IMPLEMENTATION ASPECT OF INDUSTRY 4.0 IN ETHIOPIAN MANUFACTURING INDUSTRY

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Abstract- Industry 4.0 can contribute in job creation and industrial competitiveness not only for developed countries as well as in developing country like Ethiopia also. Industry 4.0 required a strong infrastructure, government policies and skill development for advancement of Ethiopian manufacturing sector into the digital revolution.

The aim of this paper to investigate and identify key factor for implementation and adoption of industry 4.0 in Ethiopian Industries and suggestion about the overcoming from these to successful implementation of Industry 4.0 in Ethiopia.

Industry 4.0 has the capabilities and potential for the change in the fastest growing economy of Africa. Despite lots of advantages of industry 4.0, there is still no definite planning and awareness in the implementation and awareness of industry 4.0. Therefore for development and advancement, it is crucial for the industrial sector in Ethiopia to investigate and identify the implementation of Industry 4.0 and find out the relationships between them so that it can be helpful for the industry practitioners and government to implement. There are lots of challenges regarding Industry 4.0 in the Industrial sector of Ethiopia. The theory of Industry 4.0 for the Ethiopia is new and not very well established in related literature and practices and this is the main motivation for this article.

This study will help to the industry practitioners and government of Ethiopia to understand the key implementation aspect of Industry 4.0.

Keywords: Industry 4.0, Ethiopia, Implementation.

1. INTRODUCTION

In Africa, Ethiopia is the second most heavily populated and economically fastest growing country [1]. This development was driven by government investment in infrastructure, education, agricultural and service sectors with long term planning. Most of the Ethiopia's economy is agricultural based, but now a day's service sector surpassed agriculture as the principal source of economy. In Ethiopia, mostly infrastructure projects related with electric power production and distribution, textile and garment industrial parks. Technological advancements in developing countries basically dependent on the foreign investments and resultant technology transfer [1,35]. In Ethiopia most of the multinational companies are using advanced technologies for production in textiles, leather and other areas and that is foundation of implementation of Industry 4.0 in developing countries like Ethiopia [2,3,4].

Industry 4.0 is basically a methodology for transformation the conventional machine based production system into the digital and artificial intelligence based system, on which machine can coordinate and communicate according to the situation and no need of human interface for controlling and direction to the production flow [5].

The Industry 4.0 is combines term and incorporated with communication network, internet, production systems, supply chain and logistic [6, 7]. This term is collection of various production aspects with internet and cyber physical systems. Industry 4.0 is playing major role in implementation of new technologies, whereas the realistic transformation from conventional manufacturing system to smart factories is also challenging aspect for researcher of this term [8].

Production process in the Industry 4.0 is unique and authenticated because it offers real time product and process information and provides better solution for the ongoing problems and difficulties [9, 10]. Environments friendly and safety is the additional term associated with Industry 4.0 for efficient and high quality production.

For implementation and successful technological up gradation of current system some very clear and object oriented road map is necessary some theories and approaches also given by researcher and universities but there are lots of complications and not suitable for the real life problems for automation and implementation problems [11]. When the uses of robot will increase than some implanted technologies like wearable internet and automated self decision system, advanced three dimensional printing will also required for up gradation.

The concept of smart city and smart factories generate the demands of sensors and automated system for daily life applications [12]. There are some important elements, which can affect the social life heavily like Internet of things. This things possible communication between machines to machine, this is the important fact by which without human interference production system can be run.

The important thing is automated decision making by machines .This is possible only by sensors and cyber physical systems and basis for machine to machine communication is possible.

The combination of cyber physical system, Internet of things and machine communication can bring the modifications in the existing production system with capabilities [13, 14]. Machine communication is very strong when machine can communicate with the human and that is possible only with the help of information network, artificially intelligence, intelligent communication and machine human interface.

2. METHODOLOGY

This research paper focused on the implementation aspect of Industry 4.0 and the in developing economies, on the basis of literature review, books and reports. For carry out extensive literature review and collection of literature, the authors covered engineering, management around 71 related literatures from publication database like Emerald Insight, ACM, Science Direct, Cite Seer X and Taylor Francis with key words like, Industry4.0 component, Industry4.0 implementation, Ethiopian Economy, Developing Economy.

3. INDUSTRIAL REVOLUTION: BACKGROUND ANALYSIS

The First industrial revolution started in the span of eighteenth century to nineteenth century, with the introduction of machines and it converts in next revolution after application of electricity and starting of concept of management in the labor and productivity [15,16]. Development of electronics and information technology, started third revolution in end of nineteenth century with automation and use of computers in the area of production [17].The advancement of digitalization and automation is converted into the “Industry 4.0” concepts with the German imitative for machine to machine communication and development of whole automated system for increase the competitiveness for the German manufacturing industry [18].

The basis of human civilization and advancement always related with the industrial production techniques and advancement, for example the use of steam and coal opened the new possible solutions in the every area from mechanical production to the new transportation medium “railway” in the first revolution [19,20].The use of coal, steam in the area of production and transport opened the chances for the second industrial revolution and the combination with the electricity , metal the second revolution changed the world in magical way[21,22].

The second phase was dependent on the coal, steel and other metals for the industrial growth and development but the emergence of computers and electronics changed the scenario and created the basis for the next revolutions [23]. The role of electronics and computers in the development of new era of industrial growth as well as development of society and this was the successful transformation of the industrial revolution into the human comforts also [24].In the new challenges of the production techniques, the importance of development in the production techniques for the facing challenges in the industrial sector for sustainability and survival in competitive global market [25,26]. The internet connectivity and strong communication for integrated machine working is the essential parts of technological upgraded production system [27].

In the next few decades, the production system will be more automated with full autonomy about the production and quality of the products because the Industry 4.0 not only working on the digitalization and technological up gradation of conventional system but the main areas are artificial intelligence, communication network and automated machine learning so the fully automated and without human interference system can be work on the optimum level for higher production with quality products[29,30].“Industry 4.0” term was introduced by people from different areas for increase the competitiveness of German industries in to the global market [31,32]

This was the conceptualization of the idea of the smart factories for the emergence of the new approaches for the collaborative manufacturing environment for the benefit of germen industries and increment in the technological competitiveness for fulfillment of up gradation and productivity improvement requirements [33, 34].The companies also want to technological advancement in different areas of production for uniqueness and superiority in the specified productions and products. Similarly, integrated production system equipped with higher technology and methodologies are the requirement of the companies and for the controlling in all the area of production from logistics to real time based management of resources and utilization of whole supply chain of the system [35]

The Industry 4.0 term firstly used by Germany and gradually accepted by the whole world .So after the acceptance of Industry 4.0 in international level , the need of redefined this term in global perspective. The concepts “dark factories” is also representing the fully automated system where lights are extinguished and the presence of any human being is not required [36, 22, 25]. The use of sensors, artificial intelligence and strong computer network is the basic requirements of dark factories for full automation and autonomy for level of working competence in integrated automated manufacturing environment [37].Now a day’s also some factories working on the concept of the dark factories, where no need of human interference in the production but the maintenance and controlling for raw material to the final product human interface is required. But in the case of dark factories no human interface from raw to the final products [38]

The unmanned factories and used of sensors with automated production system from input to raw material to the final products is the basis of Industry 4.0. The another aspect of Industry 4.0 is uninterrupted information flow across the world and sharing the ideas and product information in secured manufacturing global network for overall development and sharing the technological advancement. The effective and creative utilization of technological advancement is the key factor of success of Industry 4.0.

Some factors and motivations affected the direction and growth of the production system. Social interaction and international trade is the regional factor whereas global flow of financial resources comes into economic factor. Technological advancement and environmental and safety issues are another factors, which are the deciding factors for industrial growth in particular areas and economy [39].

In automated system, the important components like sensors and machines work together with the help of internet and information technology network. These systems interact and communicate with the help of internet for prediction of failure, repair and modification. This feature enables machine to communicate with other machines and ready to adoption new changes according to the situation and requirements and these is the basis of higher productivity, growing economy with safety [41].

For the modification and advancement of conventional production system into smart factories requires operational modification into the company's practices and preparation of significant changes for advancement and related activities for implementing Industry 4.0 in the existing system. These changes can be come, only after the collaborative approaches of skills and capabilities for the progressive and competitive manufacturing environment into the industry through the implementation [42]. Industry 4.0 is now globally accepted term for advancement and vision for the future manufacturing environment. This can be achieved through coordinated working of the product, network communication and the machine intelligence [43, 44]. For example, the taxi companies, social media platform, e-commerce companies are working on the basis of application of information technology basis with the use of available resources. The advancement and the growth of this type of services heavily dependent on the software's and network connectivity and the future and growth of business will increase with the implementation of Industry4.0 [45].

4. IMPLEMENTATION OF INDUSTRY 4.0

The major components of the Industry 4.0 are Cyber Physical Systems, machine communication Smart Factory, Cloud Systems, Internet of Things and Big data. There are some studies regarding the road map and implementation aspect of Industry 4.0 in the literature about the planning tools for implementing of Industry4.0.

- For integrated and collaborative work between different companies the standardization of system and interconnectivity is primary requirement for sharing and utilizing the information through secured manufacturing network [46, 32, 22].
- The smart companies will be very complex and complicated system and without appropriate plans and efficient optimization model management and resource utilization is very difficult [47, 35, 28].
- Internet is the most basic requirement of the implementation of Industry4.0 and existing broadband services not enough to fulfilment the requirement of smart factories and smart companies. Development of ample and reliable internet network is another requirement for implementation aspect [48,49].
- Environment friendly manufacturing facilitates is the condition of the implementation of Industry 4.0 and safety will assure about the unauthorized use of products and service [50,34,25].
- Production management with the pre set goals of process, working environment, automation for full utilization of available resources for higher productivity and quality assurance [51,17,26]
- Industry 4.0 is the rapid and continuous improvement process and for the work force and employees needed better training and professional development opportunity [52,53]
- Development of organizational framework for personal data, trade information and structural information. These are the necessity of the appropriate control measures for the organization working and employee coordination's[54,55]
- The productivity improvement is the main measurement for the efficient system and for this purpose increment in resource utilization by new technology, process and raw material and reduction in any losses due to production system or working environment [55,56]
- The minimum human interaction is the basis of automated system and the successful implementation can be considering only basis of amount of human interference for operating the system [57,55]
- The coordinate working environment between the products and process with the help of autonomy behaviour of the machine can be generating advance manufacturing environment [58].
- Big data analysis and handling capability is the basis for the smooth running environment of the smart factories for achieving goals [58].
- Technology adoption and flexibility capabilities of machines and system can be work under changing environment and simultaneous operations. Collaborative and coordinated automated system is necessary of machine to machine communication and reconfiguration of system [59,17].
- the real time CPS platforms and social infrastructure based on smart networked model can create a clear and visible roadmap for transformation of existing system into Industry 4.0 with Inclusion of supply strategy and leading market strategy into manufacturing strategy[59,23,35]

In Industry 4.0 some technologies are playing big role and for the implementation aspect these technologies very important like reality, big data analytics , industrial internet of things, robotics, machine learning, simulation, cloud computing, cyber-security, additives manufacturing, etc.

Autonomous robot is another important tool for Industry 4.0 implementation. Robots are very helpful in performing those operations, which is very difficult for human being for different reasons like harmful working condition. Now companies are performing repetitive operations by robot in manufacturing plants [60, 35,56].

Simulation is the artificial replication of the any manufacturing operations or machines, man, and products related activities [61, 25, 36]. Its applications in different fields like process simulation, optimizing process, and scientific modeling for understanding and visualizing the system . Simulations also using for ergonomic design, method study and energy consumption pattern .The use of simulation can help in minimization breakdown time, waste minimization and higher quality output [62].

Internet of things playing important role in industry 4.0. Internet of things can be defined as an industrial internet in which Manufacturing Service, People and communication devices are networked for controlling and operation [63,39].

For successful implementation and working in Industry 4.0, every components should be connect with each other and communicate through a standard protocol for production purpose. To protect this information about machines and operations, cyber security should be more secured, advanced and reliable.

The cyber physical systems used for connect physical components to digital control. It is used for the physical connectivity of components [64].

Cloud computing is another tool for storage of real time massive data from all the operational source of manufacturing system .It is used for share communication devices and component for operations and controlling .The implementation of Industry 4.0 can be achieved through cloud computing networked devices[66,41].

Additives manufacturing technologies are important for cheaper and faster production especially in the case of prototype or batch production for example selective laser sintering ,fused deposition method . The fast changing customer requirement can fulfill by application of additives manufacturing in less time and efforts [67,34,17].

Augmented reality is a network of communication devices, which helps in the manufacturing system for collecting real time data. It improves the controlling over the system through collection of real time data and support in decision making process and best suited for maintenance operations and modification process [68, 45].

Machine learning is basically software and internet based techniques that can collect the necessary information from a manufacturing system [69]. It's important role in predictive maintenance and breakdown analysis and for various purposes like fault diagnosis on gearbox. Now the all new technologies and new researches based on the conceptualization of the smart factories and use of technology for development of autonomy and higher quality production but new technology not much capable of significant change in the existing system and for the conversion of the existing system into advanced system. In the time of volatile market and demand of high quality, now also this is necessary to adoption of new technology for flexibility and survival in the competitive market.

The various researcher and industrial practitioner contributed for development the concept and term of industry 4.0 and now this is the main objective of companies for the possible development and up gradation of technology for the better future and fulfillment of highly quality products demand of the customers.

Even though there are lots of efforts to provide for a basic definition of industry 4.0 but till the modifications and change for the clear and visionary definition of industry 4.0 awaited .In the conceptualizing of the industry 4.0 there are different aspects of researcher, some researcher considering the network communication is important whereas other are giving importance to artificial inelegancy, autonomy and this is the main difficulty for proper and well accepted definition forming of the industry 4.0[69,45,32].

The new inventions in sensors devices, information network, and machine to machine communication are the basis of rapid progress in the field of robotics and machine automation. In the universities and research centers are working on the adoption and implementation in the field of supply chain, integrated manufacturing, logistic, and wide range of other applications [70].

For the technological advancement and implementation aspect of new technologies, researcher focusing on the emerging areas in the cloud computing, big data analysis, Iot, cyber physical system, smart factories and cities, only with the development in this area Industry 4.0 can be implemented in different aspects [71].

Scientist also working on the area like decomposing of moment tensors, discrete optimization, Non convex path and optimization, machine learning for the solving various problems related with the implementation problems.

Now in the development of cloud computing, process over time is also improving because it can provide access to modeling, filter and optimization of shared data in the network.

CONCLUSIONS

The Ethiopia, as one of the potential African countries and Industry 4.0 can be used for sustainable changes in country for solving many problems. But without proper infrastructure and environment, the country will not only fail to benefit from global opportunities, but will also face the risk of being marginalized furthermore from

the world's economy. Ethiopia should therefore establish effective policies to create an environment for the development of Industry 4.0.

There is lots of literature available on Industry 4.0, yet there is also scarcity of extensive studies and literature for implementation aspect of industry 4.0 in case of developing countries.

The main focused area of this research paper is identification of implementation aspect of Industry 4.0 in developing countries. The finding of this research offers important implications for the Ethiopian Industries .

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