140 million pieces of PPE which included over 22.5 million face shields, 120 million face masks, and 1.6 million washable medical gowns between donations made in 2020 and 2021. GM produced more than 13 million pieces of PPE and donated over 9 million of those pieces in 2020, mostly to hospitals and public schools. Stellantis (then known as FCA) donated close to 10 million pieces of PPE in 2020. Other large-scale manufacturers, including Honda and Mack Trucks, also produced 13 million PPE.

Sources: America Makes, "Assessing the Role of Additive Manufacturing" 3/2021. AMFG, "Applications of 3D Printing", accessed 8/2024. General Motors, "2020 Social Impact", accessed 7/2024. Ford, "Ford PPE", accessed 7/2024. Ford, "Ford Works With 3M, GE, UAW", 3/2020. GM, "One Million Masks", accessed 8/2024. Jabil, "3D Printing Technology trends", 7/2023. HP, "What is 3D Printing?", accessed 7/2024. Postprocess, "Additive Manufacturing vs 3D Printing", 8/2022. United States International Trade Commission, "COVID-19 Related Goods", 12/2020. Valdes-Dapena, "Automakers are still cranking out masks", 12/2020. Ye, "What Is Bridge Production", 6/2024.

[2] HTS statistical reporting number 9019.20.0000 is a basket category containing therapeutic respiration apparatus for ozone therapy, oxygen therapy, aerosol therapy, and other use cases which includes ventilators and their parts.