Role of Biomaterials in Automation.

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Abstract
Technology in its real sense is in an advanced state to an extent that automation is the present-day mode of operating machinery and equipment. This technique of operating or controlling a process using a highly automatic means via electronic devices thereby reducing the human interface to a minimum, if not rather than eliminating it completely. Transformation of the global workforce has already begun through automation with innovations of robotics, artificial intelligence remote connectivity, additive manufacturing and medical innovations employing the automated means of delivering or administering drugs and performing surgery on patients. In the present day, various forms of automation are increasingly taking over the place of human thereby, putting a threat to supplant it. The role of biomaterials in automation is the main objective in this discussion. The study revealed that metals play a major role in biomaterials due to its excellent thermal conductivity and mechanical properties.

Keywords: robotics, automation, metallic alloys, biomaterials, industrial automation, implants.

1. Introduction
Biomaterials have found its way out of commonly used materials world-wide in vast areas, viz are; medical, manufacturing, agriculture, technology, engineering, and all other facets. Materials which have useful increasing importance and application in daily living ever, and are effective, safe, and biocompatible are referred to as biomaterial [1, 2]. The study of biomaterials has significantly exhibited signs of progress in developing new materials that are compatible with adjusting to biological systems when, in combination with a biomedical system. In technology, advancements have by discovering other useful and consistent materials that possess not only physical properties but also great mechanical properties such as high strength, lightweight, and controlled crushing mechanism [2, 3]. Materials that are biocompatible, natural or human-made, and exist as a whole or part of the existing structure and functions, or replaces, augment a natural capacity [4-6]. These materials are mostly engineered for the desired purpose in the area of use with be it; medical, pharmaceuticals, and biotechnology applications [7]. In the manufacturing industries, the application of biomaterials has enhanced product performance in the area of weight reduction and product efficiency at large. Taking, for instance, automobile manufacturers in need to reduce the co2 emissions which constitute a significant greenhouse gas constituents, have resolved to include the use of biocompatible materials in the power system and also the fuel types used by the engines [8]. Many materials may be considered as biomaterials, such as stainless steel, titanium, tantalum, gold, silver, and some other precious metals. There are also bioceramics; aluminium oxide ceramics, cobalt-chrome-moly alloys; certain composites; hydroxyapatite; natural materials such as cadaver bone; animal-derived products, biogas; platelet gel and some other materials may also be considered as biomaterials. Today’s biomaterials are routinely rich in information, and consist of natural biologically derived active components. Biomaterials hold even a greater role in medical and also find more exceptional applications in areas of non-medical applications [9]. The purpose of biomaterials in areas of versatility, however, cannot be underestimated as it has played an important role. Biomaterials exhibit special properties which makes it more demanding in various sectors. It is essential to understand the relationships among properties, structures, and functions of the biological materials. Therefore biomaterials used in the medical surgery support part of a living system are verified since the ultimate goal is to improve or restore human health [10]. Biomaterials application cannot be completed without the introduction of automation. The clinical application of biomaterials and the industrial application as biomaterials have versatile use in the manufacturing and production industries.
which involves automation applications in general. This paper discusses the role of biomaterials in automation.

### 2. Automation and its classification

Technology, in its real sense, are in an advanced state to the extent that automation is the present-day mode of operating machinery and equipment. It involves the technique of performing a process using a highly automatic means via electronic devices, thereby reducing the human interface to a minimum. Transformation of the global workforce has already begun through automation with innovations of robotics, artificial intelligence remote connectivity, additive manufacturing and medical innovations employing the automated means of delivering or administering drugs and performing surgery on patients, from a virtual secretary to self-actuating automobile vehicles [4]. In the present day, various forms of automation are increasingly taking over the place of the human, thereby, putting a threat to supplant it. Automation is pimped with the scenarios of benefits, and this is based largely on the arguments that a better and cleaner environment is achieved with automation in the sense that, carbon impacts are reduced, cleaner and safer jobs, productivity resulting from the technological revolution. Hence workers will learn skills and find a better job [5]. In manufacturing industries, the case is out rightly different, but similar conditions still exist. Considering the “fourth industrial revolution” exist a minor distinction in which this has impacted the labour market by not replace job space but rather eliminate some roles within the job description of a worker thereby, reducing the job tasks of a worker. The result derived from automating in terms of efficiency will result in the uptake of the latest technology and applications [6]. Automation can be classified into various forms.

#### 2.1 Automation system and trends for biomaterials

Biomaterials use programmable automation because the equipment is designed to change the sequence of operations. Usually, the programmable automation system is mostly used in low and medium production systems where the products are made in batches. The system must be reprogrammed with a set of machine instructions to produce a new product, which is in-line with the latest product. The setup of the machine such as; the machine tools must be loaded, the machine settings must be changed, and fixtures must be attached to the machine table in a process where it is required. This overall change overtakes time, and all these are inclusive in the product cycle, examples of this type of automation is industrial robots and computer numerically controlled machine.

For flexible automation, It is an improved version of programmable automation in which the machine process duration is minimized compared to programmable automation. It enables the production of various combinations and schedules of a product without requiring batches. The flexible automation system is capable of producing several parts with no time loss during changeovers of different products. The reprogramming and the physical set up such as tooling, fixtures, and other set-up have typically no time loss. The ability to change over physical set up and change part programs with no time-loss in production, allows the automated production system to continue production without downtime between batches as compared with programmable automation. The total duration required for sequence programming of the various output does not interrupt with the current job since programming is accomplished off-line on a computer system and transmitted electronically to the automated production system. Change in physical set up is done off-line. The variety of parts made on a flexible automated production system is usually limited compared to a programmable automated system.

Another crucial automation is fixed automation, a system that the sequence of the processing operation is fixed is referred to set as automation, and it usually involves a simple operation sequence. The system complexity is the integration and coordination of activities into a single equipment. The high demand rate for and volumes provide the economic justification for fixed automation. Cost of unit product is spread over a large number of units in other to compensate for the high initial costs of the equipment compared to alternative methods of production examples of fixed automation includes machine transfer lines and assembly line (mechanized).

#### 2.2 Advantages and disadvantages of automation

Most times, the literature cited as advantages of automation is its association with faster production and cheaper labour costs. It replaces physical or human participation in production processes. The
advantages of automation may be limited because not all tasks can be automated while others may be more expensive to automate. System maintenance could be high and failing the product itself. Literature also reveals that some system automation could impose defects beyond operational concerns [7]. Advantages of automation include the following:

- Reduction in occupational injuries.
- Increase productivity.
- Improved quality of products improved robustness.
- Increase consistency.
- Reduced direct human labour costs and expenses.
- Frees workers to take up other roles.
- Replace human operators in a task involving monotonous work.
- It reduces operation time and works handling significantly.

Some of the main disadvantages of automation include:

- It displaces workers due to job replacement.
- High initial costs.
- Possible threats due to susceptibility for committing errors.
- High development costs.

3. **Metallic biomaterials**

Resistance to high corrosion and wear propagation is often seen with metallic biomaterials. Stainless steel and titanium remain the most commonly used metallic biomaterials. These metals possess excellent mechanical properties and formed good biocompatibility due to the position and arrangement of the metallic bond and ions which essentially non-directional and can be altered without destroying the structure of the crystals and forming a plastic deformable solid. Corrosion is the major challenge faced with metallic biomaterials. Here are some classification of metallic biomaterials.

- Titanium base alloys
- Stainless steel
- Cobalt-based alloys
- Special metal alloys

3.1 **Titanium and titanium-based alloys.**

These materials are classified as biologically inert biomaterials due to their ability to remain unaffected by the host body, and this is done by the isolation of the host body and enclosing it in fibrous tissues. Titanium is very low in density with 4.5g/cm³. Pure titanium is allotropic with a hexagonal close pack structure below 882 °C and transforming into a body cubic centred structure above the same temperature. Because of its microstructure in a single phase, cold working also is an advantage in the applied strengthening mechanism. The formation of an oxide film i.e. TiO₂ makes it a good biomaterial. This oxide prevents the diffusion of oxygen from the environment, thereby preventing corrosion formation by its spontaneous growth in contact with air. Above all other qualities of titanium, it is a material with high superficial energy [8].

3.2 **Stainless steel.**

Stainless steel materials used today have low carbon content lower than 0.03% [9]. Other good mechanical properties possessed by this metal include; corrosion resistance, durability, ductility, and relatively low price. Its corrosion resistance is a result of the formation of a thin layer containing Cr(iii) oxide, Cr₂O₃. It has an austenitic microstructure with a face-centered cubic cell and a delta-ferritic structure forms a corrosion resistance than the austenitic structure making it a desirable quality in vast areas of application. It is also not ferromagnetic and that makes it not desirable for implants in patients. With a density of 7.9g/cm³, almost double that of titanium and its alloys.

3.3 **Cobalt-based alloys.**

Cobalt-based alloys are considered to be better than stainless steel in terms of its corrosion stability. There is a balance between the biocompatibility and mechanical properties exhibited by cobalt-based alloys
and both of these forms are to some extent more costly to design than stainless steel [10]. Cobalt-based alloys show corrosion resistance in an extremely high degree due to the unstructured creation of a chromium oxide (Cr₂O₃) passive layer within the human body, cobalt alloys exhibit in chloride surroundings also its high degree of corrosion resistance. These biomaterials possess advanced mechanical properties such as greater wear resistance to corrosion as well as good resistance to fatigue. These materials are known to not be brittle due to their 8% elongation performance and they also display a high elastic modulus (220-230 GPa) similar to the one exhibited by stainless steel (200 GPa) and higher than that of cortical bone (20-30 GPa) [10]. Cobalt-based alloys are considered to be better than stainless steel in terms of its corrosion stability. There is a balance between the biocompatibility and mechanical properties exhibited by cobalt-based alloys, and both of these forms are to some extent, more costly to design than stainless steel [10].

3.4 Nickel titanium as a metallic biomaterial
Nitinol, which is also another name for nickel-titanium, is a metal alloy of nickel and titanium in which the two elements present in the alloy are in roughly equal atomic percentages. The alloy shows the super-elasticity and shape memory effect at different temperatures, and they are named according to the percentage weight of a nickel, i.e. nitinol 50 and nitinol 60.

It is said that the “shape memory” effect and the super-elasticity are also known as pseudo-elasticity are the two closely related and inimitable properties of nitinol alloys. Shape memory is the ability of nitinol to undergo deformation at one temperature, continue in its deformed shape even after the removal of the external force, and then recover its original, un-deformed shape when heated above its transformation temperature. Super-elasticity is the ability for the metal, upon the removal of the external load, to be able to immediately return to its original un-deformed shape after undergoing large deformations. Nitinol has the capability to always return to its original shape no matter the number of times it undergoes deformation as much as ordinary metals. Being above the transformation temperature of the specific alloy determines if the nitinol behaves with the shape memory effect and super-elasticity it is known to possess. It exhibits the super-elastic properties when the temperature is above the transformation temperature and exhibits the shape memory effect when the temperature is below the transformation temperature.

4. Role of metallic biomaterials in automation
Metals possess desirable qualities which makes them very good biomaterials. Due to their susceptibility to degradation through corrosion, surgical implants are incorporated with alloy as an essential characteristic [8, 9]. Due to the desired properties of metal coupled with the relative ease of fabrication of both simple and complex shapes and sizes, it has been used extensively for the fabrication of surgical parts through the well-established and effective fabrication technique. Metals undergo different processing and that, in turn, indicates the microstructure and the metallic properties. The understanding of the desired property in the metallic outcome is of a need as metallic components is essential for the desired performance of implants [10]. Metals play a major role in biomaterials, mainly because of its excellent thermal conductivity and mechanical properties. In engineering applications, steels are mostly used as the main metallic materials. It is mostly used in the fabrication of the femoral stems and head in combination with good mechanical strength and corrosion, and mainly its benefits; cost-benefit ratio. There exist a linear relationship between the properties, manufacturing process and the structure which makes steel a versatile material in the biomaterial world. With its good corrosion resistance and mechanical strength in chlorine infested environment, cobalt-based alloys give a better and longer useful life of the artificial replacement made with such by forming an oxide Cr₂O₃ passive layer. This material has found usefulness in hip resurfacing. A mostly used and emerging titanium alloys are mostly seen as the first choice for the
biomaterial world. This is due to the high immunity to corrosion, high strength, and low density and amongst others, its complete inertness to host body and environment. Titanium has been widely used in the areas of teeth or dental implants and tissue replacements in bones, and joints. Concerning the clinical uses of these materials, the utilization of industrially unadulterated titanium is increasingly constrained to the dental inserts in view of its restricted mechanical properties. Great mechanical attributes are required in hip inserts, knee inserts, bone screws, and plates. One of the most widely recognized utilization of titanium combinations is artificial hip joints that comprise of an articulating bearing (femoral head and cup) [11].

Conclusion
Automation has been considered out of production and manufacturing industries. In this context, robotics and the human implant has been considered as part of automation. A situation where half of the human body is replaced with metallic implants can be seen as nothing close to automation advancements in the technological world. The bodily replacement in the robotic realm makes use of metallic materials which are most commonly used in fabrication systems. Due to their nature and other qualities possessed. Based on the area of application, certain desirable conditions are expected for the metals to be useful in implants and coupled with unique machining processes. Little or few metals possess the required qualities in terms of strength and corrosion resistance. Titanium and titanium-based alloys, chromium and chromium-based alloys, cobalt and cobalt-based alloys and stainless steels are the most commonly used metal biomaterials in automation. The high accuracy micro-machining of titanium, treated steel and other exceptional metallic combinations pertinent to wellbeing is a case of the significance of present-day production in bioengineering. The property-upgrading forms are performed to improve the mechanical or physical properties of the work material and incorporate warm medications (tempering or extinguishing in steel, for instance) and sintering of fueled metals. Such complex materials are intended to duplicate a subset of the physicochemical properties of appropriate materials.

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