Six_Sigma_Implementation_and_Analysis___An_Empiric

by Yugowati Praharsi

Submission date: 28-Apr-2022 01:00PM (UTC+0700)
Submission ID: 1822602367
File name: 880.pdf (1.84M)
Word count: 4175
Character count: 21524

Six Sigma Implementation and Analysis - An Empirical Study of a Traditional Boat Building Industry in Indonesia

Yugowati Praharsi, Mohammad Abu Jami'in, and Gaguk Suhardjito
Shipbuilding Institute of Polytechnic Surabaya (Politeknik Perkapalan Negeri Surabaya)Jl. Teknik Kimia, Kampus ITS, Sukolilo 60111, Surabaya, Indonesia
yugowati@ppns.ac.id, jammy@ppns.ac.id

Hui-Ming Wee
Chung Yuan Christian University
Chung Pei Road No. 200
Chung Li City 32023, Taiwan
weehm@cycu.edu.tw

Abstract

There are several traditional boat building industries in East Java, Indonesia. However, the performance of these industries has not been measured yet. We aim to measure and boast the performance of traditional boat building industries using Six Sigma. The results showed that the existing performance measured by sigma value is 2.84. There are some critical factors to quality such as: the error of cutting, crack due to assembly, and crack due to burning for wood bending. Analyzing the potential causes by fishbone diagram and ranking it by risk priority number values, we propose some improvements such as: developing facilities of automatic machines, sorting material at the time of purchasing, creating training program for burning and assembly, and brainstorming with some experts especially in wood bending.

Keywords: traditional boat, boat building industry, performance, Six Sigma, Indonesia

1. Introduction

Traditional boat building has been widely spread in East Java, Indonesia. Ministry of Research, Technology, and Higher Education has planned Surabaya city and three regencies such as Lamongan, Tuban, and Gresik as a cluster of boat building in East Java (Praharsi et al, 2018). There are several traditional shipyards in those areas. However, the performance measurement of these traditional shipyards has not been conducted yet.

There are some literatures related to performance measurement. Garza-Reyes et al. (2016) found that the lean six sigma framework improves the capability of ship loading process and commercial time for more than 30% and cost savings in the range of $300,000 USD per year. Cherrafi et al (2017) built a framework consists of five stages and sixteen steps to integrate and implement green, lean six sigma to improve company performances. Ridwan and Noche (2018) measured the port performance using the sigma value, the process capability indices, and the cost of poor quality. Zu et al (2011) examined the implementation of Total Quality Management and Six Sigma practices at companies in China. The results showed that there were no significant differences of implementing Total Quality Management and Six Sigma practices in terms of company size, industry, ownership, and process type.

This study is motivated by their initiatives. We aim to measure the performance of traditional shipyard in East Java by using Six Sigma. Six sigma is a statistical technique focused on eliminating defects and reducing process variability. There are some stages in implementing Six Sigma, such as define, measure, analyze, improvement, and control. Define stage identifies what product or process will be repaired or what resources will be needed in project implementation. In this stage, the critical to quality from repaired product or process is determined. Measurement stage is used to identify process capability or the performance of production process. Indicator used in this stage is defect per unit. Analyze stage explores the reason why deviation between plan and action happened and identifies possible root causes of the problem. Improvement stage identifies, implements, and validates corrective actions to resolve any problem. Finally, control stage supports and maintains the action of improvement stage, so the process will not step back to its previous state. It is expected that we can boost the performance of traditional boat building industry by implementing Six Sigma.

The remaining of this paper is organized as follows. Section 2 presents research methodology. Section 3 discusses the implementation of six sigma using define, measure, analyze, improvement and control stages. Finally, Section 4 presents the conclusions, limitations, and future research directions derived from this paper.

2. Research Methodology

The research methodology is shown by Figure 1.

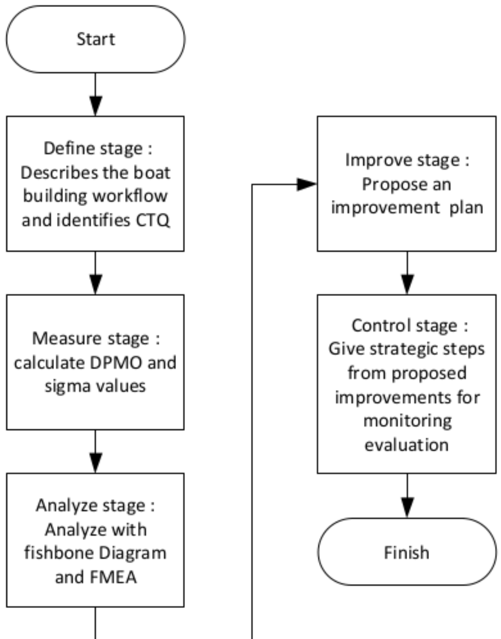

Figure 1. Research methodology

Based on Figure 1, the research was started by brainstorming to describe the traditional wooden boat building process which then was continued by identifying CTQ (Critical To Quality) that occurred during the boat building process. Subsequently, the calculation of DPMO (Defects Per Million Opportunities) was done which then was converted into a sigma value as a current parameter assessment of the boat building process. In the analyzing stage, the results of CTQ identification were analyzed using a fishbone diagram to find out the root cause of the problem which then was assessed by the RPN (Risk Priority Number) using FMEA (Failure Mode and Effect Analysis). Furthermore, in the improving stage, the design of the proposed improvement was given based on the results of the highest RPN assessment and followed by the controlling stage which provided strategic steps from the proposed improvements to do the evaluation and monitoring. In addition, we surveyed 4 traditional shipyards and 34 boats building. The study is conducted during period June-July, 2019.

3. Result and Discussion

3.1 *Define* Stage

The flow of traditional wooden boats building is described as in Figure 2 (Praharsi et al. 2019).

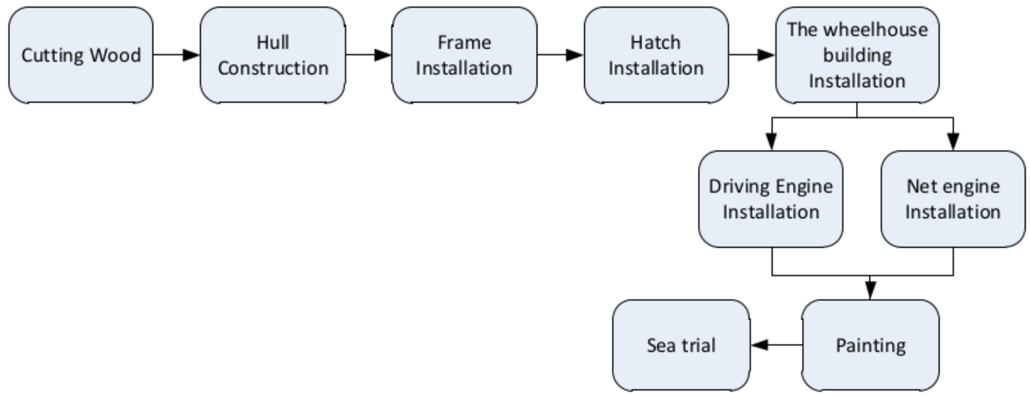

Figure 2. The building process of traditional fishing boats

From the Figure 2, it could be identified the CTQ that occurred during steps of the Hull construction, Frame Installation, Hatch Installation, and the wheelhouse building installation, were the Error of cutting, Crack due to assembly, and Crack due to burning for wood bending.

3.2 *Measurement* Stage

In this measurement stage, the process capability of traditional boat building is measured based on data of the wood usage efficiency using DPMO tools.

The results of the DPMO calculation and the sigma values from 34 boats are shown in Table 1.

Table 1 DPMO calculation and sigma values

Boat size (Gross Tonnage)	Total Amount of Woods (m^3)	Amount of Wood Usage (m^3)	Amount of Defect (m^3)	DPMO	Sigma
16	15	10.75	4.25	94444.44	2.8138732
22	32	22.93	9.07	94444.44	2.8138732
31	55	40.15	14.85	90000	2.840755
38	50	39.17	10.83	72222.22	2.9594385
48	65	46.58	18.42	94444.44	2.8138732
59	70	50.17	19.83	94444.44	2.8138732
64	75	53.75	21.25	94444.44	2.8138732
30	40	29.11	10.89	90740.74	2.8362074
30	42	29.17	12.83	101851.9	2.7710701
30	42	31.03	10.97	87037.04	2.8592289
44	60	47.00	13.00	72222.22	2.9594385
53	63	45.15	17.85	94444.44	2.8138732
54	70	50.17	19.83	94444.44	2.8138732
63	70	52.97	17.03	81111.11	2.8976366
25	40	29.11	10.89	90740.74	2.8362074
1	5	3.75	1.25	83333.33	2.8829941
34	40	28.67	11.33	94444.44	2.8138732
72	100	75.48	24.52	81746.03	2.8934225
5	11	8.62	2.38	72222.22	2.9594385
42	83	58.69	24.31	97619.05	2.7952381
1	4.5	3.30	1.20	88888.89	2.8476289

Boat size (Gross Tonnage)	Total Amount of Woods (m^3)	Amount of Wood Usage (m^3)	Amount of Defect (m^3)	DPMO	Sigma
58	60	42.43	17.57	97619.05	2.7952381
38	50	34.72	15.28	101851.9	2.7710701
6	8	5.73	2.27	94444.44	2.8138732
55	45	31.82	13.18	97619.05	2.7952381
14	24.79	17.77	7.02	94444.44	2.8138732
4	11.49	8.23	3.26	94444.44	2.8138732
5	12.82	9.19	3.63	94444.44	2.8138732
2	8.83	6.92	1.91	72222.22	2.9594385
25	39.42	29.13	10.29	87037.04	2.8592289
4	11.49	8.23	3.26	94444.44	2.8138732
2	8.83	6.62	2.21	83333.33	2.8829941
40	39	28.38	10.62	90740.74	2.8362074
11	25	18.75	6.25	83333.33	2.8829941
Average	40.505	29.52	10.99	89743.23	2.84

From the results of the DPMO calculation and the sigma value in Table 1, it can be concluded that the capability of the traditional ship building process that has been interpreted in one million opportunities exist, there will be 89743.23 possible failure of the traditional ship building process with sigma value of 2.84

3.3 *Analyze* Stage

In this analyze stage, we analyze the root cause of CTQ such as: the error of wood cutting, the crack at the assembly process, and the crack at wood bending using fishbone diagrams.

3.3.1 *Fishbone* Diagram

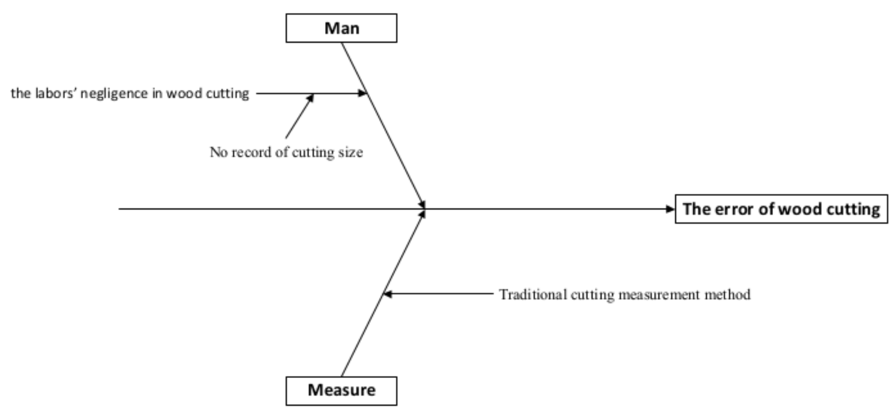

Figure 3. Fishbone diagram of the error of wood cutting

The first critical factor to quality is the error of wood cutting. Based on the analysis of the error of wood cutting as shown in Figure 3, the root cause of the problem are known as follows:

1. Man: Related to the labors who were still negligent in the wood cutting process. Based on the results of the interview, it was known that the main cause of the labors' negligence in wood cutting was due to the no record of the wood cutting size to be carried out.

2. Measure: Related with the traditional wood cutting method that was still carried out, so that it caused frequent cutting errors.

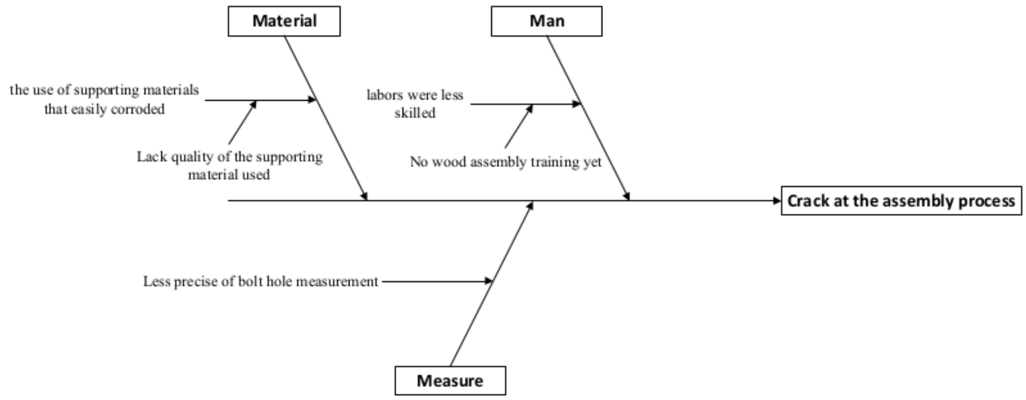

Figure 4. Fishbone diagram of the crack at assembly process

The second critical factor to quality is the crack at assembly process. Based on the analysis of the crack at assembly process as shown in Figure 4, the root cause of the problem are identified as follows:

1. Man: Related to the labors who were less skilled in the wood assembling process. Based on the results of interviews that had been conducted, it was known that the main cause of labors' less skill was because there was no wood assembly training program conducted by the traditional shipyard.
2. Material: Related to the use of supporting materials that easily corroded. Based on the results of interviews that had been conducted, it was known that the main cause of the easily corroded materials was due to the quality of the supporting material used which less good.
3. Measure: Related to the bolt holes measurement method that was less precise, causing frequent cracks during the wood assembling process.

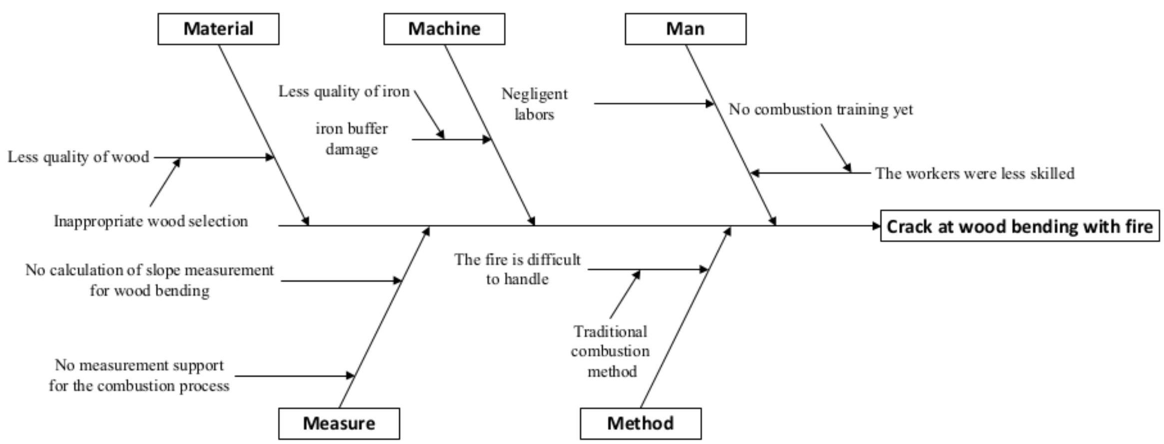

Figure 5. Fishbone diagram of the crack at wood bending with fire

The third critical factor to quality is the crack at wood bending with fire. Based on the analysis of the crack at wood bending with fire as shown in Figure 5, the root cause of the problem are discussed as follows:

1. Man: Related to labors who were less skilled in combustion process. Based on the results of interviews that had been conducted, it was known that the main cause of labors' less skill was due to the no burning training

program conducted by the shipyard. In addition, labors were also often found negligent in carrying out their duties that causing cracks during the combustion process.

2. Machine: Related to the damage of the iron buffer used in combustion process. Based on the results of interviews that had been conducted, it was known that the main cause of iron buffer damage was because of the lack quality of iron.
3. Material: Related to the low quality wood. Based on the results of interviews that had been conducted, it was known that the main cause of low quality wood was due to the quality selection from the appropriate wood material.
4. Method: Related to the combustion fire which difficult to control. Based on the results of interviews that had been conducted, it was known that the main cause of that problem, because the combustion method used was in traditional mode.
5. Measure: Related to the absence of measurement support for the combustion process and the slope measurements calculation for the wood bending process, which caused frequent cracks during the combustion process.

3.3.2 FMEA Method

After identifying the root cause using fishbone, the further step was to do an RPN assessment using the FMEA method. The data used in the RPN calculation was the assessment result of the questionnaires distribution related to how much impact was felt from the causes, the frequency of causes' occurrence, and the detection of causes that were interpreted into numerical units using the formula:

RPN = S x O x D

Table 2 was the result of RPN calculation from each potential failure mode in the waste of error cutting, cracking due to assembly, and cracking due to burning.

Table 1 Table of FMEA

Potential Failure Mode	Causes	RPN Value Resp.1	RPN Value Resp.2	RPN Value Resp.3	Total Average of RPN
Cutting Error	No record of cutting size	3	224	30	85.7
	Traditional cutting measurement method	8	35	4	15.7
Assembly *Crack*	No wood assembly training yet	96	40	4	46.7
	Lack quality of the supporting material used	162	48	20	76.7
	Less precise of bolt hole measurement	9	42	6	19
Combustion *Crack*	No combustion training yet	140	5	504	216
	Negligent labors	8	40	6	18
	Less quality of iron	40	48	35	41
	Inappropriate wood selection	252	120	8	126.7
	Traditional combustion method	16	25	1	14
	No measurement support for the combustion process	189	54	10	84
	No calculation of slope measurement for wood bending	48	315	560	307.7

Based on the results of the RPN calculation value in Table 2, it can be recommended to prioritize the problems handling to be solved at the two highest RPN values of each type of waste as shown in Table 3.

Table 3. The two highest RPN values in each failure mode and its causes

Potential Failure Mode	Causes	Average RPN Value
Cutting Error	No record of cutting size	85.7
	Traditional cutting measurement method	15.7
Assembly *Crack*	Lack quality of the supporting material used	76.7
	No wood assembly training yet	46.7
Combustion *Crack*	No calculation of slope measurement for wood bending	307.7
	No combustion training yet	216

3.4 *The Improvement* Stage

After obtaining the root causes of the priority issues to be repaired, at this stage the proposed improvements were made at the two highest RPN values. Proposed improvements that could be given to the cause of the problem were shown in Table 4.

Table 4. The proposed improvement in each failure mode

Potential Failure Mode	Causes	Average RPN Value	Proposed Improvements
Cutting Error	No record of cutting size	85.7	Making record on work
	Traditional cutting measurement method	15.7	Developing the facility
Assembly *Crack*	Lack quality of the supporting material used	76.7	Sorting in a time of material purchasing
	No wood assembly training yet	46.7	Making an assembly training program for labors
Combustion *Crack*	No calculation of slope measurement for wood bending	307.7	Doing the Brainstorming together with experts
	No combustion training yet	216	Making combustion training program for labors

3.5 *The Control* Stage

The last stage in the six sigma series is the control stage. The following data below are concrete steps in applying proposed improvements based on the two highest RPN values for each type of waste:

1. Making a work record: shipyard's recording can be done using the help of a notebook or Ms. Excel by making a size chart. So that, when doing the cutting process, labors will not forget the size should be cut. This is the example of simple tables for wood cutting sizes:

No	Cutting Model	Length	Width	Height
1	Square Cutting	60cm	15cm	200cm

2. Developing facilities: one of the proposals that can be given for the traditional wood measurement method that is to develop measurement facilities using measuring aids such as angle gauges, roll meters, elbows, screw micrometers, and calipers. If the company's ability is adequate, companies can use measurement facilities with automatic machines such as CNC (Computer Numerical Control) machines. With this CNC machine, the company can directly enter the desired cut size, and automatically the wood or material will be cut perfectly.
3. Sorting at the time of purchasing the material: to reduce the risk of the material quality used is not good, so the proposal that can be given is by sorting at the time of material purchase. Sorting can be done on the quality of materials, material prices, or even the ease of the shipyard in obtaining the material.
4. Making assembly training programs for labors: based on the cause of the problem there was no assembly training for labors, then the proposal that can be given is to attend an assembly training program on the workforce. This training program aims to standardize the ability or knowledge of the labors from beginner, medium, and expert labor in assembly process. The training program can be in the form of seminars, certifications, and knowledge sharing together with experts in boat assembly.
5. Brainstorming with experts: to be able to determine the calculation of the slope measurement of the wood bending process, the shipyard can work together with experts in the field of wood bending for boat building to do brainstorming related to the determination of calculations that can later be used by the shipyard, so cracks do not occur again during the combustion process.

6. Creating a burning training program on labors: based on the causes of the problem in the absence of burning training on labors, so the proposal that can be given is to take part in a burning training program for labors. This training program aims to standardize the ability or knowledge of the labors both beginner, medium, and expert in combustion process. The training program can be in the form of seminars, certifications, and knowledge sharing together with experts in boat assembly.

4. Conclusion and Implications

We have implemented six sigma measured the performance of traditional boat building industry in East Java, Indonesia. The existing performance shows the sigma value of 2.84. It was found that there were 3 CTQ, such as: the error of cutting, crack due to assembly, and crack due to burning for wood bending. These main problems were analyzed using fishbone diagram. The results showed that the potential causes of cutting error are no record of cutting size and traditional cutting measurement method. Meanwhile, the potential causes of assembly crack are lack quality of the supporting material used and no wood assembly training yet. Finally, the potential causes of combustion crack are no calculation of slope measurement for wood bending and no combustion training yet. Several improvements are proposed ranked by RPN values such as: developing facilities of automatic machines, sorting material at the time of purchasing, creating training program for burning and assembly, and brainstorming with some experts. We expect that in control stage, the proposed improvement are monitored and evaluated so that the boat building industry performance can be boasted through six sigma.

5. References

Praharsi, Y., Jami'in, M. A., Suhardjito, G., and Wee, H.-M., Product quality characteristics for the standardization of traditional boats in East Java, Indonesia, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Pretoria/Johannesburg, South Africa, October 29th -November 1st, 2018.

Praharsi, Y., Jami'in M.A., Suhardjito, G., and Wee, H.-M., Modeling a traditional fishing boat building in East Java, Indonesia, *Ocean Engineering*, Vol. 189, Available: https://doi.org/10.1016/j.oceaneng.2019.106234, 1 October 2019.

Garza-Reyes, J.A., Al-Balushi, M., Antony, J., and Kumar, V., A lean six sigma framework for the reduction of ship loading commercial time in the iron ore pelletising industry, *Production Planning and Control*, Vol. 27, No. 13, 2016.

Cherrafi, A., Elfezazi, S., Govindan, K., Garza-Reyes, J.A., Benhida, K., and Mokhlis, A., A framework for the integration of green and lean six sigma for superior sustainability performance, *International Journal of Production Research*, Vol. 55, No. 15, pp. 4481-4515, 2017.

Ridwan, A., and Noche, B., Model of the port performance metrics in ports by integration six sigma and system dynamics, *International Journal of Quality and Reliability Management*, Vol. 35, No. 1, pp. 82-108, 2018.

Zu, X., Zhou, H., Zhu, X., and Yao, D., Quality management in China: the effects of firm characteristics and cultural profile, *International Journal of Quality and Reliability Management*, Vol. 28, No. 8, pp. 800-821, 2011.

Acknowledgement

This research was supported by Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Indonesia under grant Basic Research in 2019, No. 1616.10/PL19/LT/2019.

Biographies

Yugowati Praharsi is an Assistant Professor at Shipbuilding Institute of Polytechnic Surabaya, East Java, Indonesia. She earned B.Sc. in Mathematics from Satya Wacana Christian University, Indonesia; M.Sc in Electronic Engineering and Ph.D in Industrial and System Engineering from Chung Yuan Christian University, Taiwan. She has published national and international journals and conference papers. Her research interests are in the field of operation research, production system, quality management, and supply chain management.

Mohammad Abu Jami'in received the B.E. degree in Marine Engineering and M.E. degree in Control Engineering from Institut Teknologi Sepuluh Nopember (ITS) Surabaya, Indonesia in 2000 and 2008, and the Doctor of Engineering in Neurocomputing from Waseda University, Japan in 2016. He is currently a lecturer with the Politeknik Perkapalan Negeri Surabaya (Shipbuilding Institute of Polytechnic Surabaya), Indonesia. His research interests include artificial intelligence and its applications such as system modeling and control, ship propulsion, renewable energy, and image processing.

Gaguk Suhardjito has received his B.E. degree in Marine Engineering from Institut Teknologi Sepuluh Nopember (ITS) and the Master degree in Management from IBMT School of Management, Surabaya, Indonesia. His research interests include ocean engineering and shipyard management.

Prof. Hui-Ming Wee is a distinguished Professor in the Department of Industrial and Systems Engineering, former Associate Dean and Chaplain at Chung Yuan Christian University (CYCU) in Taiwan. He has received his B.S. degree (honors) from Strathclyde University (UK), M.Eng. from Asian Institute of Technology (AIT), and Ph.D from Cleveland State University, Ohio (USA). He has received an Excellent Research Award from the Taiwan Ministry of Science and Technology, Excellent Life Researcher Award, the Medal for Distinguished Industrial Engineer Award, and Life Distinguished Professor Award. He has published more than 400 papers in refereed journals, international conferences, and book chapters. His papers were cited over 4709 (7778) times in Scopus (Google Scholar) with h-index: 40 (47). He has co-edited seven books and holds two patents; was keynote speaker in a number of International conferences, senior member for Asian Council of Science Editors (ACSE), Board of Directors for International Engineering and Technology Institute (IETI) and Editor/editorial Board member for a number of International Journals. His research interests are in the field of production/inventory control, optimization, logistics, renewable energy, technological singularity, and supply chain risk management.

Six_Sigma_Implementation_and_Analysis___An_Empiric

ORIGINALITY REPORT

15%	12%	11%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Sriwijaya University Student Paper	5%
2	recycling.conferenceseries.com Internet Source	4%
3	Submitted to Universiti Putra Malaysia Student Paper	1%
4	joiv.org Internet Source	1%
5	Submitted to Sheffield Hallam University Student Paper	1%
6	Ivan Darma Wangsa, Hui Ming Wee. "An integrated vendor–buyer inventory model with transportation cost and stochastic demand", International Journal of Systems Science: Operations & Logistics, 2017 Publication	1%
7	derby.aws.openrepository.com Internet Source	<1%

8	Anass Cherrafi, Said Elfezazi, Jose Arturo Garza-Reyes, Khalid Benhida, Ahmed Mokhlis. "Barriers in Green Lean implementation: a combined systematic literature review and interpretive structural modelling approach", Production Planning & Control, 2017 Publication	<1 %
9	International Journal of Quality & Reliability Management, Volume 28, Issue 8 (2011-09-13) Publication	<1 %
10	macrothink.org Internet Source	<1 %
11	duepublico.uni-duisburg-essen.de:443 Internet Source	<1 %
12	Chandra K. Jaggi, Sunil Tiwari, Mamta Gupta, Hui Ming Wee. "Impact of credit financing, storage system and changing demand on investment for deteriorating items", International Journal of Systems Science: Operations & Logistics, 2017 Publication	<1 %
13	www.emerald.com Internet Source	<1 %
14	D. C. Nugroho, Y. Mayaratri, M. Syai'in, M. K. Hasin, N. H. Rohiem, N. P. U. Putra, A Soeprijanto. "Household electricity network monitoring based on IoT with of automatic	<1 %

power factors improvement using neural network method", IOP Conference Series: Materials Science and Engineering, 2021
Publication

15	Fabio Francisco da Silva, Lukas Daniel Filser, Fernando Juliani, Otávio José de Oliveira. "Where to direct research in lean six sigma?", International Journal of Lean Six Sigma, 2018 Publication	<1 %
16	core.ac.uk Internet Source	<1 %
17	archive.ceciis.foi.hr Internet Source	<1 %
18	ieomsociety.org Internet Source	<1 %
19	journal.oscm-forum.org Internet Source	<1 %
20	Karla María Alvarado-Ramírez, Víctor Hipólito Pumisacho-Álvaro, José Ángel Miguel-Davila, Manuel F. Suárez Barraza. "Kaizen, a continuous improvement practice in organizations", The TQM Journal, 2018 Publication	<1 %

Exclude quotes Off
Exclude matches Off

Exclude bibliography On