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Applying Computer Integrated Manufacturing for Productivity Improvement: A Literature Review

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Abstract. In this era of globalization, information technology, especially through the use of computer technology (program and software) is developing rapidly and has aN enormous impact on the manufacturing industry to support companies as a solving problems tool related to manufactured products that rely on input, process, and output, as well as Increasing effectiveness, efficiency, and productivity. The purpose of this study is to review various literature regarding the application of Computer Integrated Manufacturing (CIM) in the manufacturing company. Also, the scope of this study is to discuss and analyse in depth the related articles through the identification of scientific publications from 2001 to 2021, published in databases and electronic journals in English, and 30 items selected

Keyword: Computer Integrated Manufacturing, Computer Technology, Information System

Abstrak. *Di era globalisasi ini, teknologi informasi khususnya melalui pemanfaatan teknologi komputer (program dan software) berkembang pesat dan memberikan dampak yang sangat besar bagi industri manufaktur untuk mendukung perusahaan sebagai alat pemecahan masalah yang berkaitan dengan produk manufaktur yang mengandalkan input, proses, dan output, serta Meningkatkan efektivitas, efisiensi, dan produktivitas. Tujuan dari penelitian ini adalah untuk mengkaji berbagai literatur mengenai penerapan Computer Integrated Manufacturing (CIM) pada perusahaan manufaktur. Selain itu, ruang lingkup penelitian ini adalah untuk membahas dan menganalisis secara mendalam artikel terkait melalui identifikasi publikasi ilmiah dari tahun 2001 hingga 2021, diterbitkan dalam database dan jurnal elektronik dalam bahasa Inggris, dan 30 item terpilih.*

Kata Kunci: Computer Integrated Manufacturing, Teknologi Komputer, Sistem Informasi

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1. Introduction

Today, manufacturing companies face unpredictable high-frequency market changes driven by global competition. To remain competitive, these companies must have the characteristics of cost-effective and fast response to market needs, it is necessary to apply technology by integrating mechanical electronic systems and computers optimized to produce high-precision products and manufacturing processes [1].

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As global competition in the manufacturing sector continues to increase, and at the same time the exploitation of Big Data can dramatically improve manufacturing efficiency, a completely new manufacturing paradigm should get attention in the industrial sector [2]. Moreover, Kumile et al [1] stated that today's businesses are pressured to face the increasing complexity and challenges of customers demanding high-quality products, low cost, greater product variety, smaller batches, and shorter production times. Various strategies have been implemented to increase the competitiveness of the business world. This includes, but is not limited to, agile manufacturing, computer integrated manufacturing, reconfigurable manufacturing, and automation.

By using programmable tools to connect separate manufacturing functions to integrated systems, the company has introduced a new type of automated called Computer-Integrated Manufacturing (CIM). The integration of electronics from several manufacturing functions is believed to provide flexibility, quality, and production responsiveness to companies that are the basis to meet diverse market demands [3].

Suh et al [4] said that the computer has a dramatic impact on the development of production automation technology. Almost all modern production systems are implemented using a computer system. As advances in computer technology have been achieved, the domain of simulation applications has evolved. Simulation models are used to predict system performance characteristics and have been considered as a useful tool in many areas of research. To develop an effective simulation model, it is important to understand the fundamental of the system, especially for complex system design and control.

According to Dogmin et al [5], in an era where computers are at the core of worldwide production processes, understanding a Computer Integrated Manufacturing (CIM), and how computers can improve operations, is more important than ever. Computer Integrated Manufacturing System (CIM) has played an important role in manufacturing. Operates some of the computer-controlled equipment in a highly automated technique, the CIM system has contributed to the increased productivity of the manufacturing system.

The term of a Computer Integrated Manufacturing (CIM) was created to demonstrate the widespread use of computers to design products, production planning, conduct operations, and perform various business-related functions required in a manufacturing company [6]. The CIM concept enables the effective use of IT technology as part of computer production integration. The current paradigm assumes that the modern manufacturing industry is currently being transformed into a global manufacturing network and supply chain that allows the use of globally distributed manufacturing systems and resources. The concept of CIM is considered one of the key indicators in the development of the manufacturing industry [7].

The purpose of this study is to investigate and analyze the Computer-Integrated Manufacturing (CIM) literature on several previous studies through reference articles and international journals by considering its application in various case studies in the manufacturing industry and investigating the results achieved. This paper is organized into 5 section, that is, Section1 is an introduction that contains a background on the urgency and importance of applying computer technology by manufacturing companies in the face of global competition in the 21st century.. Section 2 describes a review of the literature related to the concept of Computer Integrated Manufacturing (CIM) and its integration with other approaches in increasing company productivity.

Also, section 2 discusses the concept of information systems integrated with computer technology through the application of Computer Integrated Manufacturing (CIM) systems. Section 3 presents a methodology of the literature review of several previous studies that elevate the case studies of Computer Integrated Manufacturing (CIM) systems in the manufacturing industry. The case studies analyzed in this article are limited to the manufacturing industry. The results of a selection of several previous international journals/articles related to the application of Computer-Integrated Manufacturing (CIM), which have previously been selected are summarized in the table presented in Section 4. Analysis in-depth discussion of some studies summarized in section 4 is presented in section 5. Finally, some conclusions and outlines of this study are provided in section 6.

2. Computer-Integrated Manufacturing (CIM) Concept and Fundamental

CIM is a fully automated manufacturing concept where all Manufacturing processes are integrated and operated by a CAD/CAM system. This allows production planners and schedulers, shop floor foremen, and accountants to use the same database as product designers and engineers. This is one of the most advanced tools for improving economic performance. This is also the fundamental basis for planning and developing the next generation of more advanced manufacturing systems [8]. Also, the use of CIM or (Computer Integrated Manufacturing), the integration between marketing, production, and delivery more quickly. Another advantage, data is integrated so that finance calculations or cost accounting more accurate. With the application of CIM in the factory, companies able to produce orders based on products, not on forecasts. CIM can shorten lead time and reduce the inventory significantly. CIM also significantly reduces the use of human resources in product processing [9].

Moreover, Vasu and Swaroop [10] said that the use of CIM or (Computer Integrated Manufacturing), then the integration between marketing, production, and delivery faster and more accurately. Also, the data is integrated to calculate the financing or cost accounting tends to be more accurate.

Wu et al [11] argued that CIM is a new type of philosophical theory used in organizing, managing, and running out the company's production; it leverages computer software and hardware, synthetically utilizes modern management technology, manufacturing technology, information technology, automated technology, system engineering technology, and organically integrates three relative factors, namely people, technology, management that carried out in the company's entire production process, as well as information and material flows, and performs it optimally, to make the best service, bring products to market on time, create high quality and cheap products, so that the company will lead the market competition.

Boshle et al [12] noted that CIM is a system consisting of software that covers many business processes that covering the integration of automatic assignment and reporting of factory floor operations through sensors and software machine tools, material handling tools, and also includes enterprise resource planning modules in manufacturing operations such as design, purchasing, inventory, store floor handling, Material Requirement Planning (MRP), customer order management, and cost accounting.

Computer Integrated Manufacturing (CIM) covers the entire range of product development and manufacturing activities with all functions implemented with the help of specialized software packages. The data required for various functions are passed from one application software to another seamlessly. For example, product data are created during the design. This data should be transferred from modeling software to manufacturing software without loss of data [13].

CIM uses a common database where possible and communication technology to integrate the design, manufacturing, and related business functions that incorporate automated segments of a factory or manufacturing facility. CIM eliminates human components from manufacturing and thus reduces its slow, expensive, and error component processes. CIM stands for a holistic approach and methodology to the activities of the manufacturing company to achieve a major improvement in its performance [14].

In addition, Hassan and Bright [15] said, that CIM provides the architecture for manufacturing companies to succeed in today's competitive market. As an automated and programmable process, CIM involves the integration of many manufacturing functions. These include Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Automated Material Handling (AMH), Computer Numerical Control (CNC), ASRS, and AGV.

Figure 1 Key Elements of the CIM System

The successful CIM implementation strategy should include the use of computers to integrate information and material flow, small batch production with online production control systems (such as FMS), and local area networks (LANs) to integrate information flow within them. The conceptual framework is presented in figure 1 above to illustrate the key issues involved in improving the integration and adaptation aspects of CIM. This model presents a series of key elements of CIM implementation that cover strategic, organizational, behavioral, technological, and operational issues [16].

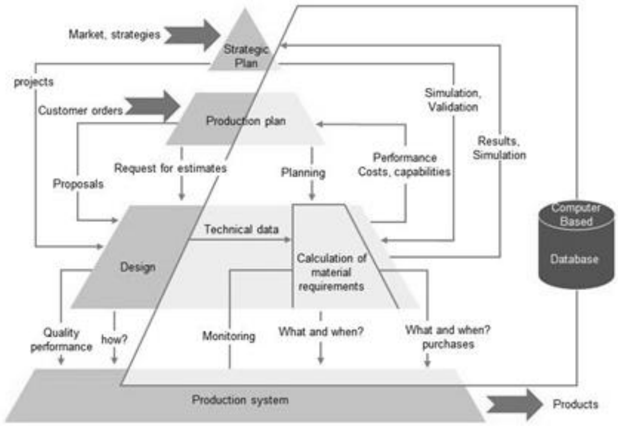

Figure 2 CIM Concept

Remli et al [10] state that there are three main challenges in developing a CIM system:

1. The integration of components from different suppliers: If different machines, such as CNCs, conveyors, and robots, using different communication protocols can cause problems.
2. Data integrity: The higher the level of automation, the more important the integrity of the data used to control the machine. While the CIM system saves the machine labor, it requires additional manpower to ensure that there is appropriate protections for the data signals used to control the machine.
3. Process control: Computers can be used to assist human operators in a production facility, but there must always be a competent engineer to handle situations that cannot be predicted by the control software designer.

Some or all of the following subsystems are available in CIM operations, i.e; CAD (computer-aided design), CAE (computer-aided engineering), CAM (computer-aided manufacturing), CAPP (computer-aided process planning), CAQ (computer-aided quality assurance), PPC (production planning and control), and ERP (enterprise resource planning). Meanwhile. the equipment and devices needed are CNC (Computer numerical controlled) machine tools, DNC (Direct numerical control machine) tools, PLCs, (Programmable logic controllers), Robotics, Computers, Software, Controllers, Networks. Interfacing and Monitoring equipment. In addition, the technologies are FMS (flexible manufacturing system), ASRS (Automated Storage And Retrieval) system, AGV (Automated Guided Vehicle), Robotics and Automated conveyance systems [10].

2.1. Productivity Increasing Through Computer-Integrated Manufacturing (CIM)

In today's competitive international business environment, companies are calling for new manufacturing. Through the use of various computer-assisted technologies, Computer-Integrated Manufacturing (CIM) can attract all business areas into a cohesive, interconnected, interactive, and self-aware [11].

CIM covers activities such as product/process design, manufacturing technology, materials procurement, information resource management, and total quality management. CIM uses computer-assisted technology to maintain quality, accelerate new product development, minimize costs, and maximize flexibility to respond the changing customer desires. Thus, CIM's competitive advantage in the industry stems from its ability to [17] :

1. Develop a large number of new products quickly;
2. Produce small production of efficiently customized goods; and
3. Maximize the flexibility of manufacturers in responding quickly to changes in the environment.

Meanwhile, the advantages and disadvantages of using CIM:

1. To coordinate and organize data
2. To eliminate costs associated with its use
3. Faster response to data changes for manufacturing flexibility
4. Improved product quality compared to conventional manufacturing
5. High Rate of Return

2.2. Productivity Increasing Through Computer-Integrated Manufacturing (CIM)

To reduce production and administration time, the organizations should create an integrated manufacturing system, which is a problem of organizational system design rather than the technology system design. The integration process is based on the relationship of functional elements with relationships in such a way that they become part of a particular structural entity. By definition, an integration process is an activity or network of activities that need to be carried out to achieve the desired effect, e.g. combines two industry firms - functional relationships, organizational structure, technological processes, pricing policies, and product quality [18].

Moreover, according to Kamiński [18] the problem of IT systems integration at the level of technology, data logical (concerning programs, formats and data structures, programming languages, facts, and events description language), and info logical (representation of knowledge in systems). He also proved that the most important requirement of IT system collaboration is semantics, i.e. consistency of concepts used to describe sentences, facts and events. The levels of consistency are, respectively, the unification of classification measures, norms, and rules.

Based on the diversity of software and simulation objectives, the information management between a product and production process including source-related data is very important and requires a specialized Information System [19].

Kamble et al [20] said that Computer Integrated Manufacturing (CIM) under the control of general information systems to increase their competitiveness. In addition, he also argued that CIM is centered on decisions about data flow planning and control, data processing, and data dissemination in a factory.

An information system can be defined as a set of individual or collective instruments that participate in the information management process in an organization [21]. Another definition has been put forward by Hairulazwan et al [22] ‘an information system is a group of resources organized for the collection, storage, care, maintenance, use, sharing and dissemination, providing, displaying or transmitting information. Resources are defined as personnel, equipment, budgets, and information technology. Therefore, the main purpose of an information system is to provide all the information about the current or previous situation to persons in the organization.

The integrated system consists of the standard modules intended to serve all data transfers that support the functions of the industry organization. Integrated systems are intended for computers that help process economic operations at the operational and management levels [23]:

1. Operational level - employees benefit from process automation, e.g. after the introduction of source documents to the system, it is possible to gain access to system functions that make it possible to realize certain tasks.
2. Management level - top management can monitor the financial condition of the company, check the latest product and raw material stocks, logistics planning, maintenance, and logical action in case of irrelevancy.

The CIM system relies on an information system for data transfer between different modules. The main challenges for manufacturing systems are to meet the demand for simultaneous manufacturing, environmental compatibility, reconfiguration, integration in a corporate context, and pro-innovative integration [24].

The CIM system relies on an information system for data transfer between different modules. The main challenges for manufacturing systems are to meet the demand for simultaneous manufacturing, environmental compatibility, reconfiguration, integration in a corporate context and pro-innovative integration [25]. Production management encompasses all functions related to customer orders, design, fabrication (e.g., machining), inspection, and customer support of products. Data management includes all functions related to the accurate and timely delivery of information for the production management process. Communication management covers all the functions required for reliable message transmission between all computer systems in the company [26].

According to some experts, CIM's approach to integrating manufacturing systems is very different from the JIT approach. Experts argue that CIM integrates organizations by automating the flow of information between interconnected processes and organizational functions using advanced information technology. In addition, flexible manufacturing technologies - such as robotics, NC or CNC machines, automated guided vehicles, and automated storage and retrieval systems-reduce production time by processing various products quickly in a small batches. Therefore, the main approach used in CIM systems to address organizational connectivity is increasing the level of flexibility to address the connectivity at the impact point (in manufacturing) [27].

Since the information technology should be able to reduce the processing time (time throughput) by increasing the speed of data transmission, it should be considered the extend to the delivery time contributes to processing time. In information terminology, the throughput time between two processes A and B consists of the information transmission time and the processing time of the information in A and B. When one assumes that the processing of information for activities such as engineering design, marketing, and accounting can be done for weeks, months, or even years (in terms of new product development), it becomes clear that the focus on the transmission of high-speed information in no way removes critical barriers [28].

Furthermore, Mikell [31] said that to reduce the administrative processing time (Time throughput), the focus of improvement should be placed on the information processing. To reduce processing time, the actual activities performed by the various functions must be coordinated.

The installation of computer integration systems varies from flexible manufacturing machining centers to specialized computer technologies. Computerized manufacturing technology is often used for three manufacturing tasks. (1) Computer-aid design (CAD) and Computer-Aided Engineering (CAE) are used for product development. (2) Computer-Aided Manufacturing (CAM), and Material Requirement Planning (MRP) or the combination is often used to automate the expense process, and (3) Manufacturing Resource Planning (MRP-II) and Computer Automated Process Planning (CAPP) are often used to assist management planning [29].

Technology integration gives the following benefits [30]:

1. Creation of a truly interactive system that allows manufacturing functions to communicate easily with other related functional units.
2. Accurate data transfer between manufacturing plants or subcontracted facilities at different factories or locations.
3. Faster response to data changes for manufacturing flexibility
4. Increased flexibility in introducing new products.
5. Improved accuracy and quality in the manufacturing process.
6. Improved product quality.
7. Data flow control between various units and the maintenance of user libraries for system-wide data.

8. Reduction of waiting time which results in competitive advantage.
9. Efficient production flow from order to delivery.
10. Easier retraining and training facilities

3. Methodology

The purpose of this study is to review the literature of Computer Integrated Manufacturing (CIM) from several previous studies with reference guides, especially related to the context of previous research. One of the most important steps of this study is review is to determine the context of the literature review based on its approach and application. Generally. the parameters that need to be considered are the methods used. Tables are used in this study to record the articles. This study focuses on articles aimed at developing the theoretical concept work, literature review as well as case studies considered.

It should be noted in this study, although the identified methods were used during the screening process, the number of publications is large enough that it was not possible to analyze all articles, and in particular, the author analyzes several studies focused on Integrated Computer Manufacturing (CIM) and Information Systems (IS). As a result, 29 articles and theses were selected, reviewed, and documented using tables for further analysis. The methodology structure of this study can be seen in Figure 3 as follows:

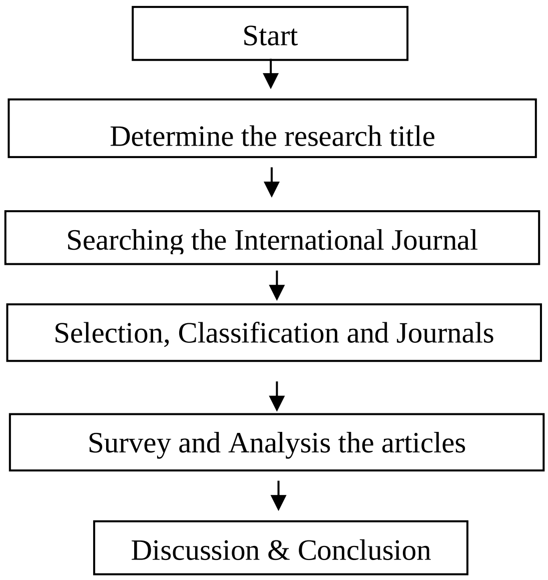

Figure 3 Methodology of Literature Review

4. Survey the Previous Research of Literature

Several case studies related to the integration of information systems using Computer Integrated Manufacturing (CIM) were selected for review in this study, and 25 articles were studied for further analysis. These articles are presented in Table 1; summarizes the analysis of the CIM application in various fields.

Table 1 Several selected articles related to Computer Integrated Manufacturing (CIM)

Title	References	Method/Approaches	Applied in
Computer Integrated Manufacturing Implementation: Benefits and Challenges	[23] Charles Chikwendu Okpala et al, (2020)	• Computer Integrated Manufacturing • Computer-Aided Design (CAD) • Computer-Aided Manufacturing (CAM)	Production Quality of Air Conditioner (AC) at the Electronics Development Institute (ELDI) in Nigeria.
Reference Architecture for Efficient Computer Integrated Manufacturing	[10] Abdelkarim Remli et al. (2021)	• CIM for ANSI/ISA-95 • OPC Server/PLCs-Measuring Tools • MES/OPC Server • Workstations-GUIs/MES. • Print Server/MES • ERP/MES	*Shopfloor at Automotive Factory*
Computer Integrated Manufacturing	[13] Akash Mahto et al. (2017)	• Computer Integrated Manufacturing (CIM) • Computer-Aided Design (CAD) • Computer-Aided Manufacturing (CAM)	Component of the Medium complexity axisymmetric rotary
Computer integrated enterprise in the MRP/ERP software implementation	[18] Andrzej Kamiński (2010)	• IT system • MRP, ERP • SQL language • Windows NT/XP/VISTA • IBM AIX platforms	Designing and Programming the Navision Attain (Microsoft Business Solutions)
Sensor Fusion Control System For Computer Integrated Manufacturing	[1] C.M. Kumile dan G. Bright (2008)	• Computer Integrated Manufacturing (CIM) • Mechatronic Sensory System (MSS)	Laboratory of the Robotics Research in Africa's KwaZulu University
Computer Systems Aided Management in Logistics	[21] K. Chwesiuk (2012)	• Computer Integrated Manufacturing (CIM) • Computer-Aided Design (CAD) • Computer-Aided Manufacturing (CAM) • MRPI, MRPII • ERP • WMS • CMR	Logistic
Implementing Ethernet In Computer Integrated	[22] Hairulazwan et al (2009)	• Computer Integrated Manufacturing (CIM) • CIM-70A	Communication Network Industry

Manufacturing System Planning And Design Of Computer Integrated Manufacturing Systems Using An Expert System	[25] Iftikhar Hussain et al. (2002)	• Computer Integrated Manufacturing (CIM) • Expert System Shell (AM) Software • Expert System (ES) • Knowledge-Based Systems (KBS) • List Processing (LISP) • Programming in Logic (PROLOG)	• Request information • Process plan • Machine information • Information Material Handling System (MHS) and Local Area Network (LAN) Information
Relating Learning Capability to The Success of Computer-Integrated Manufacturing	[3] Jason et al (2002)	• Computer Integrated Manufacturing (CIM) • Computer-Aided Design (CAD) • Computer-Aided Engineering (CAE) • Computer-Aided Manufacturing (CAM) • Material Requirement Planning (MRP) • Manufacturing Resource Planning (MRP-II) • Computer-Automated Process Planning (CAPP)	124 companies: • Ward's Industrial • Motor vehicle industry & accessories • Aircraft Industry & spare parts • Medical instruments • Household appliances
A Software Framework For Coping With Heterogeneity In The Shopfloor	[26] Fernandez et al (2007)	• Computer Integrated Manufacturing (CIM) • Computer-Aided Design (CAD) • Ethernet Profibus Gateway • SimaticPLCTiming • CP5431_Profibus • SimaticProfibus_Broadcast	Cell Industry, with classifying goods transported by conveyor
Design of Computer Integrated Manufacturing System for Irankhodro Auto Industry	[27] Morteza Sadegh Amalnik (2014)	• Computer Integrated Manufacturing (CIM) • Computer Aided Design (CAD) • Computer-Aided Process Planning (CAPP) • Computer-Aided Manufacturing (CAM) • Automated Storage &	Automotive Manufacturers - Iran-Khodro Industrial Group (IKCO)

		Retrieval Systems (AS/RS) • Computer-Aided Quality Control (CAQC) • Computer Numerical Control (CNC) • Computer-Aided Assembly (CAA) • Computer-Aided Financial Accounts (CAFA)	
A Hybrid Reconfigurable Computer-Integrated Manufacturing Cell For The Production Of Mass Customised Parts	[15] Hasan and Bright (2012)	• Computer Integrated Manufacturing (CIM) • Flexible Manufacturing Systems (FMS) • Reconfigurable Manufacturing Systems (RMS), • Computer Numerical Control (CNC)	Production scheduling of mass products.
Scheduling of A Computer Integrated Manufacturing System: A Simulation Study	[28] Bhuiyan et al (2013)	• Computer Integrated Manufacturing (CIM) • ARENA Simulator Software • Flexible Manufacturing Systems (FMS) • Automated Storage and Retrieval System Station (AS/RS) • ANOVA	• Production scheduling • Identify the maximum amount of material to produce • Specifies the minimum buffer size • Determine the Earliest Due Date (EDD) and Shortest Process Time (SPT)
A Study on Computer Integrated Manufacturing Method in Bangladeshi Textile Industry	[29]Mahabubuzzaman et al (2010)	• Computer Integrated Manufacturing (CIM) • Architecture for integrated Information Systems (ARIS) • The Computer-Integrated Manufacturing Open-System Architecture (CIMOSA)	Bangladesh Textile Industry (Minimize Lead Time)

5. Discussion and Result

The fourteen selected articles that summarized in Table 1 above. According to that, this study presents an analysis in-depth discussion of several previous articles related to Computer Integrated Manufacturing (CIM), as follows:

Okpala et al [23] discussed CIM, and the impact of manufacturing strategy at the Institute of Electronics Development (ELDI) in Awka - Nigeria. Many manufacturing process benefits covered, but are not limited to faster response to data changes for manufacturing flexibility, increased flexibility with new product introduction, improved accuracy and quality in the manufacturing process, and improved product quality are also discussed in detail. As a result, during the production rate of the manual Ac stabilizer, ELDI got many pending orders due to production delays. However, with the adoption of CIM in stabilizing manufacturing, the increase in production rate is very significant. In addition, other advantages that can be achieved by using CIM in the company include flexibility, facilitation the concurrent techniques, increase and production speed, reduction of waiting time, and reduction of errors.

Remli et al [10] A proposed CIM that can link production and company information systems. This CIM is based on six aspects that we have identified, namely data integration, system integration, security, data analysis monitoring, mobility, and cloud computing. Furthermore, this study provided a reference in terms of architecture for CIM, which can cover each system in the context of CIM. The results of this study revealed that MES allows researchers to customize several dashboards that will provide information to the operator, which includes aspects of Dash-boarding. The input used is the manufacturing data collected, which also allows researchers to develop web applications using cross-platform frameworks. Web applications can be accessed from the operator's workstation or the mobile terminal. The central level of the company's architecture contains an ERP. ERP manages production at the company level and delivers the company's strategy to the factory for MES to translate as the order to Shopfloor.

Mahto et al [13] conducted research focusing on the significant aspects of Computer Integrated Manufacturing (CIM) integrated Computer Design (CAD) and Computer-Added Manufacturing (CAM). They reported that the architecture and performance of networks interconnected with device functionality are essential for the efficient and reliable operation of integrated design and manufacturing processes. The lack of reliability, flexibility and interoperability in network design can lead to chain reactions of jams and delays resulting in a loss of control and poor productivity.

Kaminski et al [18] studied the design and programming of the Navision Access system makes it possible to isolate IT technicians–programmers from tables, fields, and relationship-making mechanisms for certain database management systems. The operating system is quite simple. The programming and design are designed to automatically generate scripts in the SQL language, which perform precise modifications in the database structure from the server-side. The planned system is part of Microsoft Business Solution-Navision; is an ERP package (Microsoft Business Solution-Navision Attain and Microsoft Navision Standard Business Solutions), which was built by the Danish company Navision Software. Navision Attain is an integrated IT System, aimed at midsize companies. Navision consists of modules: main books, material assets, sales and accounts payable, purchases and liabilities, stocks, orders, human resources-wages, and production. The system used enables multi-currency transfer, multilingual selection of user interface, and use of special Navision Developers Kit programming tools. The system works in a Client-Server environment using the Windows NT/XP/VISTA and IBM AIX platforms. Microsoft Business Solutions - Navision Standard is a solution design for small companies.

C.M. Kumile dan G. Bright [1] focused on a methodology for improving flexibility and reusability of generic Computer Integrated Manufacturing (CIM) cell control systems using the concept of simulation and mechatronics sensory system (MSS) modeling. The use of sensors in CIM cells is specifically highlighted data acquisition, analysis, and multi-sensor data consolidation. Thus, the designed reference architecture provides a comprehensive analysis of the functionality and methodology of the generic Shopfloor control system (SFCS), allowing the rapid deployment of flexible systems. Furthermore, this study demonstrates the use of the MSS approach for CIM synthesis, emphasizing features such as universality, synergistic design, computational efficiency, and high system performance. This research provided knowledge (design guidelines related to the integrated design of CIM systems) on how to improve SFCS by using sensory data derived from various fusion sensors so that the overall performance SFCS increases at a lower cost.

Chwesiuk et al [21] applied an integrated computer system management concepts in logistics, especially in the supply and distribution chain, which includes basic ideas of computer-based management concepts in logistics and system components, such as CAM and CIM systems in the production process, and management systems for storage, material flow, and for managing transportation, delivery and logistics companies. The platform used to integrate computer-assisted management systems is an electronic data exchange. Furthermore, this study also discussed the concept of integrated computer system management in logistics utilizing computer-assisted systems that are already used in manufacturing process management and control (CAM and CIM), used in supply logistics (MRPI, MRPII, and ERP), and in distribution logistics (WMS and CMR). Integrated computer systems also incorporate computer systems that support management in delivery, transportation, banking, insurance, customs, etc.

Hairulazwan et al [22] proposed integration between industrial communication networks based on Ethernet protocol and Computer Integrated Manufacturing (CIM) systems. An Ethernet module is attached to the OMRON monitoring PLC to integrate multiple stations in the CIM-70A system to address real-time communication in terms of data retrieval from other stations. The feasibility of this communication technique is analyzed and compared with conventional serial communication that is widely used in automation network systems. In addition, this study examined Ethernet-based communication network applications using the CIM-70A system. To investigate communication techniques, a CIM system communication network hardware infrastructure based on Ethernet protocol was developed to identify and solve emerging real -time communication problems. The results of this study successfully provide an Ethernet-based communication network implementation for CIM systems with the ability to monitor each station from multiple points in the system.

Iftikhar Hussain et al [25] developed the Knowledge-Based Computer Integrated Manufacturing System (KBCIMS) to planning and designing the CIM systems using production rules and analytical techniques. Production rules help consumers make decisions. Meanwhile, analytical methods are used to optimize and calculate the design parameters. The methodology developed using an AM specialist systems software. The software work system they develop is implemented in two stages, namely systems and analytical methods. The first stage (planning) obtains information on demand forecasting, process plans, machines, MHS, and LAN. Thus, detailed analysis in the planning stage, the next (design) stage is loaded. At the design stage, suitable machines are selected and calculated, suitable MHS are selected and design factors are calculated, quality control techniques are applied and finally, an in-depth cost analysis is performed to check the viability of the designed CIM system.

Jason et al [3] conducted a research with the aim to fill the gaps and enrich the understanding of the role of organizational learning in the implementation of CIM through empirical analysis of samples of 124 manufacturing companies. Their study was aimed to implement CIM to determine the marginal contribution of organizational learning to the achievements of the CIM system. The main hypothesis is that higher learning ability will result in better CIM system performance. The steps they take in implementing CIM were: eleven variables are selected as a proxy for the multidimensional performance of CIM systems, i.e. the dependent variable in the model. The CIM variables and organizational learning variables were used to describe variants of dependent variables. Then statistical control was carried out on dependent variable variance based on the antecedent causal variable; CIM. Therefore, this study considers the learning variable as the treatment variable and CIM as the covariate.

Fernandez et al [26] proposed a metal language, called H, and a set of tools that functions to plan, implement, and debug heterogeneous software distributed in Shopfloor. The metal languange includes fault tolerance and Real-Time mechanisms. Also, they recommended a new approach to address heterogeneity and flexibility from a programming point of view, which aimed to produce software applications that can adapt to the heterogeneous components of Shopfloor. The study claimed that their approach encompasses a level of physical and application CIM integration since the interoperability between various elements and/or applications in Shopfloor was achieved through a common and transparent information exchange methodology.

Almanik et al [27] designed a general model and system of CIM architecture for an Irankhodro automotive industry manufacturing company. The approaching model used in this study is divided into three, namely *First*, covering three parts of data management, data representation, and communication. *Second*, a decision support system (DSS) that includes three parts DSS for design, DSS for manufacturing, and DSS for management. *Third*, functional fields include marketing, design, process planning, manufacturing, designing and production control, quality control, warehouse, management, and finances. The CIM model applied to the automotive company includes 7 elements, namely; business level, facility level, factory floor, warehouse floor, workstation, machine, and sensor level.

Hasan and Bright [15], using CIM integrated with Flexible Manufacturing System (FMS) and Reconfigurable Manufacturing System (RMS). The RCIM in this research was designed with sufficient flexibility and configuration capabilities to produce standard parts. The approach that is designed prevents the flexibility wasted by expensive production equipment. The results obtained from this study help modern dynamic market demand for large-scale customizable products. Scheduled products can be further customized and their quantities vary without increasing production costs. CIM's approach with FMS and RMS provides a way to enhance the range of products offered by the company. This hybrid/integrated approach qualifies to respond to the stochastic behaviors that continue to demand special, cost-effective products. Their approach provides a way for the manufacturing industry to compete in today’s global marketplace, by providing cost-effectiveness advantages, shorter waiting times ,and reduced equipment costs.

Bhuiyan et al [28] presented research that examines the impact of selected Scheduling delivery procedures for the actual performance of CIM systems using a different performance measurement. This study used computer simulations of the existing CIM systems, which were then developed to test the performance of different scheduling rules pertaining to the average flow time, machine efficiency, and total running time as a performance measure. The procedures of this research were conducted using the existing CIM system simulation model based on the control logic that describes the operation of the system. The ARENA simulator software was used to model the CIM system. Design of Experimental (D.O.E.) was also used to study environmental factors influencing the performance of selected delivery rules on existing CIM systems. Then, the performance of the transmission rules was evaluated and analyzed using ANOVA (analysis of variance). This study claimed that the increase in the number of buffers in the system reduced the influence of the number of early component discharges on machine efficiency, as it had a smaller buffer measure; and the machines used more efficiently to complete job orders.

Mahabubuzzaman et al [29] proposed the application of CIM to the Bangladesh Textile Industry based on the establishment of an effective information exchange structure between high-level company management, assembly line, scheduling department, and single production supervisor. The CIM model implementation resulted in a low-cost solution developed to reduce production costs, production time, and inventory levels. By adopting CIM's flexibility, good quality and logistics were achieved.

6. Conclusion

Computers have been used to operate high-speed production machines, and Computer Integrated Manufacturing (CIM) which is assisted with Computer-Aided Design (CAD), Computer-Aided Engineering (CAE), Computer Numerical Control (CNC), and Computer-Aided Manufacturing (CAM); an entire factory automated manufacturing system operated by central processing unit (CPU) to design a product that manufactured in an industry or factory. From several international journals/articles described in sections 4 and 5, it was observed and summarized that CIM is a concept/philosophy for integrating various business functions (marketing, design, delivery, transportation, production, and distribution) with automation functions in a manufacturing system. The intended automation function is the integration of process automation with data communication using computer networks.

From Table 1 in section 4 and also analysis-in depth in section 5, this study summarized and identified that Computer Integrated Manufacturing (CIM) integrated with Manufacturing Information System is a computer-based manufacturing technology concept/system that works in relationship with other functional information systems to support company management as solving problems related to the manufacturing company products that are essentially still reliant on inputs, processes and outputs.

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