Study and Overview on Disruptive Technology in an Advanced Manufacturing Environment

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Abstract—**In this paper, the review of various disruptive technologies in an advance-manufacturing environment was studied. Few of the various applications where robots and other emerging technologies have been effectively used in the manufacturing environment were discussed. The replacement of some traditional process of manufacturing with the new disruptive technologies has highly improved manufacturing outputs. A few of the technologies that have an impact in advance manufacturing environment include; the use of computer-based technology in manufacturing, the application of internet in various aspects of manufacturing, the use of robotics to automate or augment human services during the manufacturing process. The various progress made by this technology towards the growth of industries forms part of this review paper.**

Index Terms—**advanced-manufacturing, disruptive technology, efficiency, impact**

I. Introduction

The focus of industry 4.0 is the proper application of emerging technologies to improve the production process in an advance-manufacturing environment. The use of automation in various stages of manufacturing has reshaped the manufacturing environment for higher productivity [1]. There exist numerous improvements in productivity during manufacturing with the advent of disruptive manufacturing technologies. Robots are one of the widely used automated tools among manufacturers. Its unique design enables it to be efficient in performing some difficult tasks within the shortest period. These disruptive technologies go a long way to reinforce the manufacturing system. This enables adequate competitiveness among manufacturers [2]. These technologies are smart technologies that replace substantial means of manufacturing [3]. This paper gives an overview of some related research where disruptive technologies find their application in an advanced-manufacturing environment.

II. Literature Review

Emerging technology from industry 4.0 brings about numerous benefits among manufacturers in an advanced manufacturing environment. Various researchers have studied the use of various disruptive technologies. Few of which are been reviewed and form part of this paper. Computer-Aided Design (CAD) is an advanced manufacturing technology that uses the application of computer systems to support the creation, analysis, optimization, and modification of a specific design [4]. The demand for high-quality parts in the marketing environment gave rise to competition in the labor market [5]. With the advent of technology, there exist new designs of components with high complexity in manufacturing. To solve the existing problem, an efficient manufacturing system is required [6]. Advance manufacturing technology transforms the manufacturing sector by using 3D printing to disrupt the traditional methods of manufacturing [7] [8]. Some of the few areas where disruptive technology has been efficiently used are discussed in the sections below.

A. 3D Printing Technology

3D printing has progressively become a disruptive tool to traditional manufacturing processes. It is an efficient technology that creates components layer upon layer through the application of a laser beam [9]. The laser beam melts the raw material and solidifies upon cooling to form the desired design [9] [10]. 3D disruptive technology can give product outputs at a reduced time with minimal production cost [11] [7]. 3D printing has been useful for the rapid manufacturing of prototypes and can transform the design to finished products by skipping some manufacturing steps [12]. In addition, Selective laser melting (SLM) is a member of 3D advance manufacturing technology that economically supports mass production of parts [13] [7].

The customization of parts using 3-D printing technology is another application of disruptive technology [13] [14]. This technology encourages products in the design of the manufacturer's choice [13]. The 3D printing technology maximizes raw materials and effectively reduces waste [15] [16]. The manufacturing process of 3D printing also allows the material to be re-

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melted and used for another manufacturing purpose [17]. Parts manufactured using the 3D technology gives a good surface finish and does not require further finishing operation [18] [19] [20].

3D modeling and printing are suitable for the manufacturing of structured parts, intricate and geometric shapes [21] [22]. 3D printing technology eliminates the use of expensive tools as it does not require tooling to carry out the required task [21] [23]. Composite can be manufactured through additive manufacturing technology of laser metal deposition. This disruptive measure can impact certain properties into a material to improve its physical, chemical, mechanical, and microstructural nature [24] [25] [26]. Some of these composites' material parts are useful in industries like aerospace, marine, medical, automobile, etc. [26] [27].

3D technology was used to fabricate functionally graded materials with improved mechanical and chemical properties [27] [28]. These functionally graded materials are useful in various industrial applications such as in marine industries, automobiles, medical equipment, aerospace, and some other [29] [30]. This technology is useful in the advanced manufacturing environments because of its high efficiency of processing materials, improved quality to obtain optimal productivity [8] [31]. Composites and functionally graded materials produced through this advanced manufacturing process have better material properties [27] [32].

Laser metal deposition is an advance manufacturing technology that uses 3D printing for manufacturing and can effectively repair worn out component parts [33]. This saves the cost of purchasing new parts and reduces waste during manufacturing processes [34]. Damaged and worn out parts can be repaired and restored back to its normal functioning form using additive manufacturing technology [35]. Additional parts were included in existing components using 3D printing technology [11]. Moreover, the beauty of a manufactured part is the surface finish, which can add more value to its function ability. This surface finish is of high priority in industries where highly graded components parts are assembled such as; automobile, medical, aerospace, marine, and in sport components [36].

Selective laser sintering is an advanced manufacturing technology that can recycle excess material to be re-used for another production [37]. This helps the manufacturer to effectively utilize materials and control waste [38]. The facilitation of manufacturing process and product give room for competitiveness in the global market [38]. This will give production output at reduced time and cost [39].

B. Automation Technology

The effective transformation of the manufacturing sector using disruptive tools provides a more efficient and flexible manufacturing process. The increase in the level of competition among manufacturers continuously promotes the implementation of automation tools that can enhance production processes for optimal throughput [40] [41]. Designing an autonomous and nearly autonomous vehicle was made possible with the implementation of disruptive technologies into the operating system[42].

Industrial robot as an automation tool served as a disruptive tool that can be used to augment human labor for faster and efficient productivity [43]. Robots are designed with a high degree of freedom, which makes them capable of rotating about many axes when performing multiple production tasks [44] [45]. The design configuration in robots allows effective communication and interpretation of human-related activities in an advance-manufacturing environment [46].

Robots are used as automation tools in a manufacturing environment to demonstrate human-related tasks effectively and reduces manufacturing processing time [47] [48]. The robotic automation tool is capable of carrying out continuous production processes without error in a safer and efficient manner [48]. Robots have the ability to avoid repetitive tasks during manufacturing processes, which reduces the waste of raw materials during the process [49]. Robots can handle dangerous tasks and capable of seeing tiny objects. This makes them useful in most areas such as in automobile industries where assembling of component parts is required [50].

Robots can withstand extreme heat, electric shock, high radiation, toxic chemicals that can be dangerous to human operators during manufacturing in an advance-manufacturing environment [51]. This makes its application suitable in welding operation which is an essential task in automobile industries. The application of robots made the welding of the metal sheet for the body of automobiles to be performed at a faster speed [52] [53].

Advance manufacturing technologies of the autonomous vehicle can adequately overcome various challenges on-road such as; traffic, accident, and even detect shorter routes to locations [54]. The use of sensors adequately replaces the camera and quickly detect any upcoming consequences and provide a solution immediately. Also, a logic processing unit as a disruptive technology incorporated into the operating system enables quick decision making in autonomous vehicles in an advanced manufacturing environment [54].

The advent of automation is a threat to the service sector because customers can interact with computers directly and disengage human to customer relationship [55]. This gives room for the automation of many processes in a cheaper and accessible manner. Product design and specifications can be easily computed into the robotic operating system. This sends a signal to the robot to execute the desired task.

Kuka robot was used for the additive manufacturing process of the laser metal deposition of composite materials [56]. The new disruptive technology of fabrication disrupts the traditional method of fabrication. The Kuka robot attached to the equipment controls the efficient delivery of the powders during the fabrication of the composite material. The robot was effective for proper handling and adequate control of raw materials [43] [57].

C. Human Robot Collaboration

Human-robot collaboration (HRC) in the advanced manufacturing industry has been effective for effective productivity [58]. The collaborative robot used in an industrial application interacts with data processing, actuators, sensors, and human labor to support the manufacturing process. In [47], the handover process, removal of adhesive, backing strip, and fabric layup in mold were effectively controlled with the HRC system. The HRC promotes and creates proactive behavior of dangerous awareness during manufacturing [47].

In HRC, there is enrichment in communication between humans and robot this prevents collision from occurring during manufacturing in an advanced-manufacturing environment. The proper control of HRC makes advanced manufacturing technology to be highly effective in an advance-manufacturing environment [59]. In the food industry, the cost of production was maximized by using robots as an automation tool during some stages like picking, palletizing, placing, and packaging [60]. This gives higher precision and reliability during food processing [60].

Fatigue and downtime have been a great challenge in a manufacturing environment among human labor. Convenient control of robots for supporting related manufacturing tasks using mental command was a success [61]. This use of robotics in the assembling process in some automobile industries reduces noise that would have been associated with human-to-human operators. Robot and human collaboration adequately reduce parts assembling time and provide a positive impact on the product, process, and productivity in advance manufacturing environment [61].

The hybrid of different robots can create a changeable advanced manufacturing system, by carrying out various functions in the production and delivery of goods and services [62]. In addition, the hybrid of different robots induces structural changes like scheduling of manufacturing tasks in an advanced-manufacturing environment [62]. Hybrid robot using brainwave effectively collaborates with other operators to coordinate collaborative task in an automobile industry [51].

The addition of new technology to the production line creates a process that reacts to customer specifications and changes in the finished products. [63]. The orientation of robots during the manufacturing process adequately and effectively controls the manufacturing process as there is no fellow robot that distracts like a human operator. Furthermore, waste that may likely set in during the manufacturing process in an advanced manufacturing environment can be adequately recycled when using robots in collaboration with human labor during manufacturing [37].

During the additive manufacturing process, robots as a disruptive tool communicate with computers and human labor to achieve the fabrication of components [64] [65]. This technology partially eliminates human intervention during the fabrication process [66]. A computer-based technology controlled by a human sends' signals of the design to the robots, which will carry out the desired task [67]. This technology saves production time and reduces waste to the minimum [67].

D. Internet of Things

The Internet of a thing is a disruptive technology that facilitates the easy flow of information and proper resource enterprise that is required during the manufacturing process [68]. Effective applications of the internet of a thing disrupt the traditional method of manufacturing and transform the manufacturing sector to meet up with strategic objectives [69]. This technology allows manufacturers to sustain competitive advantage among others. Proper monitoring of the manufacturing process using the internet of a thing, controls, organizes, and integrate manufacturing process to improve productivity [69].

Internet technology and communication enhances the fast promotion of new products and services globally. This technology introduces smart production management skills and intelligent shopping. Feedbacks from end-users create an avenue for improvement in the quality of products and manufacturing processes [70]. The implementation of the internet of a thing, artificial intelligence, cloud-based solution, and smart machine support the manufacturing environment for optimal productivity [71]. Disruptive technology introduces new ways of marketing products and services in an advanced-manufacturing environment [71].

The innovative idea developed through the internet of a thing also leads to the successful creation of an intelligent parking system, suitable for traffic management [72]. This advanced-manufacturing technology economically displaces the local way of parking that consumes a lot of time and space [72]. The implementation of internet technologies makes the relationship between manufacturers and customers easier and prompt relationship and communication, encourages standard production, and diversifies products in advance manufacturing environment [73] [74].

In the past, manufacturers go about to meet individuals and stores to introduce their products. The disruptive technology of the internet of a thing makes communication easier between manufacturers and individuals [75]. Many products can be accessed for availability using the internet from phones and computers. This enables an individual to bargain and request for products of their choice without having to visit the manufacturing industry. The disruptive technology of using the internet gives enough marketing orientation among manufacturers and individuals. This enables quick response upon requesting a product and enhances the fast delivery services of the products within a short period of time [75].

E. Impact of Disruptive Technology in Industries.

Advance manufacturing technology brought various innovations that disrupt some production methods and processes [76] [77]. The new revolution of industry 4.0 in the manufacturing environment supports manufacturers in producing high-quality goods and services [78]. This introduces smart manufacturing technology such as;

smart machining, smart scheduling, smart monitoring, and smart decision-making [79]. The smart machining process using robots that can easily sense and interact with other equipment and machine to accomplish the desired task [80] [81].

The implementation of disruptive technology into the publishing industry has a great effect on improving manufacturing processes. This technology makes it easier to search for various books online, and open new ways of marketing. The digital technology that was introduced into the publishing process resulted in a shorter publishing chain [82]. The introduction of e-book eliminates the stress attached to physical distribution among various customers and eliminates the damage caused during transit. This makes intermediaries and customers to easily request directly from publishers [82].

The convergence of disruptive knowledge and technology introduces flexibility into the manufacturing process [73]. The convergence of disruptive technologies enhances the customization of high-quality products in batches instead of primitive mass production [73] [83]. Batch production of commodities introduces a variety of designs of products into the global market. An example is the production of women's shoes in customized batches, which enhances various designs to be available when compared with the mass production of only one design. This improves the market value and its level of competitiveness among others [73].

Furthermore, Disruptive technology, which is an emerging trend for technological growth, can also become a disruptive measure for the labor market and manufacturing firms [84]. Studies showed how robots impact advanced manufacturing positively and its effect on the decline of shareholders' values in the large market and they degenerate in the market [84]. The effect on the labor market affects most workers whereby they find it difficult to secure a better job that will retain them for sustainability [77] [85].

F. Disruption and Manufacturing Environment

Disruptive technologies do not only affect manufacturing processes. It also has a great impact on environmental factors like inventory and supply chain management [63]. The implementation of disruptive technology into a manufacturing system has been successful in controlling and avoiding inventory risk [63]. This technology also makes the fabrication of parts to be made available when required by the market. This eliminates the storing of irrelevant parts and creates enough space within the manufacturing environment.

Certain environmental problems that can arise in the manufacturing environment due to waste were eliminated. The recycling of materials during fabrication controls waste and saves manufacturing costs [86]. These processes undertake efforts on recycling and recovering materials in order to make them available for new products or processes. This creates more space and decreases inventory risk by only producing only requested parts. This helps to maximize manufacturer capital and free the environment from junks [87].

Well established advance manufacturing industries adequately carry out marketing research to conduct proper planning and analysis before taking risk of purchasing any product. However, proper decisions must be made before implementing disruptive measures into the marketing system [88]. Therefore, computer-based technology and the internet of a thing can promote marketing in a competitive market [88]. The portable 3D printing manufacturing technology can reduce the time spent to get a product closer to the market [89]. This brings customers closer to products when needed. This adequately reduces supply chain management in the marketing structure of an advance manufacturing environment [90].

G. Impact of Disruptive Technology in Health Sectors.

The health care sector makes use of disruptive technology as an effective tool to enhance the effective productivity of services [91]. Health care sectors carry out various forms of diagnosis and therapy on the patient to obtain quick medical solutions. The innovation of advance manufacturing technology is useful and facilitates decision making in health sectors. Visualization based technology is a disruptive technology that is controlled by a human to facilitate medical processes [91].

A portable V-scan is a disruptive medical apparatus that can diagnose different health conditions. This tool is portable and easier to use for self-diagnosis. It does not require medical practitioners to interpret the result, as its diagnosis and shows the outcome on the screen [92]. This disruptive technology has been able to control the time spent on diagnosis. Artificial intelligence is a disruptive innovation introduced and widely used in the manufacturing of advanced neurological equipment. Artificial intelligence creates an effective patient management system that can enable high-value care, real-time tracking that is required for patient recovery, and can control risk associated with delayed treatment [81].

H. Impact of Disruptive Technology on Education

The impact played by disruptive technology in the education sector has made many institutions assessable and affordable by any category of learners [93]. The commencement of short programs among learners of advanced manufacturing environments has gained a lot of advantages to learners and institutions. This innovative technology adequately open ways to an individual student who wishes to study but cannot afford the time and fees of prolonged study. It also increases the profit margin among owners of the institution as it attracts more individuals that bring in extra fees to an affordable means of study [93].

Disruptive technology also enhances the educational environments such as online teaching and learning. Webinar and zoom have been effectively used for presenting conferences and lectures [94]. This encourages and motivates most institutions to set up more means of assessing their academic activities. In addition, grants offered by some of the world-leading companies and foundational philanthropists in the education sector are a disruptive measure [95]. This grant is being accessed electronically using internet facilities.

I. Simulation in an Advanced Manufacturing Environment

A simulation is a tool that supports decision making during the manufacturing process [96]. This tool helps to build a virtual system using different methods before the real implementation of the system [97]. The simulation model described and investigate the relationship between 3D printing supply chain networks and traditional supply chain networks in an advanced manufacturing production process [98] [99]. The scenario was been studied using a Life Cycle-CAD to provide a suitable design of a product and its life span [100].

Simulation tools provide the platform on which models can be developed and used to simulate the management of an advanced manufacturing process. The use of simulation tools for supporting decision making during manufacturing allows manufacturers to plan and optimize manufacturing processes [101]. Furthermore, the need for further improvement in the technical stages of manufacturing was successfully achieved with a simulation measure [102].

III. CONCLUSION

Disruptive technologies have gone a long way to influence the advance manufacturing positively. The disruptive technological tools used in advance manufacturing environments enable an effective manufacturing system. It has reshaped the manufacturing sector by getting a more quality output within a very short period of manufacturing. The implementation of disruptive technology like 3D printing, the internet of things, and automation in the manufacturing environment has reshaped the advance-manufacturing environment. These disruptive technologies have significantly made the manufacturing process more effective and productive. Disruptive technologies also facilitate decision makings, allow manufacturers to meet up with challenging demands, satisfies customer needs, improves quality, and was capable of efficient production at a reduced time and cost. The implementation of disruptive technology like modeling and simulation into manufacturing systems has gone a long way to save manufacturers from making the wrong decisions in the early stage of manufacturing. The technology is cheap and also a faster means of solving problems during manufacturing processes. A few of the areas where disruptive technology finds its application in manufacturing environment is been reviewed in this present work. From the overview of various literature presented in this work, disruptive technology has positively influenced the manufacturing system. Moreover, there is a need for further improvement in some manufacturing processes such as hand tracking, laying out of products, and scheduling of tasks.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to the success of this review paper.

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