

A Review of Micro Factory and Its Concept

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Abstract: The concept of a micro-factory, which is a small-scale manufacturing setup with more collection of process capabilities, is discussed in this study. It is a manufacturing facility where the finished products are created in large numbers by replicating in higher quantities. Micro-factories are essential because they utilize less energy and have fewer material requirements. The micro-factory concept focuses on reducing the size of manufacturing equipment and systems used to create micro goods. It is viewed as a viable alternative to existing conventional machines because it requires less capital and occupies less space. Because of its highly adjustable nature and low-cost micro-production, it is efficient and cost-effective equipment.

Keywords: Micro factory, Micro machines, Micro machining, Micro parts, Desktop factory.

I. INTRODUCTION

The advancement of the micro factory technologies have been increased in recent times which focuses on the production of smaller products. The features of the micro factory include the decrease in inertia force because of its lighter weight, increase in flexibility since the layouts are customizable in nature. The overall micro factory structure is in a way of providing parallel machining processes with a feature of easy assembling and dismantling the machine components [1-2]. In the development of micro factory concept there is an increasing demand for higher precision for the complex structures. The classical ultra-precision machining has a drawback in the fabrication/production of the micro-components [3]. The requirement of the micro machine parts in the industries leads them to adapt the micro-forming and micro manufacturing systems which have an advantage of being used in the mass production of the micro metal parts [4]. Individual micro machine tools like a lathe turning machine which cuts a work piece ranging from 10 μ m to 0.3 mm in diameter was the initial stage of downsizing the machine tools to a micro manufacturing setup [5]. Although a micro factory is used for mass production, it is also considered as an alternative for testing a product before mass production without incurring any losses related to the acceptance of the product among the customers. A micro factory connects the artisanal manufacturing to the mass manufacturing of the products [6]. In a micro factory, the implementation of the micro machine tools and micro assembling manipulators makes the micro manufacturing to be suitable for producing the micro parts with a dimension ranging from nanometres to millimetres by using well-defined cutting tools which makes the micro machining to be an efficient way of production [7-9].

II. MICRO MANUFACTURING

Micro-manufacturing technique has its own place among the available manufacturing methods because a large number of day to day products are produced. It involves in increasing the ability of production systems to manufacture smaller devices which has higher sustainability than the classical manufacturing systems. The factors of using rare materials and obtaining higher product quality to be concerned while adopting the micro manufacturing processes. [10-11]. During the micro manufacturing, there is a need of a material handling system for assembling the individual components which is accomplished by employing micro-handling systems because of its good material positioning skills [12]. Micro-manufacturing is mainly adopted for generating micro features on larger surfaces/components utilising various scaled down manufacturing techniques. Today the use of micro parts is unavoidable in most of the products which has made the existing manufacturing methods to adapt the micro manufacturing technique. Around the world, the research and development of micro-manufacturing regarding the machine tools and manufacturing processes are carried out because it significance in the manufacturing field [13]. Micro-forming process which comes under the micro-manufacturing method is carried out because of its higher precision than the macro-forming process and is considered as an economic means of manufacturing. Micro-casting, micro-forging, micro-extrusion, micro-rolling, micro-stamping and micro-hydroforming are the other processes of the micro-manufacturing [14]. Manufacturing methods and tactics in micro-manufacturing may differ from those used in macro-manufacturing which can be utilised to manufacture micro-products, such as merging component/part production with assembly/packaging, which is common in MEMS and micro-systems manufacturing. To properly solve difficulties linked to production in the micro-

world of manufacturing systems, micro-manufacturing primarily employs a typical manufacturing method or scaling down or changing established methods [15]. Nowadays, the use of composite materials for micro-manufacturing which has its application in the medical and aircrafts. Micro-manufacturing using composite materials come under non-silicon type of manufacturing. The manufacturing of the micro products includes the processes like etching, plating, forging, stamping, etc. and can be classified as silicon and non-silicon based micro-manufacturing systems based on the materials used [16-17]. Although micro-manufacturing involves small-scale machines, there is a vibration concern while operating the machine. This can be rectified by using a vibration isolation system consisting of springs, actuators, pedestal and a layer of rubber [18]. In the field of micro-machining a machine tool with higher precision is required because it influences the overall micro factory efficiency [19]. Today there is a need for the materials with natural composition in the field of micro-manufacturing which act as the biological hybrid material [20]. Micro-manufacturing can be done by implementing a framework used for combining the process plans of the production system [21]. There is a chance of irregularities in the measurements of the machine products which is to be solved by using a proper monitoring system and providing proper quality of measurements [22]. A digital twin atmosphere could be adopted in the micro-manufacturing process which makes use of a replicate of a machine being used [23]. Micro-manufacturing utilizes the classical method of electrochemical processing because of obtaining good accuracies and precision during the production of the micro-parts [24-25]. For the manufacturing of microfluidic devices on small-scale by employing micro-injection and laser micro machining techniques [26]. There should be higher repeatability for a micro-manufacturing system and must involve in a continuous manufacturing of micro-parts [27-29].

III. MICRO MACHINING

Since the demand for the micro-products are increasing nowadays, the need for micro-machining arises which plays a vital role in the micro factory concept. The manufacturing operations like turning, grinding and EDM can be done with the help of micro-machining [30]. The precision of micro-machining is considered to be larger than any of the existing methods [31]. Micro-machining applied to the non-conventional machining processes are dependent on the factors of accuracies, rate and the process to be used for machining. This method leads the way to electrochemical micro-machining which comprises of mechanical, electrical and electrolyte machining systems [32- 33]. The micro-electro discharge and micro-milling processes are employed in the micro-machining systems which use high speed machining tools [34]. In the electrochemical micro-machining, pure water is used in which the water dissociates and several tests for various working conditions are undergone [35]. A desktop manufacturing setup can be applied to the micro-machining purpose which can fulfil the higher precision requirements [36].

IV. DESKTOP FACTORY CONCEPT

Although the micro machining is done in larger machines, the desktop factory concept is employed which is the base of micro factory. It involves in the machining of the micro parts with precision and the assembling of sub millimetre sized machine parts [37]. A system with high modularity and higher flexibility in material handling makes the desktop factory concept an essential one in the field of micro machining [38]. The desktop factory used in the production process has the difficulty in integrating the individual machining units which can be solved by applying cloud network model to manufacture the customized micro products [39]. This concept would make the micro machine tools to be affordable by applying them in most of the DIY (Do It Yourself) activities. Also because of easy assembling and dismantling it can be used as a demonstration model for teaching purposes [40-41]. The continuous technological improvements made in the manufacturing sector based on the concept of desktop factory focuses on the flexible production systems at lower costs and achieving good quality of the finished products and also used in lean manufacturing [42-44]. The desktop factory culture makes a person to be a creator than being a customer. Although 3D printers have a significant role in this concept, the micro-machining processes employed make an individual to maintain a relationship with large manufacturers in terms of production [45]. There is still a lag in the commercial aspect of making this desktop factory to reach the market which needs to be rectified by enhancing the ability of this setup [46]. Today through web the desktop factories are operated for doing the manufacturing processes with the use of automated systems of rapid prototyping. It is achieved through the usage of CAD files and involving in producing individual layers to finally make products of complex structures [47- 49]. The micro-electromechanical areas in the desktop concept are developed as a system having three degrees of freedom in nature which focuses on better machining conditions [50].

V. APPLICATIONS

The industries use the micro factory due to the special features available in the field of manufacturing. The products manufactured by using the micro factory are employed in the areas of medicine, automobiles, aircrafts and communication devices. Most of the dental and heavy duty applications are in a need of the micro factory setup. The

micro factory concept makes use of the online production systems for manufacturing processes. Also it is used to make smaller to medium sized products by involving in the lower cost of production and mainly focuses on the change of classical manufacturing processes with instant techniques [51 - 54]. The micro factory designed as a modular manufacturing system has been currently employed in the R&D of an industry which is employed for the machining of the micro-parts and the assembling processes. In addition to the innovative aspect its mobile manufacturing ability is a peculiar application in the manufacturing field. One of the major applications is to manufacture a micro-part in a most economical way [55-60].

VI. CONCLUSION

The micro factory concept had laid the way for implementing the use of the micro manufacturing systems in the production of the highly needed micro-parts in most of the industries. Due to its successful application in the manufacturing field it is largely opted by most of the budding start-ups. This has become an unavoidable aspect in terms of small-scale production. Minor improvements are to be made in the micro-machining equipment to compete with the production rates of the existing machines. Although the micro factory plays a vital role in today's manufacturing field, the scaling down of the components should be based on the continuous growth of the particular micro product in the market. In the future, the micro factory setup which is mostly employed in the research and development should be improved in its ability to cope up with the larger production rates of the industries.

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