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Table of Contents

Cover page

Preface

- Welcome Speech from Conference Chair
- Welcome Message from Rector of ITS Surabaya
- Welcome Message from Rector of Universitas Atma Jaya Yogyakarta
- Keynote Speakers
- Industrial Engineering ITS
- Universitas Atma Jaya Yogyakarta

Committee

Conference Sponsor

List of Papers

Industrial Engineering - Decision Making

1. Annisaa Novieningtyas and Pri Hermawan. Group Model Building for Policy Making (Case Study: Beef Cattle at West Sumatra) 1
2. Pri Hermawan, Yuliati Komar and Soehartati Gondhowiardjo. A Network-based Collaborative Decision Making Model in Reducing Cervical Cancer Spread in Indonesia. 13
3. Erika Fatma. Development of Sustainable Tuna Processing Industry through System Dynamics Simulation. 20
4. I Made Ronyastra, I Ketut Gunarta and Udisubakti Ciptomulyono. A Multi Criteria Decision Analysis for Reinvestment Action Portfolio Selection Problem in an Indonesian Real Estate Company 27
5. Stefanus Eko Wiratno, Effi Latiffianti and Kevin Karmadi Wirawan. Selection of Business Funding Proposals Using Analytical Network Process: A Case Study at a Venture Capital Company 36

Industrial Engineering – Logistics

1. Farida Pulansari, Dwi Donoriyanto and Iriani. Performance Assessment Mechanism for Reverse Logistics Maturity Implementation toward Sustainable Manufacturing Systems: A Conceptual Framework 42
2. Adi Budipriyanto, Budisantoso Wirjodirdjo, Nyoman Pujawan and Saut Gurning. Berth Allocation Problem under Uncertainty: A Conceptual Model Using Collaborative Approach 51
3. Nur Ulfa Hidayatullah and Ali Musyafa. Hazop Study on Fuel Distribution System Based on Anfis Layer of Protection Analysis in Surabaya Installation Group PT Pertamina Tanjung Perak 59
4. Ardian Rizaldi, Meditya Wasesa and M Noviar Rahman. Yard Cranes Coordination Schemes for Automated Container Terminals: An Agent-Based Approach 66
5. Meditya Wasesa, M Noviar Rachman, Ardian Rizaldi and M Mashuri. Relocating Multiple-Tenants Logistics Center: Lesson Learned from an Air Cargo Terminal Relocation Project 74
6. Siti Nurminarsih, Ahmad Rusdiansyah and Nurhadi Siswanto. Inventory Ship Routing Problem (ISRP) Model Considering Port Dwelling Time Information 80
7. Sonny Sanjaya and Tomy Perdana. Logistics System Model Development on Supply Chain Management of Tomato Commodities for Structured Market 89

Industrial Engineering – Manufacturing system

1. **Wiwid Widiasih, Putu Dana Karningsih and Udisubakti Ciptomulyono.** Development of Integrated Model for Managing Risk in Lean Manufacturing Implementation: A Case Study in an Indonesian Manufacturing Company 95
2. **Joko Sulistio and Tri Astuti Rini.** A Structural Literature Review on Models and Methods Analysis of Green Supply Chain Management 103
3. **Sri Indrawati and Muhammad Ridwansyah.** Manufacturing Continuous Improvement Using Lean Six Sigma: An Iron Ores Industry Case Application 111
4. **Sri Hartini and Udisubakti Ciptomulyono.** The Relationship between Lean and Sustainable Manufacturing on Performance : literature review 117
5. **Maria Anityasari and Aulia Nadia Rachmat.** Lesson Learnt from Top-Down Medium Enterprises Selection for Green Industry Pilot Project in Surabaya 126
6. **Putu Karningsih, Dewanti Anggrahini and Muhammad Syaff'i,** Concurrent Engineering Implementation Assesment. Case Study in an Indonesia Manufacturing Company 133
7. **Nani Kurniati, Ruey-Huei Yeh and Jong-Jang Lin.** Quality Inspection and maintenance: the framework of interaction 140

Industrial Engineering – Operation management

1. **Suhendi Irawan.** The Effect of Choosing a Transportation Vendor and the Performance of Transportation Vendor on the Performance of Shipping Goods to Consumer: A Case Study of DB Schenker Freigh Forwarder 147
2. **Jugkrit Mahoran, Sukanya Wonglakron, Sumalee Namachote and Naruphon Oanwimon.** Risk Management of Village Funds in Muang District, Suphanburi Province. 152
3. **Susanto Sudiro and Sha'ri Mohd Yusof.** Managing WIP buffer with combination of feeding materials scenario and conventional control theory of single type of hospital bed production 159
4. **Agung Sutrisno, Indra Gunawan and Stenly Tangkuman.** Modified FMEA Model for Accessing the Risk of Maintenance Waste 167
5. **Filemon Yoga Adhisatya, The Jin Ai and Dah-Chuan Gong.** Economic Lot Scheduling Problem with Two Imperfect Key Modules 173
6. **Bupe Mwanza and Charles Mbohwa.** An Assessment of the Effectiveness of Equipment Maintenance Practices in Public Hospitals. 179
7. **Bupe Mwanza and Charles Mbohwa.** Design of a Total Productive Maintenance Model for Effective Implementation: A case study of a Chemical Manufacturing Company 185
8. **Hafid Budiman.** Increasing Compressor Reliability with The Weibull Distribution Analysis 194
9. **Paulus Wisnu Anggoro and Baju Bawono.** Reverse Engineering Technology in Redesign Process Ceramics: Application for CNN Plate 199
10. **Endang Retno Wedowati, Moses Laksono Singgih and I Ketut Gunarta.** Integrated Production Planning and Scheduling for Mass Customization in Food Industry: A Conceptual Framework 205
11. **Taufik Djatna and Wenny Dwi Kurniati.** A System Analysis and Design for Packaging Design of Powder Shaped Fresheners Based on Kansei Engineering 213
12. **Taufik Djatna and Muhammad Raja Ihsan.** A Fuzzy Associative Memory Modeling for Production Equipment Status Assessment 220
13. **Taufik Djatna and Fajar Munichputranto.** An Analysis and Design of Mobile Business Intelligence System for Productivity Measurement and Evaluation in Tire Curing Production Line 225

14. Sazli Tuttur Risyahadi. Scheduling Model of Harvesting Strawberry Considering Product Decay During Storage	231
15. Chaterine Alvina Prima Hapsari, Deny Ratna Yuniartha and Ignatius Luddy Indra Pumama. Tour and Break Scheduling for Shift Operators in Hard Disk Drive Manufacturer	239
16. Jwannaraksu Phen. An influence of packaging design on customer purchase intention	247
17. Dewanti Anggrahini, Putu Dana Karningsih and Martian Sulistiyono. Managing Quality Risk In A Frozen Shrimp Supply Chain (A Case Study)	251
18. Anny Maryani, Sritomo Wignjosebroto and Sri Gunani Partiw. A System Dynamics Approach for Modeling Construction Accidents	259
19. Naning Aranti Wessiani and Satria Oktaufanus Sarwoko. Risk Analysis of Poultry Feed Production Using Fuzzy FMEA	265
20. Mohamad Faisal Mohamad Sobri, Hawa Hishamuddin, Noraida Azura Md Darom. Disruption Recovery for a Single Stage Production-Inventory System with Optimal Safety Stock	OM1
 Industrial Engineering – Operation research	
1. Wahyuda and Budi Santosa. Dynamic Pricing in Electricity: Research Potential in Indonesia	276
2. Chirag Sancheti, Aditya Balu and Amit Kumar Gupta. Simulation based optimization of productivity using Flexsim	283
3. Budi Santosa and I Gusti Ngurah Agung Kresna. Simulated Annealing Algorithm to Solve Single Stage Capacitated Warehouse Location Problem (Case Study : PT. Petrokimia Gresik)	289
4. Yuanita Handayati, Togar Simatupang and Tomy Perdana. Value Co-Creation in Agri-Chains Network: A Hard Agent Based Simulation	298
5. Budi Santosa and Ade Lia Safitri. Biogeography-based Optimization Algorithm for Single Machine Total Weighted Tardiness Problem	307
6. Gilang Almaghribi Sarkara Putra and Rendra Agus Triyono. Proposing a Neural Network Method for Instrumentation and Control Cost Estimation of the EPC Companies Bidding Proposal	313
7. Sattarpoom Thaiparnit, Baramee Osatcerakul and Danupon Kumpanya. Algorithm Design in Leaf Surface Separation by Degree in HSV Color Model and Estimation of Leaf Area by Linear Regression	320
8. Danupon Kumpanya and Sattarpoom Thaiparnit. Parameter Identification of BLDC Motor Model via Metaheuristic Optimization Techniques	326
9. Sinta Dewi, Imam Baihaqi and Erwin Widodo. Modeling Strategy of Purchasing Consortium to Optimize Total Purchasing Cost Considering the Dynamic Condition of Organizaion	332
10. Taufik Djatna and Imam Muharram Alitu. An Application of Association Rule Mining in Total Productive Maintenance Strategy: An Analysis and Modelling for Wooden Door Manufacturing Industry	340
 Industrial Engineering – Product Development	
1. Yosephine Suharyanti, Subagyo, Nur Aini Masruroh and Indra Bastian. The Scheme of Product Development Process as a Trigger to Product Success: A Theoretical Framework	347
2. Ishardita Pambudi Tama and Wifqi Azlia. Development of Customer Oriented Product Design Using Kansei Engineering and Kano Model (Case study of Ceramic Souvenir)	355
3. Taufik Djatna, Luh Putu Wrasiasi and Ida Bagus Dharma Yoga Santosa. Balinese Aromatherapy Product Development Based On Kansei Engineering And Customer Personality Type	362

4. **Dyah Santhi Dewi, Bambang Syairudin and Eka Nahdliyatun Nikmah.** Risk Management in New Product Development Process for Fashion Industry (Case Study : Hijab Industry) 368

Industrial Engineering – Project Management

1. **Jeyanthi Ramasamy and Sha'ri Mohd Yusof.** A Literature Review of Subsea Asset Integrity Framework for Project Execution Phase 376
2. **Baju Bawono and Paulus Wisnu Anggoro.** Utilization Of Rapid Prototyping Technology to Improve Quality Souvenir Product 384

Industrial Engineering – Supply Chain Engineering

1. **Irwan Syahrir, Suparno and Iwan Vanany.** Healthcare and Disaster Supply Chain : Literature Review and Future Research 390
2. **Yudi Fernando and Sofri Yahya.** Challenges in Implementing Renewable Energy Supply Chain in Service Economy Era 398
3. **Araya Uengpaiboonkit.** The Marketing's Factors that Effect to Consumers Decisions of Organic Rice in Surin, Thailand 404
4. **Layung Prasetyanti and Togar Simatupang.** Proposed Framework for Service-Dominant-Logic Based Supply Chain 408
5. **Taufik Djatna and Rohmah Luthfiyanti.** An Analysis and Design of Responsive Supply Chain for Pineapple Multi Products SME Based On Digital Business Ecosystem (DBE) 416
6. **Erwin Widodo.** A Model Reflecting the Impact of Producer Substitution in Dual-Channel Supply-Chain Inventory Policy 423
7. **Taufik Djatna and Hety Handayani Hidayat.** An Optimized Supply Chain Model for Determination of Distribution Center and Inventory Level in A Coconut Water Agro-Industry 430
8. **Slamet Setio Wigati and The Jin Ai.** An Integrated Production System Model for Multi Supplier Single Buyer with Non Conforming Item and Product Warranty 436
9. **Yoshua Perwira Hartono, Ririn Diar Astanti and The Jin Ai.** Enabler to Successful Implementation of Lean Supply Chain in A Book Publisher 443
10. **Sutrisno and Purnawan Adi Wicaksono.** Optimal Strategy for Multi-product Inventory System with Supplier Selection By Using Model Predictive Control 450
11. **Iwan Vanany, Anny Maryani and Bilqis Amaliah.** Blood Traceability System for Indonesian Blood Supply Chain 457

Industrial Engineering – Safety & Ergonomic

1. **Natalie Carol Skeepers and Charles Mbohwa.** A Study on the leadership behaviour, safety leadership and safety performance in the Construction industry in South Africa 464
2. **Herry Christian Palit and Debora Anne Yang Aysia.** The Effect of Pop Musical Tempo during Post Treadmill Exercise Recovery Time 470
3. **Eko Nurmiyanto, Udisubakti Ciptomulyono, Suparno and Sudiyono Kromodihardjo.** Manual Handling Problem Identification in Mining Industry : the Ergonomic Perspective 475
4. **Wiyono Sutari, Murni Dwi Astuti, Yusuf Nugroho Doyobekti and Yuvie Mutiarasari.** Analysis of Working Posture Effect on Muscular Skeleton Disorder of Operator in Stamp Scraping in Batik Stamp Industry 483
5. **Rino Andias Anugraha, Wiyono Sutari and Ilma Mufidah,** The Design of Working Desk of Batik Scrapper by Using the Principles of Ergonomy 488

6. **Budi Praptono, Yusuf Nugroho Doyo Yekti, I Gede Wisuda Pura and Fransiskus Tatas Dwi Atmadji.** Prevention of Musculo Skeletal Disorders of Green Beans Farmer Through Application of Ergonomics in Order to Developing Manual Handling Equipment 496
7. **Manik Mahachandra, Yassierli and Erdo Garnaby.** The effectiveness of in-vehicle peppermint fragrance to maintain car drivers' alertness 500
8. **Yassierli, Manik Mahachandra and Iftikar Satalaksana.** Fatigue Evaluation of Fuel Truck Drivers 506
9. **Ayu Bidlawati and Eva Suryani.** Improving the Work Position of Worker's Based on Quick Exposure Check Method to Reduce the Risk of Work Related Musculoskeletal Disorders 512
10. **Bernadus Kristyanto, Brillianta Budi Nugraha, Anugrah Kusumo P and Kristanto Agung N.** Head and Neck Movement: Simulation And Kinematics Analysis 518
11. **Ronny Noriyati, Wisnu Rozaaq, Ali Musyafa and Adi Supriyanto.** Hazard & Operability Study And Determining Safety Integrity Level On Sulfur Furnace Unit : A Case Study In Fertilizer Industry 525
12. **Dyah Santhi Dewi and Tyasilia Septiana.** Workforce Scheduling Considering Physical And Mental Workload: A Case Study Of Domestic Freight Forwarding 531

Industrial Engineering – Supporting topics in Industrial Engineering

1. **Hatma Suryoharyo and Niken Larasati.** Sustainable Livelihood Framework As An Approach To Build Community Based Security 539
2. **Ngurah Wira, Amelia Kurniawati and Umar Yunan.** The Design of Best Practice on The Media Transfer Activities and Preservation Based on Knowledge Conversion with SECI Method 546
3. **Sri Gunani Partiw, Elly Agustiani and Anny Maryani.** Preparation for Designing Business Strategy of Bamboo Cultivation in Bondowoso 552
4. **Yosephine Suharyanti and Alva Edy Tontowi.** Market Response as a function of Design, Competition, and Socio-political Condition: An Empirical Model 558

Service Science – Service Business Design & Strategy

1. **Tri Ramadhan, Dermawan Wibisono, Reza Ashari Nasution and Santi Novani.** Design of Self Service Technology on Passenger Shipping Transportation Service System in Indonesia 566
2. **Ratna Hidayati and Santi Novani.** A Conceptual Complaint Model for Value co-Creation Process 574
3. **Mikhael Tjhi, Jann Hidajat Tjakraatmadja and Santi Novani.** Designing value co-creation process in organic food product distribution Case study in Bandung 579
4. **Nurtami Prihadi and Santi Novani.** Value Co-Creation among Stakeholders in Solo Tourism Development: Service System Science Perspective 591
5. **Arlavianyssa Pradiva Arru and Santi Novani.** Value Co-Creation in Solo Tourism by Using Soft System Dynamics Methodology 601
6. **Rizki S. Nurfitri and Mursyid H. Basri.** Developing Clinical Pathway Model in Public Hospital as Basic Component of Casemix System 609
7. **Watcharee Phetwong and Krisorn Sawangsire.** The Development of Computer Game for Historic Sites Learning in Suphanburi. 617
8. **Lidia Mayangsari and Santi Novani.** Multi-stakeholder Co-Creation Analysis in Smart City Management: An Experience from Bandung 622

Service Science – Service Delivery & Operations

1. **Imam Djati Widodo and Harwati Sutanto. AR MBA: Linkage Pattern of Visited Tourism Object** 628
2. **Liane Okdinawati, Togar M. Simatupang and Yos Sunitiyoso. Value Co-creation Map in Collaborative Transportation** 635
3. **Americo Azevedo and Maratus Sholihah. Innovative Costing System Framework in Industrial Product-Service System Environment** 642
4. **Iwan Vanany, Udisubakti Ciptomulyono, Muhammad Khoiri, Dody Hartanto and Putri Nur Imani. Willingness to Pay for Surabaya Mass Rapid Transit (SMART) Options** 649

Service Science – Service Quality

1. **Agus Mansur and Rizky Destiana Hapsari. Analysis of the Public Transportation Service Quality on Trans Jogja Transportation** 658
2. **Zya Labiba and Mulih Wijaya. Improvement Quality of Industrial Training Center Through Service Quality Based on Participation Perspective** 663

Service Science – Supporting topics in service science

1. **Gembong Baskoro. The concept of balancing Higher Education Institution (HEI) organization towards global and regional challenges** 670
2. **Samhuri Ikbal Pradana, Amelia Kurniawati and Nia Ambarsari. Knowledge Management System Implementation Readiness Measurement in PDII LIPI Based On People and Organizational Structure Factors** 674

A Fuzzy Associative Memory Modeling for Production Equipment Status Assessment

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ABSTRACT

Overall Equipment Effectiveness or OEE is the most common method to measure the performance of production particularly for equipment status assessment. OEE comprises of three elements such as availability, performance and quality. The three elements consist of at least two factors which are known as parts of Six Big Losses. However, OEE itself is most sufficient to provide information to triggers a proper maintenance response for performance improvement. This paper proposed a model to determine the maintenance status of production equipment. Fuzzy Associative Memory (FAM) is customized to meet the requirement for performing analytical capability. Basically, it analyses the proportion of events that reduced an equipment's utilization which is caused nearly by equipment. FAM aids the assessment to map a relationship between the factors and the status. The model gives two points in hedonic scale to machine with two events happened caused by machine itself. Thus the condition is interpretable for that machine maintenance requirement. Model implementable as one of modules used in Enterprise Resource Planning for production improvement.

Keywords: *Fuzzy Associative Memory, Overall Equipment Effectiveness, Performance Measurement*

1. Introduction

Controlling becomes a part of subjects in Operation and Production Management (OPM) to achieve the 4 objectives of OPM as known as right quality, right quantity, right time and right cost [1]. A production system consists of some input factors such as man, material, machine, information and capital. Thus, controlling the production factors becomes important thing to manage a good production system especially production equipment or specifically a machine. Often being a main factor for producing goods, appropriate controlling method for industrial machine is needed. It can be done by implementing good analytics platform for performing the task. [2] asserts that well-suited analytical platform helps to optimize processes in industry. As for machine, it helps to keep machine stays in good shape while in it's mission time.

Total Productive Maintenance (TPM) is a well-known method introduced by Nakajima Seiichi in 1988 for utilizing production resources and improving performance of a production system [3]. Nakajima Seiichi classifies top losses in production activates into six categories also known as Six Big Losses. Overall Equipment Effectiveness (OEE) is a method for measuring performance of a production particularly for equipment status assessment maintenance based on TPM method regarding the Six Big Losses [4]. However, there are still limitation to use OEE for assessing machine status condition as Six Big Losses comprises not only machine's fault but also other obstacle interfering production activity.

This paper proposed a model rules for assessing maintenance of production equipment status based on Fuzzy Associative Memory (FAM). This model only regards production losses caused by the equipment itself. So the equipment status becomes measureable. Case study of this paper is a cup filling machine in dessert and beverages manufacturing company (PT X). The objectives of this paper is to formulate the assessing model based on FAM and to assess cup filling machine condition in PT X using the model formulated before.

The rest of paper is arranged as follows: methodology will be described in Section 2. Membership function and the assessing rules will be explained in Section 3, while result of the measurement will be discussed in Section 4. Finally, we provide the conclusion of this paper in Section 5.

2. Methodology

As we explained before, this research has two objectives. The first objective is to make an assessing model based on FAM and the second is to assess the machine's condition using the model built before. Detail of the methods is depicted in figure 1 and figure 2.

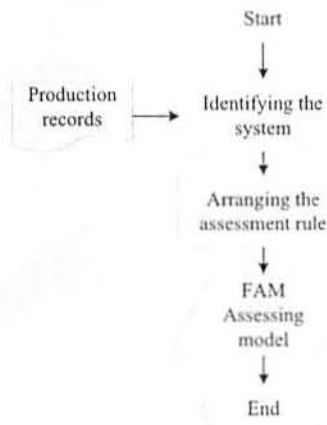


Figure 1. Model preparation flow chart

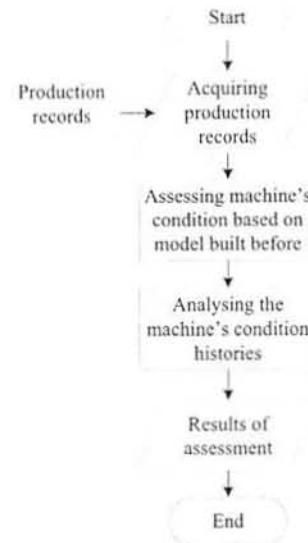


Figure 2. Machine's condition assessment flow chart

Data used in this research is production records during May to June 2014. Model is built regarding to the data obtained. Thus the model is used to assess the machine's condition. Score of machine's condition is plotted to chart with it's period of measurement as the axis. Afterward, the trend of machine's condition series is analyzed using simple linear regression to obtain the smoothing line. Correlation is also calculated to analyze the trend. Average score summarizes the information about condition of machine during one month.

3. Membership Function and Rules

Frequency and total downtime duration caused by the machine became parameters to assess machine's condition. Membership functions of frequency, total duration, and machine's condition are triangular fuzzy numbers. Frequency has 6 fuzzy sets, None (0,1). Very low (0,1,2). Low (1,2,3). Moderate (2,3,4). High (3,4,5). Total duration has 8 fuzzy sets, Too Short (0,5,10). Very Short (5,10,30). Short (10,30,60). Moderate is (30,60,240). Long (60,240,360). Very long (240,360,480). Too long (360,480). Machine's condition has 5 fuzzy sets, Good (0,1). Fair (0,2,4). Quite unfair (3,5,7). Unfair (6,8,10). Very unfair (8,10). The mapping rule is described in table 1 and table 2.

Table 1. Mapping rules

IF		THEN
Frequency	Duration	Condition
None	None	Good
	Too Short	Fair
	Very Short	Fair
Very Low	Short	Fair
	Moderate	Fair
	Long	Quite Unfair
	Very Long	Quite Unfair
	Too Long	Unfair
Low	Too Short	Fair
	Very Short	Fair
	Short	Fair
	Moderate	Quite Unfair
	Long	Quite Unfair
	Very Long	Unfair
Moderate	Too Long	Unfair
	Too Short	Fair
	Very Short	Fair
	Short	Fair

Table 2. Mapping rules (continued)

IF		THEN
Frequency	Duration	Condition
Moderate	Moderate	Quite Unfair
	Long	Quite Unfair
	Very Long	Unfair
High	Too Long	Unfair
	Too Short	Quite Unfair
	Very Short	Quite Unfair
	Short	Quite Unfair
	Moderate	Unfair
	Long	Unfair
Very High	Very Long	Unfair
	Too Long	Very unfair
	Too Short	Quite Unfair
	Very Short	Quite Unfair
	Short	Quite Unfair
	Moderate	Unfair
Very High	Long	Unfair
	Very Long	Very unfair
	Too Long	Very unfair

FAM applied matrix operation to map the antecedent and the consequent [5]. The mechanism of FAM operation is depicted in Figure 3. The mapping rules were encoded into matrix M using correlation product encoding. Correlation product encoding was also used in operating the matrix M with matrix A to obtain B_n' . Matrix B was derived from B_n' using sum product method. This model applied winner takes all as

defuzzification method to obtain the matrix crisp value from matrix B. The methods were selected to avoid flat zone of result.

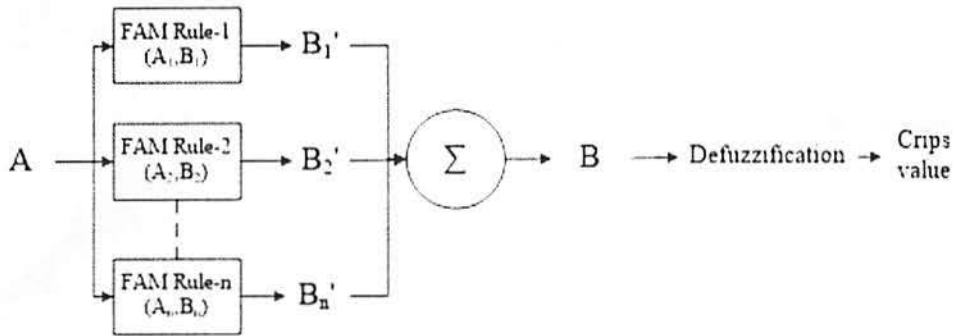


Figure 3. Model preparation flow chart

4. Result and Discussion

Machine's condition is assessed according to downtime record during May to June 2014. The graphs below show the assessment result.

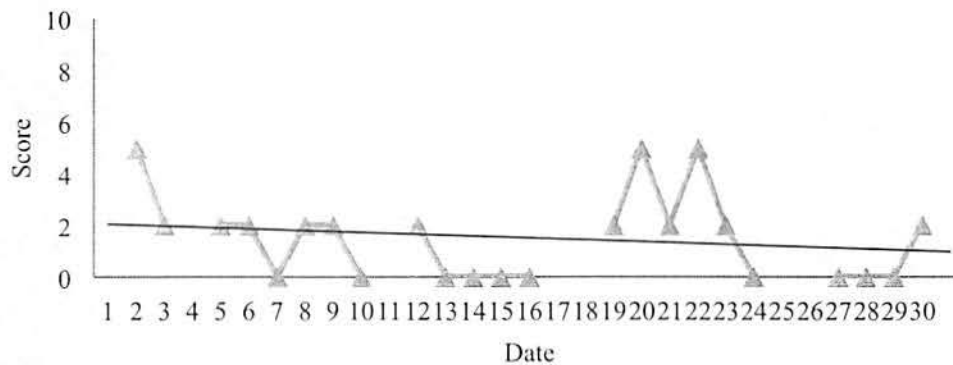


Figure 4. Machine's condition on May 2014

The highest machine's condition score on that day was plotted to the graphs. Average score for machine's condition on May 2014 is 1.52 with its correlation value shows negative value (-0.188). This shows that machine ran in fair condition without any concern shows declining of machine's condition. Negative correlation value is expected on assessing machine's condition.

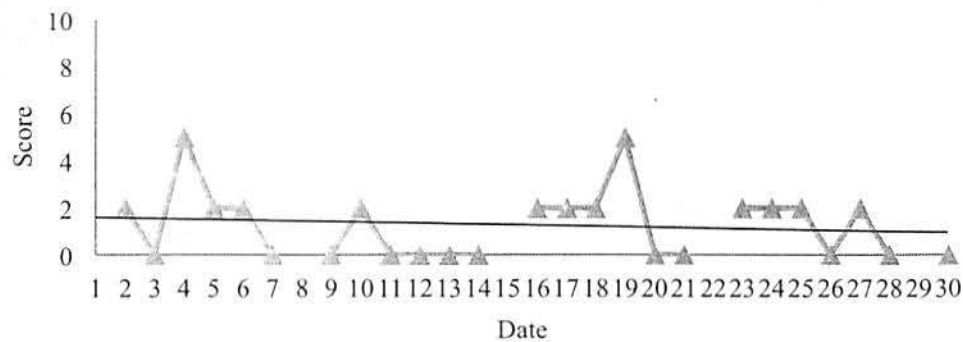


Figure 5. Machine's condition on June 2014

On June 2014, average score of machine's condition is 1.28. Same with previous month, it shows negative correlation value which is -0.125. It also shows that machine ran fairly without any concern of worse condition. For instance during May to June machine maintenance was required. Performance of machine during May to June 2014 is also measured using OEE method. The result shows OEE scores for May and June 2014 are 81.6% and 76.5%. Which this case shows declining performance of machine during those two months. Positive

correlation value is expected in this measurement as it is only shown by result of measurement in June 2014. Average OEE score is still below the world standard which is 85% [6].

Comparing two measurement explained before, machine's condition contributes insignificantly to its performance. It is identified by opposite results shown by each measurement. It also can be concluded that non-machine factor is the major problem interfering cup filling machine's performance in PT X. Factors affecting the machine's performance is explained using causes and effects diagram in Figure 5. However, machine breakdown is a category which has the most factors contributing to performance loss among those four according to Figure 5.

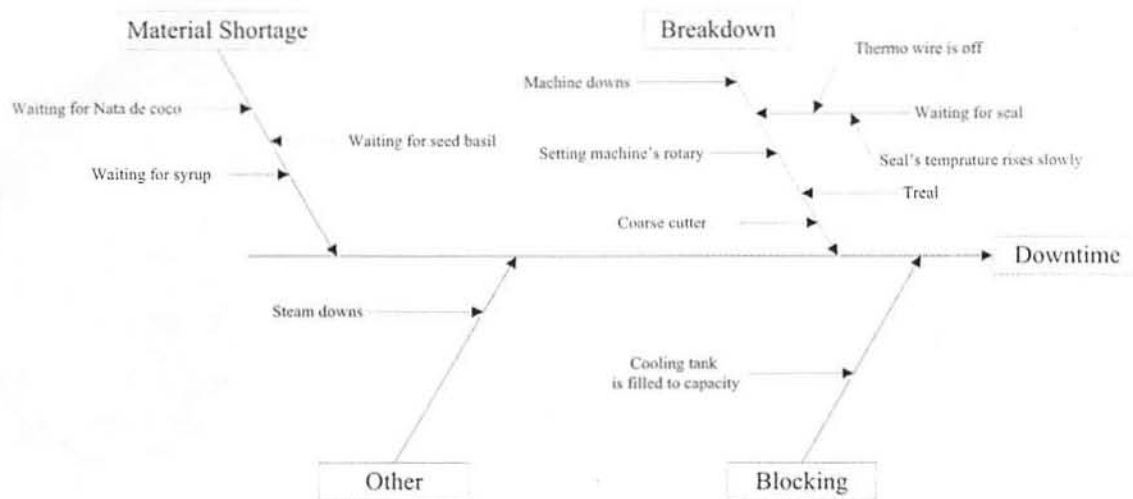


Figure 6. Causes and effects diagram showing downtime factors

This model has succeeded in assessing machine's condition based on six big losses caused only by the machine itself. Thus it can be used as a tool for supporting implementation of preventive maintenance, as the preventive maintenance is driven by statistics of machine [7]. The model also may be customized to meet the requirement of the enterprise to suit the machine they use.

There is an advantage of using FAM as the assessment model compare to Reliability approach. Unlike the Reliability method, FAM model proposed in this paper is independent to lifetime of machine factor. The calculation of Reliability involves operating time of machine and Mean Time Before Failure (MTBF)[6]. The result of assessment also depends on MTBF set in the formula. MTBF was defined as average interval time between failures [6]. Lifetime of machine affected the machine's performance[8]. Thus MTBF, which representing the performance of machine, should be adjusted in order to validate Reliability function used. Unless there will be a bias in assessing two machine which one of the machines is older than the other operating in same duration.

5. Conclusion

According to the assessment, machine ran in fair condition during observation. The average score and correlation value obtained from analyzing the time series of measurement show improvement of machine's condition during those two month. The result of this model proved that machine contributed insignificantly to performance loss, which the opposite result is shown by the OEE score, in observation. This model is applicable to support maintenance strategy for machine used utilization and improvement.

6. References

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