Institut
Teknologi
Sepuluh Nopember

PROCEEDINGS

6TH INTERNATIONAL CONFERENCE ON OPERATIONS AND SUPPLY CHAIN MANAGEMENT (OSCM)

"Making the world more comfortable, sustainable, and socially responsible: the role of operations and supply chain management."

Sanur Paradise Plaza Hotel, Bali
10-12 December 2014

Organized by:

Industrial Engineering Departement
Faculty of Industrial Technology
Sepuluh Nopember Institute of Technology

LSCM

Organized by: Laboratory of Logistics and Supply Chain Management, Industrial Engineering Department, Institut Teknologi Sepuluh Nopember (ITS) Surabaya - Indonesia

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CONTENT

WELCOME SPEECH FROM CONFERENCE CHAIR

Welcome to the sixth International Conference on Operations and Supply Chain Management. As you all know, this year conference brings a very important theme "Making the world more comfortable, sustainable, and socially responsible: the role of operations and supply chain management ". It is this theme that motivates us to work and contribute to the world. Operations and Supply Chain Management has always been aimed toward better processes, better working environments, more efficient use of resources, more respect toward human life as well as the environment.

This conference is the continuation of the five earlier conferences which were held in Bali (2005), Bangkok (2007), Malaysia (2009), Maldives (2011), and India (2013). This year we are able to attract submissions of more than 200 abstracts from about 35 countries. We did the review in two stages: abstract submission and full paper submission. The number of papers scheduled for presentation is 124 which represent authors from 28 countries. In addition, we also have three keynote speaker sessions and one workshop for young academics and doctoral students. Also, this is the first time we run a forum for PhD program director / coordinator. We are very proud with the quality of submissions and the internationalization of the conference. It is also our aim to enhance the OSCM Forum with the formation of Board Members. The Board Members will set the direction of the forum, give suggestions for organization of future conferences, and supporting the publication of the associated journal "Operations and Supply Chain Management" which is now in its 7th year. It is also our first time giving awards to best reviewers and best papers. Without neglecting the roles of other reviewers and other authors, our aim is to give appreciation to excellent works and contribution of the conference participants.

Finally, I would like to thank all parties that have contributed to this conference. First of all, I would like to thank the three keynote speakers: Professor René B.M. de Koster from Rotterdam School of Management, Erasmus University, The Netherlands; Professor Mahender Singh, the CEO/Rector of Malaysia Institute for Supply Chain Innovation (MISI); and Walter Kuijpers from Deloitte Consulting's SE Asia. My sincere thanks also goes to Professor Suresh Sethi from University of Texas at Dallas, USA and Professor Yossi Aviv from Olin Business School, Washington University, USA who both will give talks in the workshop for doctoral students and emerging scholars. I would also like to thank the supports and participation of the supporting organizations and sponsors. The support from our institution (Institut Teknologi Sepuluh Nopember) is also instrumental to the success of this conference. Finally, to all committee members I would like to thank for the hard work, without which this conference would never be a success.To all participants, have a nice conference and we look forward to your continuing support to OSCM.

Bali, December 2014

Professor Nyoman Pujawan, Ph.D, CSCP
Conference Chair

WELCOME MESSAGE FROM RECTOR OF ITS SURABAYA

On behalf of the Institut Teknologi Sepuluh Nopember (ITS), I welcome the participants to this year Operations and Supply Chain Management (OSCM) Conference. I am truly proud that the Laboratory of Logistics and Supply Chain Management in the Department of Industrial Engineering has managed to organize such a prestigious conference, attracting delegates from various countries. Being Lab-Based Education, this conference is one of the strategies to achieve our vision as a world class research university.

This year conference theme: "making the world more comfortable, sustainable, and socially responsible: the role of operations and supply chain management" is very timely. This conveys a strong message that all of our activities to improve the companies' performance must also consider the quality our environment and social development as well. I believe, with such diverse and large participation, this conference will serve as an effective platform for academics, practitioners, and students to learn, share, and exchange their expertise and insights, especially on how the operations and supply chain management could contribute to maintain the sustainability of our planet.

I congratulate and thank Prof. Nyoman Pujawan, the conference chair and his team from the Department of Industrial Engineering, who have worked tirelessly to make this OSCM 2014 conference possible.

I sincerely hope that this conference will facilitate the establishment of international joint research programs and become a forum for the exchange of research ideas. I wish the conference a grand success.

Surabaya, December 2014

Professor Dr. Triyogi Yuwono
Rector of ITS

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SPONSOR PROFILE

Chevron Indonesia

Chevron is one of the world's leading integrated energy companies. Our success is driven by our people and their commitment to get results the right way—by operating responsibly, executing with excellence, applying innovative technologies and capturing new opportunities for profitable growth. We are involved in virtually every facet of the energy industry. We explore for, produce and transport crude oil and natural gas; refine, market and distribute transportation fuels and lubricants; manufacture and sell petrochemical products; generate power and produce geothermal energy; provide renewable energy and energy efficiency solutions; and develop the energy resources of the future, including research into advanced biofuels.

Company Roots: We trace our beginnings to an 1879 oil discovery at Pico Canyon, north of Los Angeles, which led to the formation of the Pacific Coast Oil Co. That company later became Standard Oil Co. of California and, subsequently, Chevron. We took on the name Chevron when we acquired Gulf Oil Corporation in 1984, which nearly doubled our worldwide proved crude oil and natural gas reserves. Our merger with Gulf was then the largest in U.S. history.Another major branch of the family tree is The Texas Fuel Company, formed in Beaumont, Texas, in 1901. It later became known as The Texas Company and, eventually, Texaco. In 2001, our two companies merged. The acquisition of Unocal Corporation in 2005 strengthened Chevron's position as an energy industry leader, increasing our crude oil and natural gas assets around the world.

Global Scope: Our diverse and highly skilled global workforce consists of approximately 64,500 employees, including more than 3,200 service station employees.
In 2013, Chevron's average net production was nearly 2.6 million oil-equivalent barrels per day. About 75 percent of that production occurred outside the United States. Chevron had a global refining capacity of 1.96 million barrels of oil per day at the end of 2013.
Our marketing network supports retail outlets on five continents.

Technology and Emerging Energy : We focus on technologies that improve our ability to find, develop and produce crude oil and natural gas from conventional and unconventional resources.We also invest in the development of emerging energy technologies, such as finding better ways to make nonfood-based biofuels, piloting advanced solar technology for our operations and expanding our renewable energy resources.

Environment and Safety: As a company and as individuals, we take great pride in contributing to the communities where we live and work.We also care about the environment and are proud of the many ways in which our employees work to safeguard it.Our persistent efforts to improve on our safe work environment continue to pay off. In 2013, we achieved world-class performance in the days-away-from-work metric for both Upstream and Downstream operations.

Our Work: We recognize that the world needs all the energy we can develop, in every potential form. That's why our employees work to responsibly develop the affordable, reliable energy the world needs.

PT. Semen Indonesia (Persero) Tbk.

The Company inaugurated in Gresik on December 7 Agustus1957 by the first President with an installed capacity of 250,000 tonnes of cement per year, and installed capacity in 2013 reach 30 million tons/year. On July 8, 1991 the Company's shares listed on the Jakarta Stock Exchange and Surabaya Stock Exchange (now Indonesia Stock Exchange) and is the first state-owned companies to go public by selling 40 million shares to the public. The composition of the shareholders at the time: State of RI 73% and 27% people.In September 1995, the Company made a Rights Issue I (Right Issue I), which alter the composition of share ownership to the State of RI 65% and 35% people. On June 15 September 1995 by PT Semen Gresik consolidate with PT Semen Padang and PT Semen Tonasa. Total installed capacity of the Company at the time of 8.5 million tons of cement per year.On September 17, 1998, the State of RI off its stake in the Company by 14% through an open offer, which was won by CEMEX S. A. de C. V., a global cement company based in Mexico. Shareholding composition changed to Republic of Indonesia 51%, the 35%, 14% and Cemex. Then on 30 September 1999 shareholding changed to: The Government of the Republic of Indonesia 51.0%, 23.4% and the 25.5% Cemex.On July 27, 2006, there was the sale of shares of Cemex Asia Holdings Ltd. to Blue Valley Holdings PTE Ltd. so the shareholding composition changed to 51.0% RI State Blue Valley Holdings PTE Ltd.. 24.9%, 24.0%, and the community. In late March 2010, Blue Valley Holdings PTELtd, sold all of its shares through a private placement, so the composition of the shareholders of the Company changed to 51.0% Government 48.9% and the public.Dated December 18, 2012 was a historic moment when the Company signed a final transaction acquisition of 70 percent stake in Thang Long Cement, the leading cement companies of Vietnam has a production capacity of 2.3 million tons / year. Acquisition of Thang Long Cement Company is also to make the Company's status as the first state-owned multi-national corporation. Has established its position as the largest cement producer in Southeast Asia with a capacity up to the year 2013 amounted to 30 million tonnes per year.

- Complete the construction of a cement factory unit
- The acquisition of Thang Long Cement Joint stock Company (TLCC), in Viet Nam.
- Became Strategic Holding Company and changed its name to PT Cement Indonesia (Persero) Tbk.

Transformation of the Company as an effort to improve the performance, after the application of Functional Holding through synergy of their respective companies’ competence both in operational and marketing field. Improve the quality of management of the Company's organization and conduct more intensive communication with stakeholders in each operating company.

Total E&P Indonesie

Energy is vital to economic development and improved standards of living. Wherever it is available, energy is helping to drive progress, but sustainability requires changes in the way that it is used and managed. This conviction shapes everything we do. With operations in more than 130 countries, we are a top-tier international oil company and a world-class natural gas operator, refiner, petrochemical producer, and fuel and lubricant retailer. Our 100,000 employees leverage their globally acknowledged expertise so that together they can discover, produce, refine and distribute oil and gas to provide products and services for customers worldwide. We are also developing energies that can partner oil and gas — today, solar energy and tomorrow, biomass. As a responsible corporate citizen, we focus on ensuring that our operations consistently deliver economic, social and environmental benefits.

A Market Leader in Our Areas of Expertise

Exploration & Production is responsible for our oil and natural gas exploration, development and production activities in more than 50 countries.**Gas& Power** unlocks the value of our natural gas assets. Its capabilities span the liquefied natural gas chain, from liquefaction to shipping and regasification, as well as natural gas marketing. **Refining & Chemicals** is a major production hub, with expertise covering refining, petrochemicals and specialty chemicals. We rank as one of the world's ten largest integrated producers. **Trading & Shipping** sells our crude oil production, supplies our refineries with feedstock, charters the vessels required for those activities and is involved in derivatives trading. We are a leading global trader of oil and petroleum products.**Marketing & Services** designs and markets a broad array of refined products, including automotive fuel and specialty products such as LPG, heating and heavy fuel oil, asphalt, lubricants and special fluids. It also provides services to consumers and to the transportation, housing and manufacturing industries. We are a leading marketer in Western Europe[4] and the top marketer in Africa.[4]

New Energies is helping us to prepare the energy future by developing our expertise in two core renewable energies, solar and biomass

INDUSTRIAL ENGINEERING ITS

Department of Industrial Engineering (IE-ITS) as one of the biggest departments in ITS stand as study program in 1985. IE-ITS has been successful in its efforts to develop its education programs, this is reflected in the accreditation gained since 1999 to the present (A). Number of alumni is more than 1000 people spread across various sectors of national and international industry, and the number of new students is about 200 people per year, supported by qualified teaching staff and have high competence and qualifications in their respective fields. IT-ITS to be one of the best industrial engineering department in Indonesia has more than 30 faculty members with diverse areas of expertise such as ergonomics, system manufacturing, sustainable manufacturing, optimization, simulation, data mining, logistics, supply chain, quality management and performance measurement makes the Department of Industrial Engineering (IE-ITS) as the primary barometer of "Industrial Engineering" in Indonesia. ITS open undergraduate (S1) and graduate (S2 and S3) programs. The programs are also open to international students delivered in English. Some college participants both undergraduate and graduate are from various countries such as Iraq, Zimbabwe, Papua New Guinea, Thailand and Myanmar.

Vision

IE-ITS aims to be an institution of higher education in Industrial Engineering with excellent international reputation and capable of supporting sustainable national development.

Mission

- To implement educational programs and research activities in the field of Industrial Engineering with international reputation.
- To provide services relevant to the needs of industry and communities to support sustainable national development.
- To build a cooperation network for development of educational and research activities to empower human resources and all resources owned.
- To conduct research and development in the field of science and Industrial Engineering with quality and contribution to the advancement of science and technology.

Purposes

- To produce qualified graduates of Industrial Engineering relevant to the needs of industry and community and develop activities of designing, engineering, improvement, and installation.
- To produce research and development in scientific fields of Industrial Engineering with quality and contribution to the advancement of science and technology.
- To apply the concepts, methods and techniques of research results within the professional scope of Industrial Engineering.

Program Education Objectives

1. To be able to formulate problem in industrial system, either micro, mezzo or macro level, to propose alternative solutions
2. To comprehend and innovatively perform theoretical improvement in Industrial Engineering discipline by focusing on system approach to design, improve and install an integrated system
3. To be able to manage research and development activities in industrial engineering discipline based on academic norms fairly and responsibly and to be able to communicate ideas and research results effectively both in Bahasa Indonesia and English in order to achieve national and international recognition.
4. To poses professional attitude and conduct as an individual and/or a team member in working environment
5. To be able manage his/herself and to behave professionally in working environment
6. To be able to cooperate in team proportionally in accordance to working demand.
7. To be able to communicate ideas systematically, both oral and written in Bahasa Indonesia or English.
8. To have sensitivity to environmental and sustainability issues and to accommodate those issues in performing analysis, design, dan decision making.
9. To be able to be creative and innovative in some aspects of living, especially to those with relation to his/her profession.

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Operations and Supply Chain Management: An International Journal (**OSCM**) publishes high quality refereed articles in the field of operations and supply chain management. The journal invites original contributions that present modeling, empirical, review, and conceptual works. To enable maximum dissemination, the articles are freely accessible through the internet to anybody and a limited printed version will be available at cost.

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Submission of Manuscripts
All manuscript should be submitted to the journal editor electronically in an MS word file to the Editor-in-Chief at: **oscm.editor@gmail.com**.

KEYNOTE SPEAKER

Keynote Speech I: **Professor Dr. René B.M. de Koster, Rotterdam School of Management, Erasmus University, The Netherlands. "The impact of behavior on operational performance".**

Dr. René B.M. de Koster is professor of Logistics and Operations Management at Rotterdam School of Management, Erasmus University since 1995. Before that, he worked as a consultant. His research interests are warehousing, container terminal, retail, and behavioural operations. He is author/editor of 8 books and over 130 papers in books and journals like Production and Operations Management, Journal of Operations Management, Transportation Science, IIE Transactions, European Journal of Operational Research. He is in the editorial boards of journals like OR, JOM, TS (SI editor), IJOPM (SI editor) and other academic journals, member of several international research advisory boards (ELA: European Logistics Association, BVL, AIRL, University of Pisa, chairman of Stichting Logistica, Smartport, and founder of the Material Handling Forum. His research has won several awards, like the IIE Transactions best paper award (2009), JOM best paper finalist (2007), AoM best paper finalist (2013), ERIM impact award (2013).

Keynote Speech II: **Walter Kuijpers**, **Deloitte Consulting's SE Asia "Journey to supply chain reengineering – opportunities and challenges"**

Walter is a Senior Manager at Deloitte Consulting South East Asia responsible for Supply Chain Management within the Strategy & Operations service line. He earned his BSc. Engineering Degree in Analytical Chemistry from the Dutch Hanzehogeschool in Groningen (Netherlands) followed by a Post-Academic Degree in Distribution Logistics. He has over 15 years' experience with a balanced mix of consulting and industry experience in Supply Chain Management covering Inventory Management, Collaborative Planning & Forecasting, Logistics Operations, and Sales & Distribution. He has worked across Consumer Business, Hi-Tech, Telecommunications and Energy & Resources industries in supply chain project delivery, sales and P&L roles across Europe, Australia, Japan,India, China and South East Asia.

Keynote speech III: **Professor Dr. Mahender Singh, CEO/Rector of Malaysia Institute for Supply Chain Innovation (MISI)**

Dr. Mahender Singh is the CEO/Rector of the newly launched Malaysia Institute for Supply Chain Innovation (MISI) since its inception in March 2011. MISI is a joint initiative between the Massachusetts Institute of Technology, USA (MIT) and the Government of Malaysia – www.misi.edu.my. He also holds the position of the Executive Director of the MIT Global SCALE Network in Asia at the Center for Transportation and Logistics at MIT, where he has been working for the past 10 years. Dr. Singh has over 18 years of experience in the field of supply chain management. Before returning to academia in 2003, he worked with a leading consulting firm to implement innovative global supply chain planning solution for Fortune 50 companies. He has spent considerable time in various countries working on supply chain challenges. Dr. Singh's research and teaching is focused on operations and supply chain management, with particular interest in exploring the underlying structure of complex supply chains. His current research efforts span the domain of supply chain strategy, risk management and healthcare supply chains.His research has been published in leading academic journals such as Management Science and IIE Transactions, as well as Sloan Management Review and Supply Chain Management Review. Dr. Singh has an Undergraduate degree with Honors in Physics. He earned his Masters degree in Logistics from MIT and received his Ph.D. in Management Science from the University of Tennessee, Knoxville. In addition, he has a Masters degree in Statistics and is a certified Cost Accountant.

WORKSHOP FOR DOCTORAL AND EMERGING SCHOLARS

Speaker I: **Professor Dr. Suresh Sethi, University of Texas at Dallas, USA**

Suresh P. Sethi is Eugene McDermott Professor of Operations Management and Director of the Center for Intelligent Supply Networks at The University of Texas at Dallas. He has written 7 books and published nearly 400 research papers in the fields of manufacturing and operations management, finance and economics, marketing, and optimization theory. He teaches a course on optimal control theory/applications and organizes a seminar series on operations management topics. He initiated and developed the doctoral programs in operations management at both University of Texas at Dallas and University of Toronto. He serves on the editorial boards of several journals including Production and Operations Management and SIAM Journal on Control and Optimization. He was named a Fellow of The Royal Society of Canada in 1994. Two conferences were organized and two books edited in his honor in 2005-6. Other honors include: IEEE Fellow (2001), INFORMS Fellow (2003), AAAS Fellow (2003), POMS Fellow (2005), IITB Distinguished Alum (2008), SIAM Fellow (2009), POMS President (2012).

Speaker II: **Professor Dr. Yossi Aviv, Olin Business School, Washington University, USA**

Professor Aviv,Dan Broida Professor of Operations & Manufacturing Management, develops and applies operations research models and methods to study problems related to supply chain management and revenue management. His current research focuses on strategic inventory positioning in distribution networks, collaborative forecasting, and dynamic pricing. He holds several editorial positions, and serves as a Department Editor (Area of Operations Management) for Management Science, the flagship journal in his field. Aviv has consulted in the defense and electronics industries. At the Olin School of Business, he has been teaching courses on quantitative decision modeling, operations management, and supply chain management, at the undergraduate, MBA, PMBA, EMBA, and Ph.D. levels.

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AN INTEGRATED MODELING OF HUMAN, MACHINE, AND ENVIRONMENTAL ASPECTS IN SUPPLY CHAIN PLANNING AND OPERATIONS USING FUZZY LOGIC

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ABSTRACT

Supply chain planning and operations is deeply dependent on human endeavor. The performance of a supply chain is determined by the human that is involved in the process of planning and operation. Supply chain planning involves activities such as demand forecasting, developing various plans that includes production plan, procurement plan, and distribution plan. Supply chain operations are essentially executing such supply chain processes such as procurement, production, transportation, and warehousing. In all of the above processes, the roles of human are critical, although the specific roles played from one process to another are different. Human performance problems identified in real operational events often involve operators performing actions that are not required for accident response. Analyses of the major failure/accidents during recent decades have concluded that human errors on part of operators, designers or managers have played a major role. On the other hand, the effectiveness of human in planning as well as operations of a supply chain is affected by two other factors, namely the tools used and the working environment. In this paper we present a simulation modeling that establish a linkage between human, tools, and working environments in supply chain planning and operations to reduce or eliminate human error. The analysis of these relations is complex, involving vagueness and uncertainty data. Fuzzy Logics (FL) provides a mathematical framework for the systematic treatment of vagueness and imprecision data. This paper presents a simulation modeling using fuzzy logics in reducing human error.

Keywords: supply chain, human error, simulation, fuzzy logics

1. INTRODUCTION

Supply chain management (SCM) assists the business organization to compete in the international market (Habib, 2010). SCM is needed for various reasons like : increasing profits, improving operations, better outsourcing, enhancing customer satisfaction, increasing globalization, tackling competitive pressures, generating quality outcomes, and growing complexity of supply chains (Stevenson, 2002). Supply chains are relatively easy to define for manufacturing industries, where each participant in the chain receives inputs from a set of

suppliers, processes those inputs, and delivers them to a different set of customers (Habib, 2010). According to Christopher (1994), a supply chain is "a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer." The supply chain includes suppliers, manufacturers, distributors, retailers, and customers (Chopra and Meindl, 2010). A supply chain is a system of human, activities, information, and resources involved in creating a product and then moving it to the customer (Ketchen, Rebarick, Hult, Meyer, 2008).
Supply chain planning and operations is deeply dependent on human endeavor. There is evidence that 80 percent of supply chain problems occur due to human (Andraski, 1994). The performance of a supply chain is determined by the human that is involved in the process of planning and operation. Supply chain planning involves activities such as demand forecasting, developing various plans that includes production plan, procurement plan, and distribution plan. Supply chain operations are essentially executing suchsupply chain processes such as procurement, production, transportation, and warehousing. In all of the above processes, the roles of humanare critical, although the specific roles played from one process to another are different. Human performance problems identified in real operational events often involve operators performing actions that are not required for accident response. Analyses of the major failure/accidents during recent decades have concluded that human errors on part of operators, designers or managers have played a major role. On the other hand, the effectiveness of human in planning as well as operations of a supply chain is affected by two other factors, namely the tools used and the working environment. In this paper we present a simulation modeling that establish a linkage between human, tools, and working environments in supply chain planning and operations to eliminate or reduce human error. The analysis of these relations is complex, involving vagueness and uncertainty data. Fuzzy Logics (FL) provides a mathematical framework for the systematic treatment of vagueness and imprecision data. This paper presents a simulation modeling using fuzzy logics in reducing human error.

2. LITERATURE REVIEW

Supply chain is a collection of functional activities (transportation, inventory control, etc.), which are repeated many times throughout the channel through which raw materials are converted into finished products and consumer value is added (Ballou, 2004). Supply chains are responsible for the entire lifetime of the product, from preparation of materials and supply management, to production and manufacturing, distribution and customer service, and ultimately recycling and disposal at the end of product life (Jagdev, Browne, 1998). Decision phases in a supply chain are supply chain strategy or design, supply chain planning, and supply chain operations (Chopra and Meindl, 2010). Supply chain planning is concerned with the coordination and integration of key business activities, from the procurement of raw material to the distribution of final product to the end customers (Gupta, Maranas, 2003). Supply chain operations are essentially executing such supply chain processes such as procurement, production, transportation, and warehousing.

2.1 Human Role.

In order to address human in supply chain performance, humans' capabilities and limitations must first be understood. Humans' capabilities have been identified: (a) humans are not limited to one identity or any common set of emotions; (b) humans are not limited to acting in accordance with predermined rules; (c) humans are not limited to acting on local patterns (Kurtz and Snowden, 2003). Caves (1982) stated that human skills influence effectiveness level of transformation process from input into an output element of a system. Human skills are the are checked to ensure picking accuracy and may be sorted or consolidated before dispatching. Consolidation refers to grouping multiple orders for the same destination. Dispatching is the last warehousing activity in which goods are loaded onto a transport carrier. Warehouses with human as operators are confronted with returns caused by incorrect delivery of items. Picking is the problematic sub-process of warehouses operations because of its high error. The different types of errors are picking of wrong types or quantities of articles, complete omission of an article type, and an insufficient quality of articles delivered. Reason (1990) defined human error as ‘ a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency’. These errors cause high costs for warehouse operators. Thus the main goal for warehouses is to eliminate errors or at least reduce their number.

3. FUZZY LOGIC

A contribution of fuzzy logic is its capability of representing vague data. Fuzzy logic resembles human reasoning in its use of approximate information and uncertainty to generate decisions (Gonzalez, Darbra, Arnaldos, 2013).Darbra and Casal (2009) established that fuzzy logic provides a way to use imprecise and uncertain information generated by system and human judgments in a precise manner. This human reasoning can be very helpful for solving engineering problems through the introduction of expert’s knowledge in to the system. These steps of the fuzzy logic methodology developed in this study are presented in Figure 1.

3.1 Identification of the variables

As first step, fuzzy logic relies on the identification of variables that are relevant to the system (inputs and outputs). Since the objective of this study is to reduce or eliminate human error, the first step is to analyze the system of human error on warehouse operations. The variables involved in this study include: human aspect, tools aspect, and environment aspect. The fuzzy inference model developed in this study is limited to using the most dominant factors in every aspect. Based on previous research, data processing skills and analyzing data skills are the most dominant factors in performance of the human aspect. Brill et al. (1984) stated that noise and lighting factors is the dominant factor affecting human performance. These factors become part of the environment aspect. Tools aspect, tools used repetitively over an extended period of time can cause injury if they are not ergonomically designed. The use of tools frequently leads to feelings of discomfort during work. These feelings can reduce performance of human (Fellows and Freivalds, 1991; Evers et all, 2004). The tools design in this study is expressed as tools dimension. The tools dimension is determined by comparison with dimension of human body. The output variable in this model is prediction error level. The error rate was set to be three levels: low, medium and high. Fig. 2 shows the hierarchy of the Mamdani fuzzy inference system used for the manage error level.

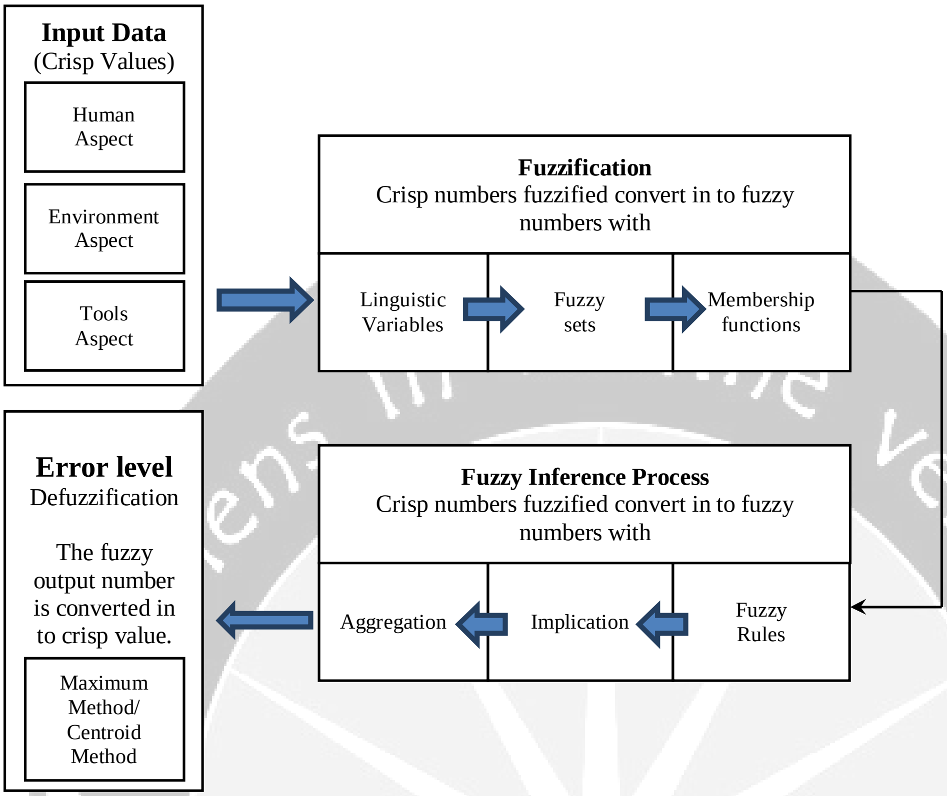


Figure 1: Fuzzy logic methodology (Adopted from Gonzales et all, 2013)

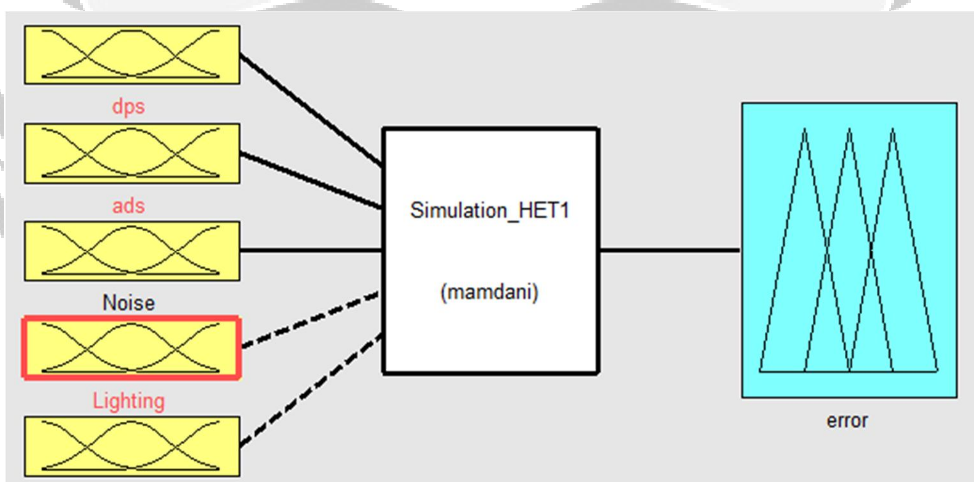
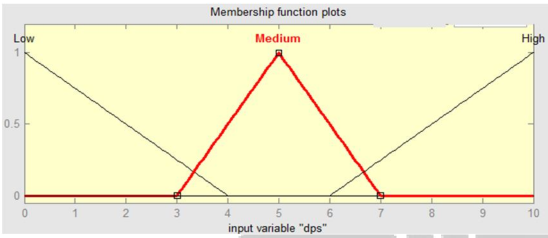


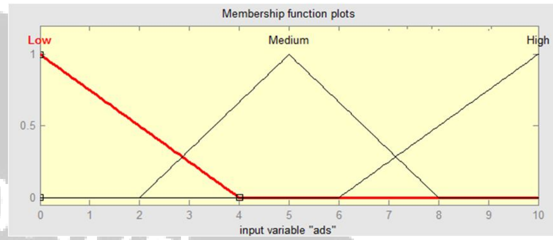
Figure. 2. Fuzzy inference system for manage error level.

3.2 Fuzzification Process.

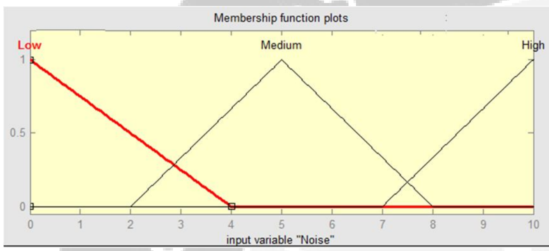
Process to establish fuzzy sets to represent numerical value of inputs and output variables (Kosko, 1995; Bojorques, Tapia et al., 2002).Basically, fuzzy sets convert the numerical values of variables to linguistic parameters such as low, median or high. Inputs and output variables have three triangular membership functions. Variable data processing skills (dps) and analyzing data skills (ads) on the human aspect was measured using a ten scale level of skill. The value of these skills then converted into linguistic parameters: low, medium and high.



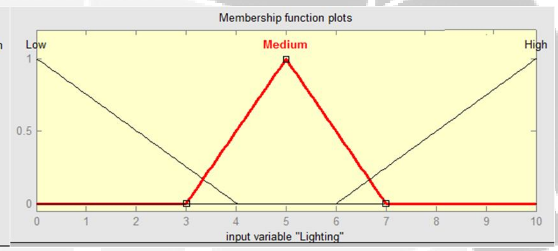
(a) Data processing skills (dps)



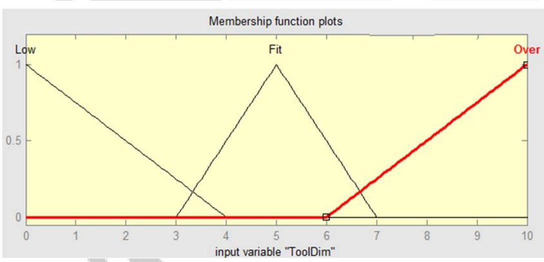
(b) Analyzing data skills (ads)



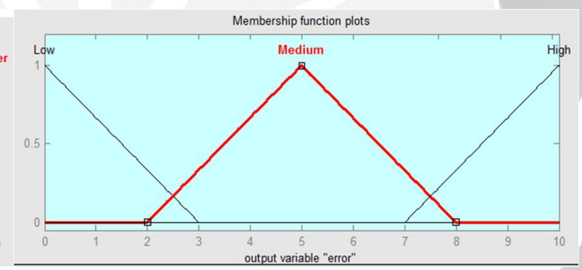
(c) Noise level



(d) lighting level



(e) Tools dimension (ToolDim)



(f) Error level

Figure. 3. Fuzzy inference system for manage error level.

Variable input on the environmental aspects are noise level and lighting level. Noise is measured in units called ‘decibels’- normally written ‘dB’. Permissible sound limits as per OSHA is 90 dBA (Jain, 2012).In this model, the value of the noise from 0 dBA - 90 dBA grouped into ranges of 0-10 to create membership function.Lighting level is measured in units called ‘lux’- normally written ‘lx’. A study indicated that an increase in illuminance from 500 lx to 1500 lx could increase the performance of workers (Baron et al. 1992). The value of lighting level from 100 lx to 1500 lx grouped into ranges of 0-10 to create membership function.

A variable tools dimension (ToolDim)set by measuring the dimension of the tools and compare with the anthropometry data (human hand). The value of tools dimension then converted into linguistic parameters: low, fit and over. The parameters is low if the dimension of tools small than the anthropometry data. The parametersis fit if the dimension of tools equals with the anthropometry data. Finally, the parameters is over if the dimension of tools bigger than the anthropometry data.The output variable in this model is prediction error level. The error rate was set to be three levels: low, medium and high. The grouping is determined based on the brainstorming process with management.Figs. 3 show the resulting membership functions for fuzzy inference system to manage error level.

3.3 Fuzzy Inference Process.

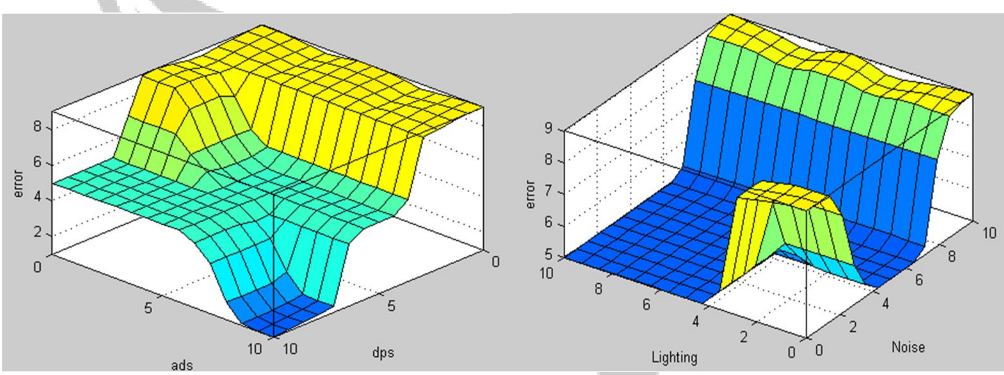
The general fuzzy inference system consists of input and output variables. The input variables in this model are five and one output variable. Total variables are six, for a total of five input variables, each having a varying 3 linguistic values, giving us a total of 243 (=3 x 3 x 3 x 3 x 3) different combinations (rules).Based on observations and results of research in the laboratory was composed fuzzy inference rules. The mapping between values of variables input and variables output (error level) is accomplished by the use of fuzzy if-then rules.

3.4 Experimental Results.

In this section, we present results obtained from simulating the influence of human, tools, and environment aspects to error level. Three scenarios are conducted to evaluate the proposed three aspects to error level. The first scenario represents the situation where variable data processing skills (dps) and analyzing data skills (ads) on the human aspect was increases in value, while the rest of the variables remain constant. The second scenario illustrates the case where variable noise and lighting level on environmental aspects was increases in value, while the rest of the variables remain constant. The third scenario represent the situation where variable tools dimension on tools aspect and analyzing data skills (ads) where usually used tools was increases in value, while the rest of the variables remain constant.

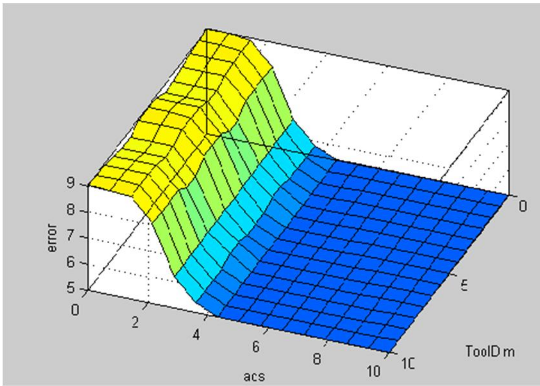
4. DISCUSSION AND EVALUATION OF THE RESULTS.

Figs. 4 show the resulting output surface error level for Mamdani fuzzy inference system. Fig. 4ashow the resulting output surface error level for the first scenario. The combination value of variable processing skills and analyzing data skill determine variety of the shape of surface error level. These results indicate that these two variable dominant in determining the error rate.



(a) Fuzzy input: data processing skills (dps) and analyzing data skills (ads).

(b) Fuzzy input: noise and lighting level



(C) fuzzy input: analyzing data skills (ads) and tools dimension.

Figure. 4. Output error level surface (Mamdani) for two fuzzy input.

Fig. 4bshow the resulting output surface error level for the second scenario. Based on shape of surface error level there are particular value combination of noise and lighting that generate low error level. Medium level on both noise and lighting level will generate low level error for the system. These results indicate that these two variable slight dominant in determining the error rate. Fig. 4cshow the resulting output surface error level for the third scenario. Based on shape of surface shape of error level, these shape more simple than result of second scenario. These results indicate that these two variable more little slight dominant in determining the error rate.

5. CONCLUSION

The relationship between human aspect, environmental aspect, and tools aspect to manage error level was investigated in this study. The main results are summarized as follows. (1) Human aspect : skills of data processing and analyzing data become dominant variable on the system to reduce the error level. (2) Environmental aspect: noise and lighting level become slight dominant in determining variable on the system to reduce the error level. (3) Tools aspect: dimension tools become variable that have a minor influence on the system to reduce error level. Finally, the human aspect has the most dominant influence on the error rate. The management should more attention to the managing human.

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Each process on supply chain will produce the expected outputs if supported by the operator that has the suitable competences. The needed competence identifications in managing the planning activities and operations on a supply chain are as follows (Dewa, Pujawan, &Vanany, 2012): (1) Dataprocessing, which is the ability to make or prepare the needed data input to make various decisions in supply chain. (2) Skills to operate tools such as software and hardware, and use the various methods such as prediction technique, the methods to determine storage parameter, and so on. (3) The ability to analyze such as analyzing data, doing what-if analysis on various parameters, making scenario simulation related with supply chain planning. (4) The ability to react or adaptive toward the existence of the new information/situation such as rearrangement of production plans, processing demands with high urgency level, changing the delivery methods, and processing the sudden consumers' demands. (5) The working ability in a team, moreover to do the selling coordination and production plans, to do the production plan synchronization with buying plans, to do the development coordination of the new products with marketing plans. (6) The ability to collaborate with business partner such as involving suppliers in products' development process, preparing selling data from the distributors, making certain that the suppliers will provide order status on time.

2.2 Factors Affecting Human Performance.

Meister (1999) stated that human beingsin order to achieve good performance requirestools or technology to overcome their limitations. The tools will effectively help human when designed in accordance with the dimensions of the individual using it. In addition, physical environment around the working humans also gives impact on humans' performance (Parsons, 2000).Sekar (2011) stated that working tools and working place were the integral parts of the work itself. Bailey (1982) proposed a human performance model to develop humans' performance in a working system. The model explains that to get high performing humans, factors to be considered aretheir activity and the place where the work carried out. Human performance level in a working system is influenced by their working environment condition (Leaman, 1995; Oseland& Bartlett, 1999; Fitch, 2004; Leblebici, 2012; Brill, 1990).

2.3 Human Error on Warehouse Operations

Rouwenhorst (2000) stated that the efficiency and effectiveness of a supply chain network is dependent on the performance of its functional elements, in particular, warehousing operations. They facilitate storage and buffer functions between upstream and downstream points of the supply chain (De Koster et all., 2007). The core warehouse operations revolve around the flow of order picking and dispatching (Gu et al., 2007; Berg and Zijm, 1999). The operations of warehousing starts with receiving, in which the arriving items are unloaded from the transport carriers. Their identity, quantity and condition is checked at this stage, and items may be repacked to different stock keeping units, i.e. put into stillages, palletized or de-palletized, after which they await for the next process called put away. Put away is the process of physical moving of the received goods from the staging area to the locations in the warehouse, where they can be stored. Storage is the placement of goods in the facility for the purpose of safe keeping, protection and retrieval as required by the next activity. Order fulfillment or order picking refers to the removal of items from the storage locations for the purpose of fulfilling customer orders. Completed orders

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