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Intelligent Supply Chain Performance for Industrial Adhesive Manufacturers

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Abstrak

Rantai pasokan memainkan peran penting dalam perusahaan manufaktur dan jasa. Selain itu, standar ISO 9001:2015 menginstruksikan organisasi untuk memantau identifikasi dan pelacakan produk dan layanan. Dengan menggunakan alat dan teknologi modern, rantai pasokan telah berkembang menjadi rantai yang efisien. Untuk meningkatkan tingkat pelayanan, penyedia rantai pasokan harus menggunakan model-model berstandar untuk mendukung operasi dan mengukur kinerja. Penelitian ini berfokus pada studi kasus yang menggabungkan situasi dunia nyata untuk memecahkan masalah dan menganalisis solusinya. Pertama, kami mengumpulkan berbagai data historis pada laporan tahunan dan laporan keberlanjutan tentang kinerja manajemen operasional saat ini dari pabrik lem dan model bisnis perusahaan. Kemudian, kami melakukan analisis perencanaan strategis faktor-faktor internal dan eksternal menggunakan metodologi SWOT dan PESTLE. Setelah itu, kami menganalisis indikator kinerja kunci untuk semua departemen karyawan di perusahaan manufaktur lem industri. Evaluasi implementasi kinerja rantai pasokan menggunakan model SCOR. Peta strategi SCOR merekomendasikan solusi optimal untuk manajemen rantai pasok berkelanjutan di pabrik produksi lem industri. Kami memutuskan untuk mengimplementasikan Enterprise Resource Planning (ERP) untuk semua sistem sisi perusahaan guna meningkatkan efisiensi, komunikasi dan koordinasi yang lebih baik, pengambilan keputusan yang lebih baik, pelayanan dan retensi pelanggan yang lebih baik, keuangan yang lebih baik, pengelolaan aset yang lebih baik, dan fleksibilitas yang lebih besar untuk pertumbuhan dan ekspansi yang lebih mudah. Terakhir, telah diajukan desain manufaktur lem yang memanfaatkan teknologi canggih seperti sistem Radio Frequency Identification (RFID) untuk sinkronisasi data inventaris secara real-time dari ujung ke ujung.

Kata kunci: *produsen lem, perencanaan sumber daya perusahaan, desain sistem pintar, identifikasi frekuensi radio, kinerja rantai pasokan*

Abstract

Supply chains play an important role in manufacturing and service companies. Additionally, the ISO 9001:2015 standard instructs organizations to monitor the identification and traceability of products and services. With the use of modern tools and technologies, supply chains have developed into efficient chains. To improve service levels, supply chain providers must use standardized models to support operations and measure performance. This research on focuses on case studies that incorporate real-world situations to solve problems and analyze their solutions. Firstly, we gather various historical data on annual reports and sustainability reports on current operational management performance of adhesive factories and the company's business model. Then, we conduct strategic planning analysis of internal and external factors using the SWOT and PESTLE methodologies. After that, we analyse key performance indicators for all employee departments in an industrial adhesive manufacturing company. Evaluate supply chain performance implementation uses the SCOR model. The SCOR strategy map recommends optimal solutions for sustainable supply chain management in industrial adhesive production plants. We decided Enterprise Resource Planning (ERP) implementation applies to all enterprise-side systems for increased efficiency, better communication and coordination, better decision-making, better customer service and retention, better finance, better asset management, and greater flexibility to easier growth and expansion. Finally, an adhesive manufacturing design has been proposed that utilizes advanced technologies such as Radio Frequency Identification (RFID) systems for end-to-end real-time synchronization of inventory data.

Keywords: *Adhesive Manufacturers, Enterprise Resource Planning, Intelligent System Design, Radio Frequency Identification, Supply Chain Performance*

PENDAHULUAN

Supply chain management involves the strategic management of upstream and downstream flows of goods, services, finance and information to enhance customer and other stakeholder satisfaction and to improve the long-term performance of each company in the supply chain as a whole (Dwiyana et al., 2022). Supply chain performance can be improved by applying continuous improvement concepts and methods that are used throughout the supply chain. Therefore, monitoring supply chain performance through performance measurement has become an important part of the management process (Lima-Junior & Carpinetti, 2019). Regulation supply chain international standardization and increased consumer awareness create new requirements for supply chain management systems. In addition, the ISO 9001:2015 standard instructs organizations to monitor the identification and traceability of products and services (Westerkamp et al., 2020).

Supply chain managers activities are more effective when the top management team understands the needs of supply chain management and why supporting these needs enhances a company's ability to remain competitive. The supply chain manager's role

includes mobilizing resources across the organization and gaining support for organizational goals, taking multiple perspectives (supplier focused, company focused, customer, and other organizational unit perspectives), facilitating communication, increasing cohesion, and promoting collaboration or partnerships from both inside or outside the company. The main knowledge competencies required by supply chain managers are analytical, interpersonal, leadership, change management, and project management (Souza-Luz & Gavronski, 2020).

Interactions between business units are expected to be more efficient and effective in order to strengthen the value chain in providing products to consumers (Syafi'i et al., 2023). In addition, the supply chain strategy is caused by transactions between business units that collaborate to provide products for end consumers. The product transformation of each business unit provides an increase in the value chain in serving consumer needs. Product added value analysis needs to be studied because it relates to the availability of raw materials, production management, technology used, market institutions, and environmental factors. Increasing the added value of products is a strategy that must be owned by business units with the aim that their products can be in demand by consumers and can improve system performance. In addition, there are many indicators to measure the added value of products, including product packaging, good service to consumers, and giving rewards to loyal customers. The added value of the production process is influenced by production capacity and the number of raw materials used for labour. Meanwhile, the influencing market factors are output prices, labour wages, raw material prices and the value of other inputs (Lestari et al., 2022).

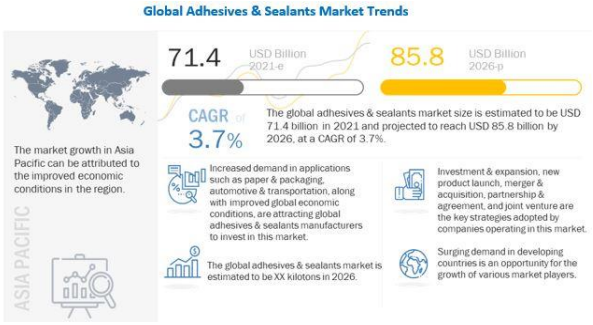

Fig. 1. Global Adhesives and Sealants Market Trends (own data)

Figure 1 shows that the adhesive and sealant market is projected to reach USD 85.8 billion in 2026, with a CAGR of 3.7%. The main market drivers are the increasing demand for adhesives in the medical industry, the increasing demand for adhesives and sealants from the building and construction industries, and the growth of the appliances industry. The industrial adhesives value chain includes major suppliers as well as manufacturers of adhesives and sealants such as H.B Fuller (Minnesota, USA), Henkel AG & Co. KGaA

(Germany), The Dow Chemical Company (United States), and Sika AG (Switzerland), among others. Growth in the industrial adhesives market is primarily due to increased demand for industrial adhesives from construction and woodworking, packaging, pressure sensitive products, and transportation, among other end-use industries.

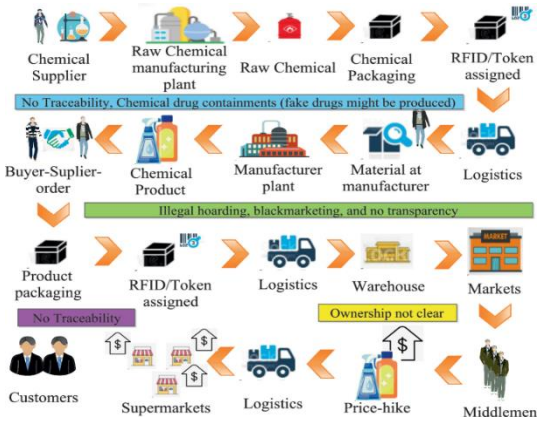

Fig. 2. Overview of Supply Chain Management in An Adhesive Production Plant for The Chemical Industry Using RFID Technology (Bhattacharya et al., 2022)

Figure 2 shows an overview of supply chain management in an adhesive production plant for the chemical industry using RFID technology. Knowledge of global supply chain networks suitable for regional characteristics and future growth is essential for supply chain management. Additionally, the scalable process allows companies to quickly integrate new acquisitions and focus on value creation. Automated material planning, labelling, back-ordering, track and trace systems coupled with more accurate sales and operations planning improve full-on-time delivery with lower working capital costs and with higher customer satisfaction (Khan et al., 2023).

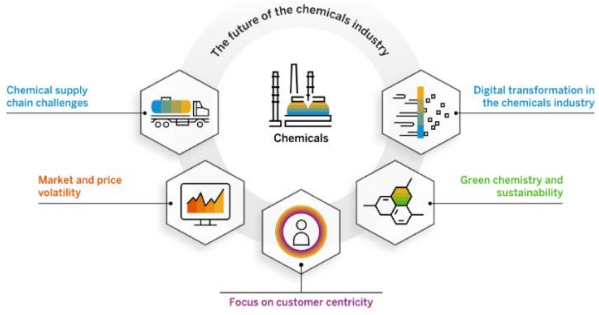

Fig. 3. 5 Key Success Factors for Future Supply Chain Management in the Chemical Industry (own data)

With the advancement of globalization, it is becoming increasingly clear that supply chains must incorporate resilience to gain a sustainable competitive advantage. The interrelated imperatives of resistance to disruption and continuity in evaluating and selecting supplier performance have become a serious strategic issue. In recent years, environmental pressures have made supply chain and its management critical for organizations to remain competitive in the marketplace. However, a company's supply chain

is exposed to many more risks, including those posed by nature, people and technology. These risks include pandemics, floods, earthquakes, transportation accidents, labour strikes and terrorist attacks. These disasters lead to supply chain disruptions, which cost organizations through loss of productivity, revenue, competitive advantage, profitability, etc. To protect buyers from shortages and disruptions, it is important to implement a robust supply chain strategy for supplier selection (Liu et al., 2019).

Large warehouse companies have higher levels of requirements for warehouse automation and information. Warehousing management is not a simple storage of commodities, but a comprehensive information management of goods entering and leaving the warehouse, storage, circulation and other links. Large warehousing enterprises require real-time monitoring of the commodity storage environment, automatically adjusting the storage environment to ensure the best storage conditions for goods. Incoming, outgoing, weighing, inventory and other business can be controlled automatically and product information can be collected in real time (Hamadneh et al., 2021).

The potential improvement in the performance of logistics processes due to the introduction of RFID technology is well known and, in the literature, it is possible to find many examples of RFID technology being successfully adopted in supply chains, from the production site to the hands of the final consumer. However, currently RFID technology has not been widely adopted among many companies that play an important role in strategic supply systems, due to implementation costs and difficulties in calculating benefits without first developing pilot projects, which often have costs that cannot be ignored both in terms of both time and money. RFID makes it possible to detect human errors and adopt corrective actions aimed at limiting monetary and time losses. Each RFID setting determines the amplitude of the time interval that elapses between when a fault occurs and when it is detected. If the time interval is small, corrective action will be implemented immediately and the consequences of errors will be reduced (Giusti et al., 2019).

This study presents a smart adhesive manufacturers plant design, conduct strategic planning analysis of internal and external factors using the Strengths, Weaknesses, Opportunities and Threats (SWOT) and Political, Economic, Social, Technological, Legal and Environmental (PESTLE) methodologies and finally uses the Supply Chain Operations Reference (SCOR) modelling approach to analyse the performance of the adhesive manufacturing industry. Case studies are a way of combining technical models with reality. At the same time, it is an intuitive method for verifying proposed solutions. Looking at the current problems in smart supply chain management, this article takes one of the large adhesive manufacturing companies in Indonesia that implements smart systems in supply

chain management as an example and combines the actual situation to analyse the problem and its solution, which provides several references to design intelligent adhesive manufacturers plants and analyse supply chain performance.

The papers are further organized as follows: Section 2 reviews the intelligent supply chain performance measurement model, Section 3 describes the research methods, Section 4 describes the results and discussion, Section 5 summarizes the research conclusions, and Section 6 offers recommendations for future research on improving intelligent supply chain performance for industrial adhesive manufacturers.

METODE PENELITIAN

Figure 4 shows the flowchart of the research stages to be carried out.

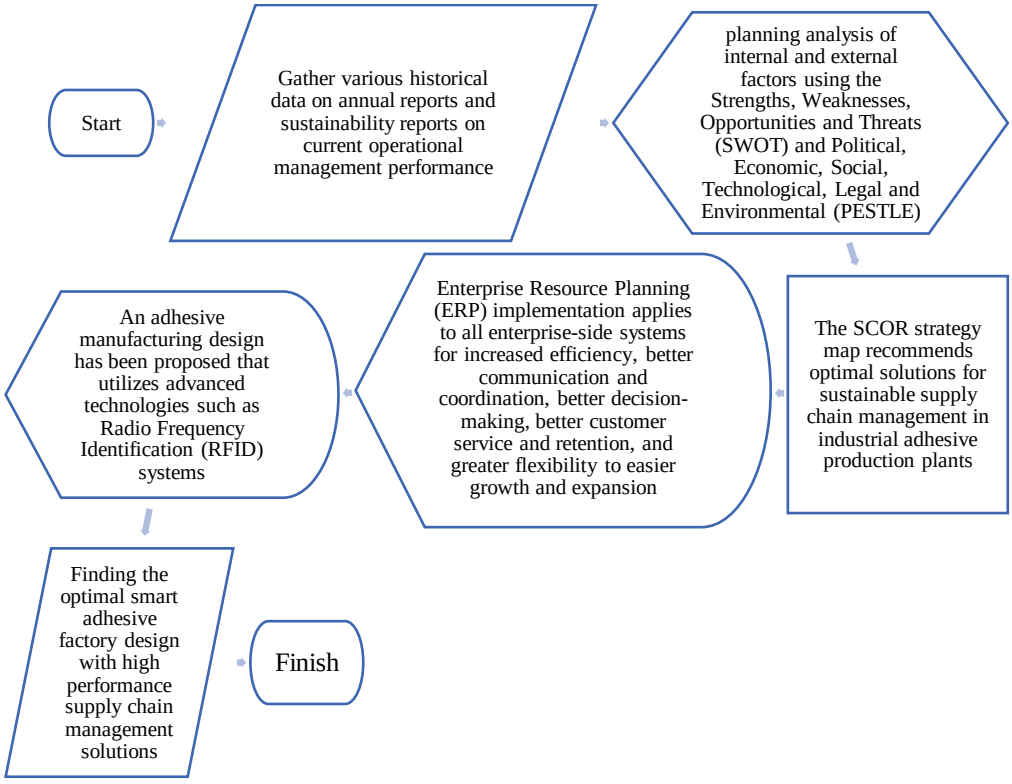

Fig. 4. Research Flowchart

In this work, we take the example of a leading adhesives manufacturer in Indonesia that has implemented a smart system in its supply chain management. It focuses on case studies that incorporate real-world situations to solve problems and analyze their solutions. Provides reference for designing smart adhesive manufacturing plants and analyzing supply chain performance using the Supply Chain Operations Reference (SCOR) model.

We apply framework solutions in multiple dimensions, minimizing external weaknesses and threats from business scenarios. Models can be used to strengthen strategy, create business, organization for planning, controlling and operating unit functions including the delivery of quality products and services for integrated projects involving multiple industries

and diverse supply chain systems.

HASIL DAN PEMBAHASAN

Data was obtained for a period of 1 year, namely 2022. There are 22 Key Performance Indicators (KPIs) which are grouped into 5 core business process dimensions, namely plan, source, make, delivery, and return. The KPIs hierarchical structure from level 1 to level 3 can be seen in Figure 5.

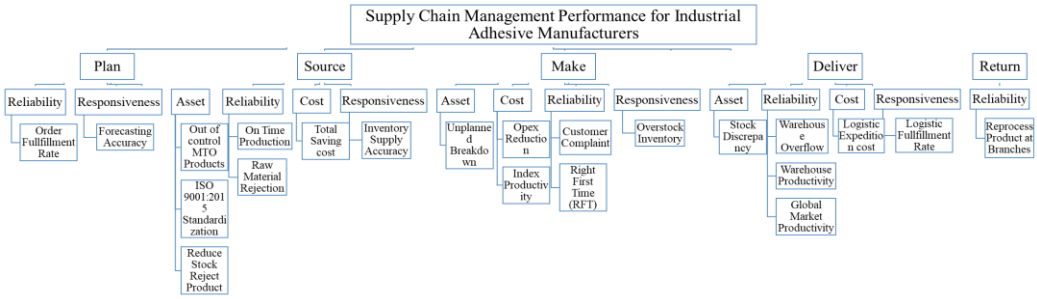

Fig. 5. SCOR Analysis Level 1 to Level 3 for Industrial Adhesive Factory

Then the SCOR calculation of the performance index is carried out based on the results of the predetermined weighting. SCOR KPIs are determined by calculating the absolute value of each metric in each area. Each indicator has a different absolute value and needs adjustment or normalization. In this study, normalization was carried out using the Storm-de-Boer formula, which agreed that the highest power value was 100 and the lowest was 0.

After knowing the value of the scoring system for each performance indicator, calculations will be carried out to find the value of each dimension using the final result which will be multiplied by the weight of each aspect. The weight of each aspect is taken from the results of calculating the second level weighting coefficient data which has been calculated in the previous calculation using the AHP principle. The calculation results are shown in Table 1.

Table 1. Value Each Core Process

Core Process (Level 1)	Weigh t	Sub-Core Dimension Process (Level 2)	Total score for each dimension	Weight	Weight x Score	Total Score for Each Core Process	
Plan	0,267	Reliability	0,886	0,353	0,313	Plan	0,490
		Responsiveness	0,389	0,324	0,126		
		Asset	0,159	0,324	0,051		
Source	0,244	Reliability	0,833	0,361	0,301	Source	0,795
		Cost	1,000	0,333	0,333		

		Responsiveness	0,497	0,324	0,161		
Make	0,244	Asset	1,000	0,238	0,238	Make	0,712
		Cost	1,000	0,238	0,238		
		Reliability	0,677	0,262	0,177		
		Responsiveness	0,223	0,262	0,058		
Deliver	0,156	Asset	1,000	0,214	0,214	Deliver	0,897
		Reliability	0,693	0,238	0,165		
		Cost	1,000	0,286	0,286		
		Responsiveness	0,886	0,262	0,232		
Return	0,089	Reliability	0,287	1,000	0,287	Return	0,287

From Table 2, the final values for each dimension are generated. Furthermore, the final value is used to calculate the company`s performance value by multiplying the final dimension value with the weight on the perspective taken from the perspective weight calculation results at level 1. The results of calculating the performance value can be seen in Table 2. The results obtained from company performance are 72. Where is the number included in the medium rating scale.

Table 2. SCOR Final Score Analysis

Core Process (Level 1)	Weight	Score	Weight x Score
Plan	0,2667	0,49	0,13
Source	0,2444	0,80	0,19
Make	0,2444	0,71	0,17
Deliver	0,1556	0,90	0,14
Return	0,0889	0,90	0,08
Total			72%

Based on the Table 3 below, the largest Gap between the ideal value and actual performance is in the Plan dimension, which is 13.59%. The second largest Gap is in the Make dimension, which is 7.04%, and for the Source Gap dimension, it is 5.01%. These three core business processes, namely the plan dimension, make dimension, and source dimension, need attention and become the main focus in system improvement to improve overall company performance so that it meets international standards and can sell products overseas.

Table 3. SCOR Gap Analysis

Core Process (Level 1)	Ideal	Actual	Gap
Plan	0,2667	0,13	13,59%
Source	0,2444	0,19	5,01%
Make	0,2444	0,17	7,04%
Deliver	0,1556	0,14	1,60%
Return	0,0889	0,08	0,91%

Based on the results of Table 4 below, on the plan dimension, the KPIs with the biggest gap is forecasting accuracy, followed by ISO 9001:2015 standardization, out of control MTO products, reduce stock reject product, and order fullfillment rate. By reducing the gaps in these plan dimensions, performance will improve, consequently improving the performance of the supply chain as a whole.

Table 4. Plan Dimension Gap Analysis

Dimension	KPIs	Ideal	Actual	Gap
Plan	Order Fullfillment Rate	1,00	0,886	0,114
	Forecasting Accuracy	1,00	0,389	0,611
	Out of control MTO Products	0,29	0,030	0,255
	ISO 9001:2015 Standardization	0,46	0,089	0,375
	Reduce Stock Reject Product	0,25	0,039	0,211

Based on the results of Table 5 below, on the make dimension, the KPIs with the biggest gap is overstock inventory, followed by customer complaint. By reducing the gaps in these make dimensions, performance will improve, consequently improving the performance of the supply chain as a whole.

Table 5. Make Dimension Gap Analysis

Dimension	KPIs	Ideal	Actual	Gap
Make	Unplanned Breakdown	1,00	1,00	0,00
	Opex Reduction	0,46	0,46	0,00
	Index Productivity	0,54	0,54	0,00
	Customer Complaint	0,54	0,22	0,32
	Right First Time (RFT)	0,46	0,46	0,00
	Overstock Inventory	1,00	0,22	0,78

Based on the results of Table 6 below, on the source dimension, the KPIs with the biggest gap is inventory supply accuracy, followed by on time production. By reducing the gaps in these source dimensions, performance will improve, consequently improving the performance of the supply chain as a whole.

Table 6. Source Dimension Gap Analysis

Dimension	KPIs	Ideal	Actual	Gap
Source	On Time Production	0,43	0,27	0,167
	Raw Material Rejection	0,57	0,57	0,000
	Total Saving Cost	1,00	1,00	0,000
	Inventory Supply Accuracy	1,00	0,50	0,503

Based on the results of the analysis calculations that have been carried out in Table 2, the final total score of the adhesive manufacturing industry company reviewed as a case study in this study is 72. So, based on the criteria for determining the standard performance indicator score from the SCOR model version 12.0 model in Table 7, it is categorized as companies that have "Good" performance, namely in the range of 70-90.

Table 7. Key Performance Indicator (KPIs) Score Criteria

Score	Key Performance Indicator
< 40	Poor
40 - 50	Marginal
50 - 70	Average
70 - 90	Good
>90	Exellent

These results indicate the need for improvement to improve KPIs performance in the company by providing recommendations for proposed solutions which will be explained in Table 8 and Figure 8.

Table 8. Supply Chain Management Performance Improvement Strategy for Industrial Adhesive Manufacturers

Number	KPIs Code	Key Performance Indicators	Proposed Strategy	Strategy Code
1	PR	Order Fulfillment Rate	Evaluate global market demand	P-1
2	PRe	Forecasting Accuracy	Production machine performance optimization	P-2
3	PA-1	Out of control MTO Products	Implementing controlled MTS (Make to Stock)	P-3
4	PA-2	ISO 9001:2015 Standardization	Improve product quality standards	P-4

5	PA-3	Reduce Stock Reject Product	Do Double Check by QC	P-5
6	SR-1	On Time Production	Increase production speed	S-1
7	SR-2	Raw Material Rejection	Increase supplier loyalty	S-2
8	SRe	Inventory Supply Accuracy	Improve delivery timeliness	S-3
9	SC	Total Saving Cost	Increase profit	S-4
10	MR-1	Customer Complaint	Open customer service	M-1
11	MR-2	Right First Time (RFT)	Implementing Lean Six Sigma	M-2
12	MRe	Overstock Inventory	Make Inventory Forecasting	M-3
13	MC-1	Opex Reduction	Identify production cost inefficiencies	M-4
14	MC-2	Index Productivity	Perform routine KPI measurements	M-5
15	MA	Unplanned Breakdown	Create a Schedule Management Plan	M-6
16	DR-1	Warehouse Overflow	Implementing Multi-stop, Routing, and Live tracking in the delivery of all goods distribution processes	D-1
17	DR-2	Warehouse Productivity	Increase worker productivity	D-2
18	DR-3	Global Market Productivity	Increase sales target every year	D-3
19	DRe	Logistic Fulfillment Rate	Collaborate with Third Party Logistics (3PL)	D-4
20	DC	Logistic Expedition cost	Implementing cargo shipping to streamline shipping costs	D-5
21	DA	Stock Discrepancy	Integration Enterprise Resource Planning (ERP) System	D-6
22	RR	Reprocess Product at Branches	3R System (Reuse, Reduce, Recycle) for material components that can still be recycled	R-1

Hopefully this mind map strategy is useful and can be applied in the adhesive

manufacturing industry. After the proposed strategy is implemented, the company's KPI performance can be recalculated so that it can be seen how much influence the improvement policy has on the company's performance results in order to meet Total Quality Management standards and adopt the development of renewable technology automation in the industrial sector.

Smart Adhesive Manufacturers Plant Design Every manufacturing process, whether fully human or fully automated, needs to be monitored to keep it under control, efficient and safe. As a result, the focus of IoT project efforts in this industrial sector should be on monitoring operations at all levels and collecting pertinent data from machines or assets that are supposed to be stand-alone pieces of equipment that cannot coordinate and manage their own processes. However, contact and communication between the means of production improves the process more than increasing monitoring and control capacities. The smart factory production approach enables real-time upgrades, which quickly leads to optimization of production cycles. Also, the more automated and manageable a process is, the less likely it is for human error to occur. By reducing downtime and maintenance costs, this not only increases productivity but also improves the quality of the final product.

Figure 7 below is an overview of the smart adhesive manufacturer plant design proposed in our research.

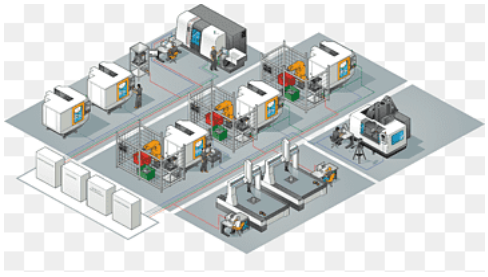

Fig. 6 Smart Adhesive Manufacturers Plant Design

The collection and analysis of data, which enables the full realization of the potential of people, resources and equipment, is an important idea in the concept of Factory 4.0. In smart factories, data can be sent to the right place at the right time in the production chain without the help of human supervisors. By sharing information for free, it enables devices to communicate more quickly and effectively. However, to achieve this, data from different production contexts must not only be obtained, but also aggregated and assessed to generate informative insights. This can be done using the powerful Factory 4.0 data analytics environment, potentially leading to the development of an extensive set of countermeasures.

Modern ERP implementations or upgrades can significantly disrupt business operations, cause organizations to lose focus, or even “break” operational procedures that

businesses deem critical to their success. As scary as it may seem, the productivity gains and increased business that your company will lose far outweigh the costs and dangers. The company will be strategically affected by modernization. It will be difficult or perhaps impossible to support new business models and benefit from the increased KPIs that accompany a successful ERP implementation without access to contemporary ERP systems. Modern ERP systems aim to unite your workforce under a common goal. This requires a significant cultural transformation in the company as a whole. The Internet of Things (IoT) and technologies such as RFID, which allow objects such as components, parts and products to be connected in real-time via radio waves with manufacturing systems implemented in the cloud, will become key components of future smart factories. The plan is for each item to have a unique Internet protocol (IP) address. Figure 14 below illustrates the smart connection scheme in the process of entering and leaving goods.

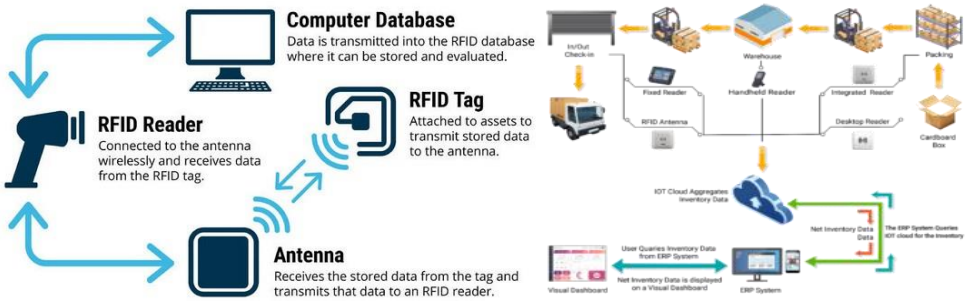

Fig. 7 Smart Connection Scheme in the Process of Entering and Leaving Goods

Ultra-high frequency (UHF), which was introduced to RFID technology after starting with low frequencies and progressing to higher frequencies throughout the 1980s and 1990s, allows for a much greater scanning range (up to 19.7 feet under ambient conditions and faster data transfer. Despite its effectiveness in many applications, such as card payment solutions and car anti-theft systems, RFID technology has not been implemented as quickly or as widely as might be expected. The two main reasons for this are the cost of the tag and the lack of international RFID standards with smart contactless systems. The RF and EPC Tag Information Service (EPCIS) has an electronic product code (EPC) developed by GS 1 which is the organization responsible for bar code standards. Figure 15 below is an illustration of the end-to-end goods distribution flow by utilizing the radio frequency identification (RFID) system.

Fig. 8 End-To-End Goods Distribution Flow by Utilizing the Radio Frequency Identification (RFID) System

Manufacturers looking to maximize the potential of their assets, personnel skills and time to gain a competitive advantage must seek intelligent factory solutions. It is true that developing a Factory 4.0 as a reality involves money, work and planning. However, in the long term, early adopters will be at the forefront of the Factory 4.0 revolution and will benefit from smart factory solutions that are properly implemented taking into account all the potential benefits of fully automated and intelligent factories.

SIMPULAN

We apply framework solutions in multiple dimensions, minimizing external weaknesses and threats from business scenarios. Models can be used to strengthen strategy, create business, organization for planning, controlling and operating unit functions including the delivery of quality products and services for integrated projects involving multiple industries and diverse supply chain systems. From the results and discussion using the SCOR model, the company's performance value of 72 can be categorized as "Good" considering the entire supply chain process.

The plan performance score is 49 which can be categorized as "Marginal". Performance improvement can be done through improving planning techniques using technological innovations, for example software that can assist in internal communication aspects if there is a sudden change in adhesive manufacturing to create an integrated communication network between the parties involved in the adhesive manufacturing industry supply chain processes including with suppliers.

Finally, we propose an intelligent plant planning system for adhesive manufacturers based on radio frequency identification (RFID) and sensor inventory system technology. In addition, we have introduced enterprise resource planning (ERP) into the financial statements of all companies involved in technology-based adhesive production. A cloud computing database system that can be recommended as a solution proposal. Of course, a good forecasting system not only increases the efficiency of supply chain management in the adhesives industry, but also reduces inventory inaccuracies and avoids overstocking. The use of cutting-edge development technology is essential to improve operational efficiency, brand image and competitiveness. If an internal improvement system is established to improve the overall performance of the enterprise, comply with international standards and enable the product to be sold abroad.

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