DIGITAL MANUFACTURING MODEL FOR REMOTELY OPERATED VEHICLE (ROV) IN INDONESIA: A CONCEPT STUDY

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ABSTRACT

Industrial revolution 4.0 era represents a paradigm shift in manufacturing and technology, which is characterized by an integrated and interconnected system to support the operation of an industry. Many countries contributed to this era, including Indonesia. As a maritime country, maritime-related products have the potential to be offered. Remotely operated vehicles (ROV) is a form of digitalization product that is frequently used to support the operation of the maritime industry. Therefore, ROV is manufactured locally to provide easier access to industries demanding ROV. Digital manufacturing for ROV can bring further contributions towards industrial revolution 4.0, which involves the usage of digital technologies such as computer-aided design and manufacturing (CAD/CAM), internet of things (IoT), artificial intelligence (AI), and robotics to create an integrated manufacturing system. Furthermore, digital manufacturing information system provides real-time information during the manufacturing process. According to this study, digital manufacturing can significantly improve the efficiency and integration in manufacturing the ROV.

Keyword: Digital Manufacturing, Remotely Operated Vehicle, Production Planning

Introduction

The Industrial Revolution 4.0 Era, which began at the beginning of the 21st century, is an era of the emergence of digital-based technologies to support the industrial sector. In this era, the Internet of Things has developed along with various new technologies in the fields of robotics, science, and so on [1]. The rapid development in the field of digitalization, especially in manufacturing and automation, significantly increases the productivity of an industry. The development of Industry 4.0 in Indonesia is strongly encouraged by The Ministry of Industry so that Indonesia can compete in the industrial sector with other countries. As an example, digital and Internet of Things manufacturing infrastructure in Indonesia has been applied to automotive industries.

As a maritime country, Indonesia has a very great potential in its maritime sector. The Coordinating Ministry for Maritime Affairs and Investment of Indonesia mentioned that the potential of marine environmental resources and services in Indonesia is very diverse from various sectors, such as biological resources, non-living resources, artificial resources, environmental services, and unconventional resources. These potentials hold an important role as Indonesia's economic driver. Therefore, exploration and preservation activities are important to maintain these potentials [2].

Remotely Operated Vehicle (ROV) is a form of digitalization product in the maritime sector that is used to explore the underwater environment through a control system above the water surface. The ROV is very suitable to be applied in maritime countries such as Indonesia to do underwater exploration to decrease the risk if done by divers. But ironically, the development of underwater vehicles in Indonesia has received a lack of attention [3]. Currently, there are very few manufacturers that produce ROVs in Indonesia. Local manufacturing of ROVs in Indonesia will be a solution to fulfill the needs of ROVs in Indonesia. As the ROV itself is a high-tech device, the development and manufacturing of the ROV are

carried out with high-tech equipment. A sophisticated production method will drive Indonesia to compete in the Industrial Revolution 4.0 era.

Methodology

Product Breakdown Structure

Product breakdown structure is defined as a structured inventory of all the equipment and services to completely define a project during its conceptual and design phases. It is a form of product management structure that only includes the physical, conceptual, or functional element of the product carried out by dividing the overall project into sub-projects to make it easier to handle [4]. The product breakdown structure is developed to provide a visual representation of the product components and the relationship between each component.

The ROV is divided into three features: platform, propulsion, as well as electrical and control systems. Where the platform feature consists of platform design, stability, and maneuverability. The propulsion system features consist of a battery as the power source, motor, and thruster. While the control system feature consists of software programs. The PBS division is illustrated in the diagram in Fig. 1.

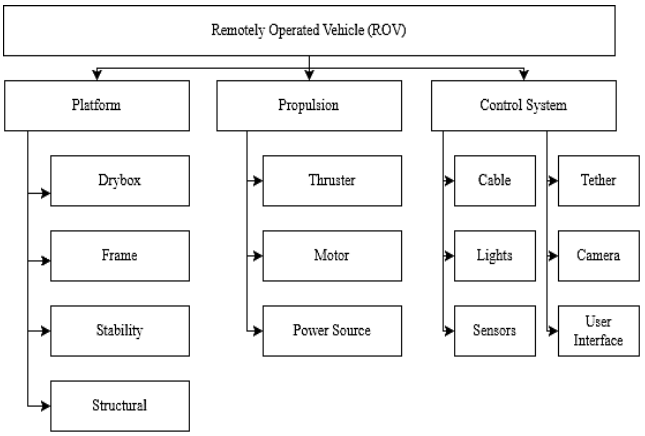

Figure 1. Product breakdown structure of ROV

ROV Manufacturing Process

The production of Remotely Operated Vehicles (ROVs) represents a complex and interdisciplinary undertaking at the intersection of engineering, robotics, and marine technology. One of the methods of describing the manufacturing process is the Work breakdown structure (WBS). Which is a decomposition process of an overall project work into several sub-tasks. The WBS was done by describing the final deliverable at the uppermost tier, followed by the next tier, until the lowermost tier where the component of WBS can be easily scheduled, estimated, and controlled [5].

Table 1. Work breakdown structure table of ROV.

Platform	Design	Geometry
		Material
		Sealing
		Assembly
	Analysis	Stability
		Structural
		Maneuvering
Propulsion	Thruster	Design
		Positioning
		Assembly
		Connection
	Motor	Motor Speed Control
Electrical	Components Installation	Lights
		Camera
		Sensors
		Sonar
		Cable
		Tether
Control System	User Interface	Camera View
		Depth Information
		Heading
		Battery Life
	Control	Motion
		Camera

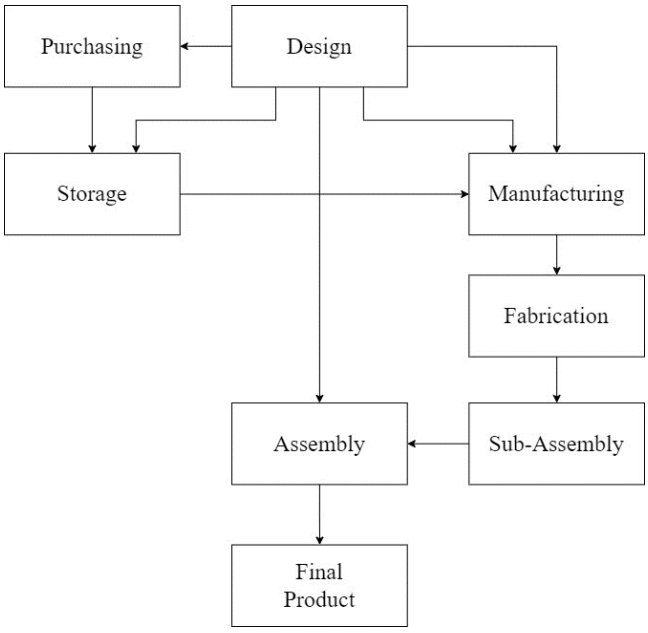

Figure 2. Framework diagram of ROV manufacturing

Manufacturing Framework

A manufacturing system that integrates equipment and labor resources to carry out one or more production actions from the material, part, or set of parts. It is influenced by many different factors, including types of operations, number of workstations, automation level,

and system flexibility [6]. A manufacturing framework takes a role in providing prototypical designs of enterprises in a particular industry by defining characteristic breakdowns of functionality and business processes that may align with capabilities. The development of digital manufacturing should consider the use of a manufacturing framework to reserve time due to the large logical data to be developed [7]. The manufacturing devices are reviewed and classified based on the intelligence level from low-intelligence level to high-intelligence level, which is control level, integration level, and intelligence level, respectively [8]. In this section, the conventional manufacturing framework is discussed as a reference in the digitalization process.

Manufacturing Process Digitalization

Digital manufacturing does not mean the complete elimination of manpower. It is primarily a transition from digital data transfer that is done centrally to ensure manufacturing efficiency and the same real-time information received in each division. Digitalization is a process of moving to a digital business, that involves the usage of digital technologies to change a business model and provide new revenue and value-producing opportunities. It aims to enhance the application of information-based technologies to manufacturing and supply chain operations. The digital manufacturing proposed must fulfill two necessary criteria: (1) the model addresses at least one of the digital manufacturing paradigms, and (2) the model is being referred to as a 'reference architecture', which guides the design of structure architectures by providing a structured template with common terminology [9].

Table 2. Comparison between conventional and digital manufacturing

Conventional	Digital
More labor required	Less labor is required due to the usage of automation and robotics in manufacturing
Unplanned material purchasing	Material purchasing has been planned from the design stage and has been standardized in a certain product.
Unpredicted Time	Every station has work time standard.

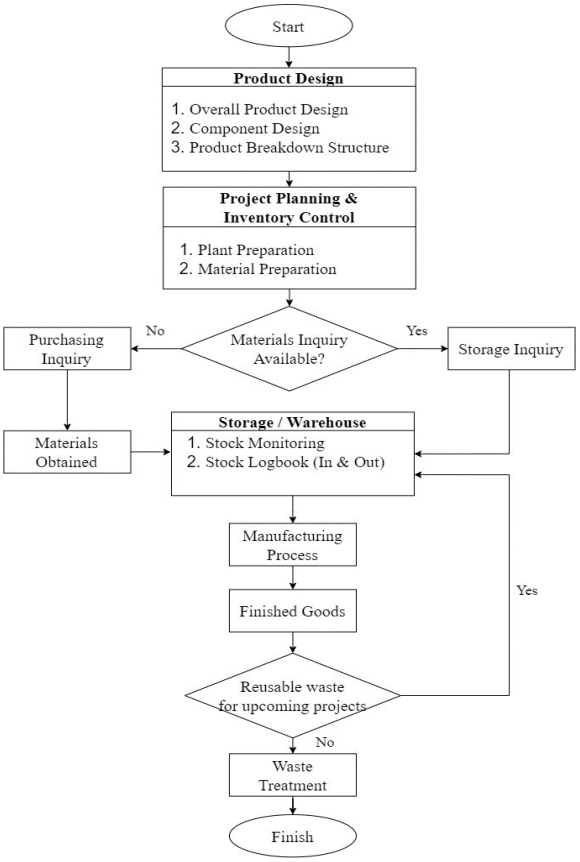

Figure 3. Digital manufacturing flowchart

Proposed Digital Model

Project Planning and Control (PPC) plays an important role in a successful project where planning and control enable workers to define project objectives, allocate resources, monitor progress, and respond to unplanned changes. A smart PPC incorporates different levels of PPC domains and manages all the key processes by using data from diverse sources and allows human intervention [10].

Computer-Aided Manufacturing (CAM) is one of the proposed digital manufacturing models referred to as the 'reference architecture' [9]. Computer Numerical Control (CNC) devices are examples of CAM applications that follow detailed instructions in the form of a computer program to shape and cut various materials. CNC machining is widely used in various industries for its precision, repeatability, and ability to produce complex parts. CNC machines come in various types, including CNC milling machines, CNC turning machines, CNC routers, and more, each suited to different types of machining tasks.

Monitoring and supervision play an important role in industry to maintain operational well-being. Monitoring is data collection from the controller to determine the action required, while supervision is decision-making to raise the indecision in the control

system, and to put the system back to its normal operation when failure occurs [11]. Digitalization in monitoring and supervision able to be applied by sensor installation at the three crucial role players in the industry: workers, plant environment, and machines [12].

Result and Discussion

The digital framework model was mainly developed with the aim of increasing the efficiency of manufacturing. In the proposed model, the efficiency can be increased by applying digitalized technologies. The following are the technologies that are possible to be used.

Computer Numerical Control

The usage of computer numerical control (CNC) devices in this manufacturing is to develop a drawing file into printed components. The computer numerical control devices ensure that the fabrication process can be done efficiently, especially in terms of time. The integration with cloud storage will make a faster data transfer process and more product consistency.

Integrated inventory control

The integrated inventory control integrates all the material requirements of the project. From the design stage, the material breakdown has been done to discover the required inventories to conduct the project. The application of integrated inventory control ensures that the required materials or inventories have been purchased in the right amount to reduce cost and waste from manufacturing.

Conclusion

In conclusion, the implementation of advanced technologies in the manufacturing of Remotely Operated Vehicles (ROVs) has ushered in a digital environment for the production processes. The development and integration of these technologies have significantly enhanced the efficiency and control of manufacturing operations. The integration of these advanced technologies not only optimizes the manufacturing processes of ROVs but also prioritizes the well-being of the workforce and the quality of production. This digital transformation represents a significant leap forward in the world of manufacturing, paving the way for more efficient and sophisticated production methods.

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