



CONFERENCE PROGRAMS AND ABSTRACT

**The 3rd FIRST 2019 INTERNATIONAL CONFERENCE
FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY
OCTOBER 09-10, 2019
*Palembang, Province of South Sumatera
Indonesia***

Organized by :



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PREFACE

The 3rd FIRST 2019 (Forum in Research, Science, and Technology) International Conference was initiated and organized by State Polytechnic of Sriwijaya in collaboration with Management and Science, University (MSU), Malaysia and National Chin-Yi University of Technology, Taiwan. The theme of the conference was “Integration of Advanced Technology to Enhance Social Welfare”. The 3rd FIRST 2019 International Conference facilitated the participants from all over the world to meet face to face to open chances in establishing connection and collaboration among them. It was not only for the researchers in academics, but also in industries and governments. This conference became an effective media to link the researchers from many parts of the world conference, for exchanging, sharing, following up and discussing the results of the latest research, industry’s needs, and government regulatory policies. The 3rd FIRST 2019 International Conference became worthwhile platform for researchers to present their finding in the areas on multidisciplinary of Engineering and Science (Track 1), Computer Science and ICT (Track 2), and Social Science (Track 3). It has also provided an opportunity for the professionals and researchers to learn and share about the latest development and research in those 3 tracks.

The 3rd FIRST 2019 International Conference attracted so many authors not only from Indonesia but also from other countries, such as Japan, Taiwan, and Malaysia. There were 180 papers were accepted in the 3rd FIRST 2019 International Conference, including 89 papers for Track 1 (Engineering and Science), 46 papers for Track 2 (Computer Science and ICT), and 45 papers for Track 3 (Social Science). In The 3rd FIRST 2019 International Conference, there were 4 keynote speakers and 2 invited speakers. As the keynote speakers, there were Prof. Yasushi Kiyoki, Ph. D from KEIO University, Japan, Prof. Nurul Taufiqu Rochman, M. Eng, Ph. D, From LIPI, Indonesia, Prof. Tjiptohadi Sawarjuwono, M. Ec., Ph. D., Ak, from Universitas Airlangga, Indonesia, and Prof. Win-Jet Luo, from National Chin-Yi University of Technology, Taiwan. As the invited speakers, there were Dr. R. Wisnu Nurcahyo, DVM from Universitas Gadjah Mada, Indonesia, and Assoc. Prof. Dr. Intan Zaurah binti Mat Darus from Universiti Teknologi, Malaysia. The 3rd FIRST 2019 International Conference committee would like to say thank you very much for all the participants and their respected institutions that have supported for the success of the 3rd FIRST 2019 International Conference, and also for all of the guess and sponsors of the 3rd FIRST 2019 International Conference.

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Authors

Affandi, Muhammad Irfan
Marketing Efficiency of Organic Rice in Lampung Province

Afrizawati
The Effect of Organization Climate on Performance with Job Satisfaction as an Intervening Variable

Akbar, Muhamad
E-Government Policy, Leadership Commitment, Apparatus Resources Development, and Their Implications on Public Service Performance

Aladin
Industrial Clusterization to Improve the Competitiveness of Small and Medium Industries in the City of Palembang

Alhadi, Esya
Impact of Customer Orientation and Quality of Service on Trust and Customer Loyalty

Alhamdari, Lailita
Analysis Method Economic Value Added of Cosmetics Companies Listed on Indonesia Stock Exchange

Amalia, Rizki Fitri
Political Connection, Profitability, and Capital Intensity Against Tax Avoidance in Coal Companies on the Indonesia Stock Exchange

Amran, Ali
Relationship Between GPA, Length of Study, and Competency with the Length of Time to Get a Job

- Amri, Darul
Determinant of Development Strategies and Leadership Styles on Organizational Commitment and Their Implications for MSMEs Performance in Palembang
- Andriani, Titi
Impact of Customer Orientation and Quality of Service on Trust and Customer Loyalty
- Anshari, Muhammad
Human Resource Role and Online Strategy
- Aprianti, Siska
The Effect of Capital Readiness and E-Commerce Utilization on the Competitiveness of Micro, Small, and Medium Enterprises Woven, Palembang
- Ardiani, Susi
The Effect of Hospital Image and Service Quality on Customer Loyalty Through Customer Satisfaction
- Arifin, Kiagus Zainal
Determinants of Village Financial Management Accountability
- Armaini, Rosy
The Impact of Village Fund Program Implementation Toward Society Welfare in Indonesia
- Aryani, Yuli Antina
Industrial Clusterization to Improve the Competitiveness of Small and Medium Industries in the City of Palembang
- Badri, Markoni
The Environmental Compliance Management of Palm Oil Plantation in Ogan Komering Ilir Regency, Sumatera Selatan, Indonesia
- Bustan, Jusmawi
Analysis Method Economic Value Added of Cosmetics Companies Listed on Indonesia Stock Exchange
- Bustan, Jusmawi
The Effect of Culinary Knowledge and Culinary Experience on Local Culinary Attractiveness
- Carlos, RS
Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park
- Choiruddin
Determinants of Village Financial Management Accountability
- Darfin, Deri
The Public Service Quality of Library Service at the Library Unit Polytechnic State of Sriwijaya
- Darlies, Meiyi
Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park
- Darmaliana
The Development of Teaching Material Speaking 2 Based on Communicative Approach
- Desiani, Anita
Relationship Between GPA, Length of Study, and Competency with the Length of Time to Get a Job

- Dewata, Evada
Industrial Clusterization to Improve the Competitiveness of Small and Medium Industries in the City of Palembang
- Divianto
The Effect of Organization Climate on Performance with Job Satisfaction as an Intervening Variable
- Djumrianti, Desloehal
Online Transportation Technology and Women's Driver Communication Skills
- Dwitayanti, Yevi
The Impact of Village Fund Program Implementation Toward Society Welfare in Indonesia
- Effendi, Ridwan
The Public Service Quality of Library Service at the Library Unit Polytechnic State of Sriwijaya
- Elisa
Evaluation of Sales Price Within Calculation Cost of Good Production SMEs Pempek Ilir Barat I and Bukit Kecil District, Palembang
- Ermatita
The Clustering of Paddy Fields Using Machine Learning Algorithms in the Province of South Sumatera
- Erwin, Muhamad
Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park
- Evawati, Nian Masna
Language Experience Approach in Teaching Reading Comprehension to the Engineering Students
- Fadila, Dewi
Impact of Learning, Socialization, and Financial Lifestyle of Students' Intention to Invest in Capital Market
- Faridah
The Effect of Taxpayer Awareness and Tax Sanctions on Compliance in Paying Land and Building Taxes
- Firdaus, Yusnizal
The Environmental Compliance Management of Palm Oil Plantation in Ogan Komering Ilir Regency, Sumatera Selatan, Indonesia
- Fithri, Eka Jumarni
Determinants of the Quality Regional Financial Statement
- Frimansyah
Determinant of Development Strategies and Leadership Styles on Organizational Commitment and Their Implications for MSMEs Performance in Palembang
- Gustiani, Sri
The Effectiveness of Blended Learning Approach on Essay Writing Subject
- Hamid, Abd.
The Effect of Culinary Knowledge and Culinary Experience on Local Culinary Attractiveness
- Handayani, Sri
Marketing Efficiency of Organic Rice in Lampung Province
- Handayani, Sri
Comparison Analysis of Added Value of Organic Rice and Inorganic Rice

- Hanifati
Online Transportation Technology and Women's Driver Communication Skills
- Hardiyansyah, Hardiyansyah
E-Government Policy, Leadership Commitment, Apparatus Resources Development, and Their Implications on Public Service Performance
- Hartati, Sukmini
Dimension of Village Expenditure in Development Sector
- Hartaty, Sri
Determinants of the Quality Regional Financial Statement
- Herawati, Yusleli
Evaluation of Sales Price Within Calculation Cost of Good Production SMEs Pempek Ilir Barat I and Bukit Kecil District, Palembang
- Herman
The Effect of Directed Reading—Thinking Activity on Students' Critical Thinking Abilities
- Husori, Al
The Environmental Compliance Management of Palm Oil Plantation in Ogan Komering Ilir Regency, Sumatera Selatan, Indonesia
- Indriasari, Desi
Determinants of Village Financial Management Accountability
- Irmeilyana
Relationship Between GPA, Length of Study, and Competency with the Length of Time to Get a Job
- Jauhari, Hadi
Human Resource Role and Online Strategy
- Koesharijadi, Koesharijadi
E-Government Policy, Leadership Commitment, Apparatus Resources Development, and Their Implications on Public Service Performance
- Koryati
Language Experience Approach in Teaching Reading Comprehension to the Engineering Students
- Kusmartini, Sri Endah
The Development of Teaching Material Speaking 2 Based on Communicative Approach
- Lisnini
Model of Empowerment as Strategies for Women SMEs Entrepreneurs Competitiveness in Palembang
- Lupikawaty, Marieska
Analysis Method Economic Value Added of Cosmetics Companies Listed on Indonesia Stock Exchange
- Lupikawaty, Marieska
Evaluation of Sales Price Within Calculation Cost of Good Production SMEs Pempek Ilir Barat I and Bukit Kecil District, Palembang
- Mahendrati, Hermina Agustina
Individual Readiness for Change and Affective Commitment to Change: The Mediation Effect of Technology Readiness on Public Sector
- Mandiangan, Pridson
Online Transportation Technology and Women's Driver Communication Skills

- Mangundjaya, Wustari
Testing the Role of Charismatic Leadership, Psychological Climate, and Organizational Citizenship Behavior on Resilience
- Mangundjaya, Wustari L.
Leader–Member Exchange and Affective Commitment to Change: Mediating Role of Change Self-Efficacy
- Mangundjaya, Wustari
Testing the Impact of Organizational Justice on Affective Commitment to Change with Work Engagement as Mediator
- Mangundjaya, Wustari
Individual Readiness for Change and Affective Commitment to Change: The Mediation Effect of Technology Readiness on Public Sector
- Mangundjaya, Wustari L.
Testing Mediation of Psychological Empowerment, Work Engagement to Affective Commitment to Change
- Maretha, Fetty
Model of Empowerment as Strategies for Women SMEs Entrepreneurs Competitiveness in Palembang
- Maria
The Impact of Village Fund Program Implementation Toward Society Welfare in Indonesia
- Mariskha, Z
Impact of Learning, Socialization, and Financial Lifestyle of Students' Intention to Invest in Capital Market
- Martini, Rita
Dimension of Village Expenditure in Development Sector
- Marwa, Taufiq
Exploring Linkage Among Experiential Value, Image of Destination, and Intention to Revisit in Nature Tourism
- Masnila, Nelly
The Effect of Taxpayer Awareness and Tax Sanctions on Compliance in Paying Land and Building Taxes
- Maulana, Riska
Impact of Learning, Socialization, and Financial Lifestyle of Students' Intention to Invest in Capital Market
- Miskiyah, Neneng
Human Resource Role and Online Strategy
- Mubarok, Muhammad Husni
The Effect of Taxpayer Awareness and Tax Sanctions on Compliance in Paying Land and Building Taxes
- Nadjmuddin, Muhammad
The Effect of Directed Reading—Thinking Activity on Students' Critical Thinking Abilities
- Natoen, Ardiyan
The Influence of Commitment on State Civil Apparatus in the Governor Office of South Sumatera
- Nirmagustina, Dwi Eva
Comparison Analysis of Added Value of Organic Rice and Inorganic Rice

- Nurhasanah
The Impact of Village Fund Program Implementation Toward Society Welfare in Indonesia
- Oktarian, Rido Prawira
Relationship Between GPA, Length of Study, and Competency with the Length of Time to Get a Job
- Oktarida, Anggeraini
Determinants of the Quality Regional Financial Statement
- Paisal
The Effect of Organization Climate on Performance with Job Satisfaction as an Intervening Variable
- Pangestu, Bramntyo Muhamad
The Effect of Capital Readiness and E-Commerce Utilization on the Competitiveness of Micro, Small, and Medium Enterprises Woven, Palembang
- Pebrianti, Yulia
Model of Empowerment as Strategies for Women SMEs Entrepreneurs Competitiveness in Palembang
- Periansya
The Influence of Commitment on State Civil Apparatus in the Governor Office of South Sumatera
- Purwati
Evaluation of Sales Price Within Calculation Cost of Good Production SMEs Pempek Ilir Barat I and Bukit Kecil District, Palembang
- Puspitasari, Dwi Andriani
Leader–Member Exchange and Affective Commitment to Change: Mediating Role of Change Self-Efficacy
- Rahma, Munaja
Students' Perception of English Blended-Learning in State Polytechnic of Sriwijaya
- Riama, Lambok Vera
Determinants of the Quality Regional Financial Statement
- Ridho, Sari Lestari Zainal
Human Resource Role and Online Strategy
- Ridhwan, Moehammad
Students' Perception of English Blended-Learning in State Polytechnic of Sriwijaya
- Rini
Model of Empowerment as Strategies for Women SMEs Entrepreneurs Competitiveness in Palembang
- Risa
The Development of Teaching Material Speaking 2 Based on Communicative Approach
- Risnawati
The Development of Teaching Material Speaking 2 Based on Communicative Approach
- Robinson
The Public Service Quality of Library Service at the Library Unit Polytechnic State of Sriwijaya

- Rusnadi, Irawan
Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park
- Sandrayati
The Effect of Hospital Image and Service Quality on Customer Loyalty Through Customer Satisfaction
- Sanmorino, Ahmad
The Clustering of Paddy Fields Using Machine Learning Algorithms in the Province of South Sumatera
- Sari, Evi Agustina
The Effectiveness of Blended Learning Approach on Essay Writing Subject
- Sari, Yuliana
Industrial Clusterization to Improve the Competitiveness of Small and Medium Industries in the City of Palembang
- Sari, Kartika Rachma
Determinants of Village Financial Management Accountability
- Sarikadarwati
The Effect of Hospital Image and Service Quality on Customer Loyalty Through Customer Satisfaction
- Sastrawinata, Hendra
Impact of Learning, Socialization, and Financial Lifestyle of Students' Intention to Invest in Capital Market
- Satriawan, Indra
The Influence of Commitment on State Civil Apparatus in the Governor Office of South Sumatera
- Seprianto, Dicky
Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park
- Setiawan, Heri
The Effect of Culinary Knowledge and Culinary Experience on Local Culinary Attractiveness
- Setiawan, Heri
Exploring Linkage Among Experiential Value, Image of Destination, and Intention to Revisit in Nature Tourism
- Shihab, Muchsin Sagaf
Exploring Linkage Among Experiential Value, Image of Destination, and Intention to Revisit in Nature Tourism
- Simanjuntak, Tiur
The Effectiveness of Blended Learning Approach on Essay Writing Subject
- Sopian, A.R
The Influence of Commitment on State Civil Apparatus in the Governor Office of South Sumatera
- Sulaiman
The Effect of Capital Readiness and E-Commerce Utilization on the Competitiveness of Micro, Small, and Medium Enterprises Woven, Palembang
- Sunani
The Effect of Directed Reading—Thinking Activity on Students' Critical Thinking Abilities

- Suryati
The Clustering of Paddy Fields Using Machine Learning Algorithms in the Province of South Sumatera
- Susilo
Testing Mediation of Psychological Empowerment, Work Engagement to Affective Commitment to Change
- Thoyib, M.
Determinant of Development Strategies and Leadership Styles on Organizational Commitment and Their Implications for MSMEs Performance in Palembang
- Tompunu, Alan Novi
Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park
- Ummasyroh
The Effect of Culinary Knowledge and Culinary Experience on Local Culinary Attractiveness
- Wahab, Zakaria
Exploring Linkage Among Experiential Value, Image of Destination, and Intention to Revisit in Nature Tourism
- Wahyudi, Riza
Determinant of Development Strategies and Leadership Styles on Organizational Commitment and Their Implications for MSMEs Performance in Palembang
- Widyastuti, Endah
Dimension of Village Expenditure in Development Sector
- Windarti, Gst Ayu Oka
Impact of Customer Orientation and Quality of Service on Trust and Customer Loyalty
- Yahya
The Effect of Organization Climate on Performance with Job Satisfaction as an Intervening Variable
- Yeny, Eli
The Effect of Directed Reading—Thinking Activity on Students' Critical Thinking Abilities
- Yulina, Bainil
The Effect of Capital Readiness and E-Commerce Utilization on the Competitiveness of Micro, Small, and Medium Enterprises Woven, Palembang
- Yulsiati, Henny
The Effect of Hospital Image and Service Quality on Customer Loyalty Through Customer Satisfaction
- Yurnalis
Testing the Impact of Organizational Justice on Affective Commitment to Change with Work Engagement as Mediator
- Yusri
The Effectiveness of Blended Learning Approach on Essay Writing Subject
- Yusuf, M.
The Environmental Compliance Management of Palm Oil Plantation in Ogan Komering Ilir Regency, Sumatera Selatan, Indonesia
- Zahara, Elvia
Impact of Customer Orientation and Quality of Service on Trust and Customer Loyalty

Zakaria

Students' Perception of English Blended-Learning in State Polytechnic of Sriwijaya

Zamheri, Ahmad

Criminal Law Policy on the Crime of Abuse to the Orang Rimba in the Bukit Duabelas National Park

Zulkarnaini

The Public Service Quality of Library Service at the Library Unit Polytechnic State of Sriwijaya

Zulkifli

Language Experience Approach in Teaching Reading Comprehension to the Engineering Students

Zulkifli, Zulkifli

Dimension of Village Expenditure in Development Sector



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TABLE OF CONTENTS

TRACK 1.....	1
ELECTRICAL ENGINEERING.....	1
A GLOBAL KNOWLEDGE SHARING AND SEMANTIC COMPUTING SYSTEM WITH 5-DIMENSIONAL WORLD-MAPFOR NATURAL AND SOCIAL ENVIRONMENT-ANALYSIS AND VISUALIZATION	1
5G Channel Model for 28 GHZ Frequency in Palembang	2
B Alfaresi , Z Nawawi , R F Malik, K Anwar.....	2
Wireless Sensor Network Data Communication and Information System to Regulate Water Volume and Turbine Rotation	3
Suzan Zefi ¹⁾ , Eka Susanti ²⁾ , R.A Halimahtussa'diyah ³⁾ , Sholihin ⁴⁾	3
Tomato Harvesting Arm Robot Manipulator; a Pilot Project.....	4
Yurni Oktarina ¹ ,Tresna Dewi ¹ , Pola Risma ¹ , and Muhammad Nawawi ¹	4
Performance Evaluation Solar Charge Controller on Solar Power System Home-Based SPV Amorphous 80 Watt-Peak.....	5
Armin Sofijan ¹ , Zainuddin Nawawi ² , Bhakti Yudho Suprpto ³ , Riman Sipahutar ⁴ , Irwin Bizzy ⁵	5
The Implementation of YateBTS Based GSM Using Raspberry PI.....	6
Sopian Soim ¹⁾ , Suroso ²⁾ , Ade Silvia Handayani ³⁾ , Ahmad Taqwa ⁴⁾ , Nur Shadrina ⁵⁾	6
Optimization of Own Electricity Usage with Electricity Supply from Solar Cells at Darajat Geothermal Power Plant.....	7
Brendy Chandra Supian Atmodjo ¹ and Rinaldy Dalimi ¹	7
Ultrasonic Sensor Application as a Performance Enhancement of Robot Two Wheels.....	8
Yeni Irdyanti ⁽¹⁾ , Rd. Kusumanto ⁽²⁾ , Masayu Anisah ⁽³⁾ , Niksen Alfarizal ⁽⁴⁾ , Zarmariesyah Erman ⁽⁵⁾ ...	8
Operation 3 Phase Induction Motor 1 KW Star Delta System Using HP (Smart Phone).....	9
Nofiansah ¹ , M. Noer ² , Nurhaida ³ , M. Hafidz Aulia ⁴	9
PLC Omron CJ1M CPU-21 Control Modification for Drill Oil Hole Machine in an Automotive Company	10



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Lin Prasetyani 1, Bayu Ramadhan1 , Tresna Dewi2 , William Sarfat1	10
Characteristics of Battery Use in Electric Car.....	11
Yessi Marniati*, Andri Suyadi, Herman Yani, Sutan Marsus**	11
Learning Module of Analog Electronics Practice	12
Sabilal Rasyad, Evelina, Amperawan, Dewi Permata Sari, Nyayu Latifah Husni.....	12
DIFFERENT METRIC DISTANCES ON THE K-MEANS METHOD IN BUILDING A CANS WASTE CLASSIFICATION SYSTEM USING THE CMYK COLOR MODEL	13
Implementation of Facial Feature Extraction Using Viola-Jones Method for Mobile Robot System ...	14
Ahmad Zarkasi ^{1,2} , Siti Nurmaini, Deris Setiawan, Ahmad Kuswandi, Sri Desy Siswanti.....	14
Effect of Load on BLCD Motor.....	15
Rumiasih, Carlos R. Sitompul, Anton Firmansyah, Indah Susanti	15
Implementation of DSK TMS320C6416T Module in Designed of Sound Detection	16
D A Pratama, N L Husni, E Prihatini, S Muslimin	16
Automatic Cooling of a PV System to Overcome Overheated PV Surface in Palembang.....	17
Ahmad Taqwa ^{1,2} , Tresna Dewi ^{1,2} , RD. Kusumanto ^{1,2} , Carlos R Sitompul ^{1,2} , Rusdianasari ¹	17
Analysis of Performance Test and Consumption of BLDC 350 W Motor Power to Mechanical Vibration with Variation of Speed and Load Variation	18
Hairul, Markori, Indrawasih dan Sudirman Yahya	18
The Influence of Change of an Angle of Illuminance on Solar Power Generating Capacity 30 Watts in Laboratory of Electrical Engineering Polytechnic of Sriwijaya.....	19
Zainuddin Idris, M. Yunus, Siswandi, Bambang Guntoro.....	19
The Effect of Drying Airflow Rate on H ₂ O MASS Evaporated for Banana Chips Drying Using Photovoltaic Solar Panel	20
Yohandri Bow ¹ , Adi Syakdani ² , Muhammad Taufik ² , Rusdianasari ³	20
Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra.....	21
Benny Junianto ¹ , Tresna Dewi ² , Carlos Sitompul ²	21
Effects of Grid Frequency Drop on The Dynamic Performance of Full Converter Wind Turbine Generator.....	22
A. M. Shiddiq Yunus ¹ ,Makmur Saini ² , Sri Suwasti ¹ , dan Purwito Purwito ³	22



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
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Modified Design for Water Metering System.....	23
Nyayu Latifah Husni ¹ , Dampito ² , Abdurrahman ³ , Evelina ⁴ , ade Silvia Handayani ⁵ , Sabibal Rasyad ⁶ , Adella Rialita ⁷¹⁻⁷ Electrical Department, Politeknik Negeri Sriwijaya	23
Implementation of Fuzzy Logic Type-2 On Mobile Robot Navigation System.....	24
Ade Silvia Handayani, Jefri Alkausar, Sarjana Sarjana, Nyayu Latifah Husni, Siti Nurmaini, Irsyadi Yani.....	24
INTELLIGENT CONTROLLER FOR FLEXIBLE ROBOT ARM	25
The Analysis of Wear on Artificial HIP Joint with Dimple on Femoral Surface	26
Hasan Basri ^{1,*} , A. Syahrom ^{2,3} , Amir Putra Md Saad ² , A. T. Prakoso ¹ , D. Wicaksono ¹ , M. I. Amarullah ¹ , Tri Satya Ramadhoni ¹	26
Optimal Design of Plasticizing Screw Using Artificial Intelligent Approach.....	27
Fatahul Arifin ^{1, 2(*)} , Min-Wen Wang ¹ , Jhen-Wei Kuo ³ , Tzong-Horng Dzw ⁴	27
Mechanical Degradation Model of Porous FE Scaffold: Simulation Approach.....	28
Akbar Teguh Prakoso ¹ , Ardiyansyah Syahrom ^{2,3} , Amir Putra Md Saad ^{2,3} , Abdul Hadi Abdul Wahab ⁴ , M. A. Sulong ^{2,3} , Achmad Rendiko Ichsan ¹ , Apreka Diansyah ¹ , Risky Utama Putra ¹ , Muhammad Imam Ammarullah ¹ , Hasan Basri ^{1*}	28
Scoopy Blade for Low Current River Waterwheel Supporting The Energy Needs in The Rural Areas of Indonesia.....	29
Darmawi ¹ , Riman Sipahutar ² , Irwin Bizzy ³	29
SELT Design as a source of renewable electricity using the Flywheel Generator and Photodiode Sensor	30
Indra Maulana, Dicky Seprianto, Yossy Yudhianto, Muhammad Najib, Muhamad Azwar.....	30
Analysis of Upgrading Process Of South Sumatera Low Rank Coal	31
Riman Sipahutar ¹ , Diah Kusuma Pratiwi ¹ , Darmawi Bayin ¹ , Irwin Bizzy ¹ , Baiti Hidayati ^{1,2}	31
The Effect of Parameters on The Process of Making Objects With Rapid Prototyping Digital Light Processing Technology on The Bending Stress	32
Romli ¹ , D Seprianto ¹ , DP Putra ¹ , M Rasid ¹ and A. Zamheri ¹	32
The Effect of Rectangular Parallel Key Manufacturing Process Parameters Made With Stereolithography DLP 3D Printer Technology against Impact Strength.....	33
D Seprianto ¹ , R Sugiantoro ¹ , Siproni ¹ , Yahya ¹ and M Erwin ²	33
Simulation of the Effect of Cutting Angle in Lathe Process on Distribution of Cutting Temperature ..	34



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Sriwijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
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Ismail T ¹ , Amrifan SM ² , Irsyadi Y ³ , Riman S ⁴ , Rahmad H ⁵	34
Conduction Heat Rate Analysis of Tool in Titanium Turning Process	35
Ismail T ¹ , Amrifan S M ² , Riman S ³ , Irsyadi Y ⁴ , Sandro O ⁵ , Fatiandari A ⁶	35
Cooling Channel Design for a Built-In Spindle of a Machine Tool.....	36
Kun-Ying Li ^{1,2} , Win-Jet Luo ^{2*} , Shih-Jie Wei ¹ , and Yan-sin Liao ¹	36
Design of Automatic Control Systems at Loader Output of Snap Gauge Machine in Manufacturing Industry	37
Syahril Ardi ¹ and Rahardian Faizal Zuhdi ²	37
The Influence of Change of an Angle of Illuminance on Solar Power Generating Capacity 30 Watts in Laboratory of Electrical Engineering Polytechnic of Sriwijaya.....	38
Zainuddin Idris, M. Yunus, Siswandi, Bambang Guntoro.....	38
The Effect of Drying Airflow Rate on H ₂ O MASS Evaporated for Banana Chips Drying Using Photovoltaic Solar Panel	39
Yohandri Bow ¹ , Adi Syakdani ² , Muhammad Taufik ² , Rusdianasari ³	39
Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra.....	40
Benny Junianto ¹ , Tresna Dewi ² , Carlos Sitompul ²	40
Effects of Grid Frequency Drop on The Dynamic Performance of Full Converter Wind Turbine Generator.....	41
A. M. Shiddiq Yunus ¹ Makmur Saini ² , Sri Suwasti ¹ , dan Purwito Purwito ³	41
Modified Design for Water Metering System.....	42
Nyayu Latifah Husni ¹ , Dampito ² , Abdurrahman ³ , Evelina ⁴ , ade Silvia Handayani ⁵ , Sabilal Rasyad ⁶ , Adella Rialita ⁷¹⁻⁷ Electrical Department, Politeknik Negeri Sriwijaya	42
Implementation of Fuzzy Logic Type-2 On Mobile Robot Navigation System.....	43
Ade Silvia Handayani, Jefri Alkausar, Sarjana Sarjana, Nyayu Latifah Husni, Siti Nurmaini, Irsyadi Yani.....	43
The Analysis of Wear on Artificial HIP Joint with Dimple on Femoral Surface	44
Hasan Basri ^{1*} , A. Syahrom ^{2,3} , Amir Putra Md Saad ² , A. T. Prakoso ¹ , D. Wicaksono ¹ , M. I. Amarullah ¹ , Tri Satya Ramadhoni ¹	44
Mechanical Degradation Model of Porous FE Scaffold: Simulation Approach.....	46



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Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
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Akbar Teguh Prakoso ¹ , Ardiyansyah Syahrom ^{2,3} , Amir Putra Md Saad ^{2,3} , Abdul Hadi Abdul Wahab ⁴ , M. A. Sulong ^{2,3} , Achmad Rendiko Ichsan ¹ , Apreka Diansyah ¹ , Risky Utama Putra ¹ , Muhammad Imam Ammarullah ¹ , Hasan Basri ^{1*}	46
Scoopy Blade for Low Current River Waterwheel Supporting The Energy Needs in The Rural Areas of Indonesia.....	47
Darmawi ¹ , Riman Sipahutar ² , Irwin Bizzy ³	47
SELT Design as a source of renewable electricity using the Flywheel Generator and Photodiode Sensor	48
Indra Maulana, Dicky Seprianto, Yossy Yudhianto, Muhammad Najib, Muhamad Azwar.....	48
Analysis of Upgrading Process Of South Sumatera Low Rank Coal	49
Riman Sipahutar ¹ , Diah Kusuma Pratiwi ¹ , Darmawi Bayin ¹ , Irwin Bizzy ¹ , Baiti Hidayati ²	49
The Effect of Parameters on The Process of Making Objects With Rapid Digital Prototyping Light Processing Technology on The Bending Stress	50
Romli ¹ , D Seprianto ¹ , DP Putra ¹ , and M Rasid ¹	50
The Effect of Rectangular Parallel Key Manufacturing Process Parameters Made With Stereolithography DLP 3D Printer Technology against Impact Strength.....	51
D Seprianto ¹ , R Sugiantoro ¹ , Siproni ¹ , Yahya ¹ and M Erwin ²	51
Simulation of the Effect of Cutting Angle in Lathe Process on Distribution of Cutting Temperature ..	52
Ismail T ¹ , Amrifan SM ² , Irsyadi Y ³ , Riman S ⁴ , Rahmad H ⁵	52
Conduction Heat Rate Analysis of Tool in Titanium Turning Process	53
Ismail T ¹ , Amrifan S M ² , Riman S ³ , Irsyadi Y ⁴ , Sandro O ⁵ , Fatiandari A ⁶	53
Cooling Channel Design for a Built-In Spindle of a Machine Tool.....	54
Kun-Ying Li ^{1,2} , Win-Jet Luo ^{2*} , Shih-Jie Wei ¹ , and Yan-sin Liao ¹	54
Design Control Systems of Marking Machine and Total Length Check Damper Assembly Based on Programmable Logic Controller.....	55
Syahril Ardi ¹ and Juliantito Ardianto ²	55
Experimental Vibration Study in Milling Thin-Walled TI6AL4V Under MQL Using Coconut Oil As Cutting Fluid.....	56
M Yanis ^{1*} , A S Mohruni ¹ , S Sharif ² , I Yani ¹ , M Zahir ¹	56
Determination Overlap Ratio on Savonius Twisted Water Turbine Using Numecca Software.....	57
Dr. Carolus Bintoro ¹ , Vicky Wuwung MT ¹ , Fathurrohman Nurdin ²	57



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

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phone +62711 353414 Fax: +62711 355918



Optimization Electricity Supply for Thousand Island Jakarta Province by Using Hybrid Photovoltaic-Wind Turbine-Diesel Generator-Crude Palm Oil (CPO) Power Plant-Battery System	58
Dharma Manurung ¹ and Rinaldy Dalimi ¹	58
Study on Using Casting Simulation Software for Design and Analysis Gate and Riser in Small Foundry Industries	59
Irawan Malik ¹ , A S Almadora ² and M Ali ³	59
Application of Vacuum Valve Technology as AFR Settings in 3500 Watt Operated by Methane Gas .	60
Tri Widagdo ¹ , Ella Sundari, Eka Satria martomi ¹	60
Innovation Utilization of Nitridation Method in Improving Hardness and Corrosion Resistance of Blacksmiths Crafts	61
Muhammad Rasid, S.T., MT. ¹	61
Performance Analysis of a Sludge Drying	62
Win-Jet Luo ¹ Nai-Feng Wu ² Cheng-Yan Lin ² Deri Suhaeji ²	62
Study on Ventilation Performance in Operating Room with Variation Ventilation Design	63
Yan-Lin Wu, Yu-Lieh Wu, Azka Hasya Hanifan	63
D Santoso ¹ , Z Abidin ¹ , J Yanto ²	64
Analysis Model for Orifice Flow Meter Correction Factor in Measuring in-Pipe Natural Gas Flow based on Numerical Simulation	65
Bunyamin ¹ , Kaprawi ¹ , Dewi Puspitasari ¹ , Sugianto ² , Nyayu Latifah Husni ³	65
The Analysis of Biogas Fermentation Time from Cow Manure on Biodigester Fixed Dome Batch Systems	66
Sajaruddin ¹ , Leila Kalsum ¹ , Zainuddin Muchtar ²	66
The Effect of Surface Modification on Heat Transfer of Heat Exchanger	67
Hong-Yi Lin, Yu-Lieh Wu, Kai-Siang Yang, Chih-Yung Tseng	67
Prototype of Biodiesel Processors Using Waste Oil (Study of The Effect of The Number of CAO Catalyst (Blood Shell Shells) and Reaction Time of The Biodiesel Rendemen)	68
Ida Febriana ^{1,2} , Anerasari M1, KA Ridwan ¹ , Taufik Jauhari ¹	68
Production of Ethyl Ester with The Influence of Electrode Type, Reaction Time And Electric Voltage from Waste Cooking Oil	69
Rosdiana Moeksin [*]), Farida Ali, Susila Arita	69



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



Biscuit Product Development Using Moringa Oleifera Flour as an Additional Source of Nutrition	70
Hilwatullisan ^{1(a)} , M. Zaman ¹ , A.Husaini ¹ and Siti Chodijah ¹	70
The Physical Characteristics of Cracked Plastic Waste	71
Selpiana ¹ , Prahady Susmanto ¹ , Lia Cundari ¹ , Dedek Oktari ² , Omar Ibrahim ²	71
The Analysis of The Use Calcium Oxide from Waste Cockle Shells (<i>Anadara Granosa</i>) and Sodium Hydroxide Catalyst on Prototype Biodiesel Processors Using Waste Cooking Oil Reviewed on Yield of Biodiesel.....	72
Sahrul Effendy, Tahdid, Lety Trisnaliani, Sandy A Putra, dan Alifah R Hefyani.....	72
Effect of Temperature and Starter Concentration on The Fermentation Process in Making MOCAF .	73
Muhammad Yerizam ¹ , Suri Andayana ¹ and Utari Oktavia ¹	73
Adsorption of Synthetic DYE by Betel Nuts Activated Carbon in a Fixed-Bed Column, Experiments And Prediction of Breakthrough Curves.....	74
L Cundari*, M N Fakhri, M Z Rizki	74
Effect of Catalysts on The Quality of Biodiesel from Waste Cooking Oil by Induction Heating	75
Rusdianasari ¹ , Aida Syarif ¹ , Muhammad Yerizam ² , M. Syahirman Yusi ³ , Leila Kalsum ¹ , Yohandri Bow ²	75
Characterization of Red Beetroot Soft Jelly Candy with Guava Extract and Gel Colloid Added.....	76
Meilianti* ¹ , Marta Aznury ¹ , Yuniar ¹ , Sofia ¹ , Ismy Farhan ¹ , Lidia Agustina ¹	76
Flow Rate Effect and NAOH Concentration to CO ₂ Reduction in Biogas Products Using Absorber	77
Lety Trisnaliani ¹ , Dina Eka Pranata ² , Fatria ³ , Tahdid ⁴ , KA Ridwan ⁵ , M. Nurizzman Alfarizi ⁶ , Mangihut Pandapotan Lumbantoruan ⁷	77
Prototype of Tray Dryer Unit for Silica Gel Drying Based on Bagasse	78
Selastia Yulianti ^{1(a)} , Fadarina ¹ , Mustain Zamhari ¹ , and Ibnu Hajar ¹	78
Modification of Starch from Yam Taro with Hydrolysis Acid as The Adhesive	79
Yuniar ^{1,2} , Martha Aznury ¹ , Sofiah ¹ , Meilianti ¹	79
The Performance of Riverse Osmosis (RO) Membrane in Producing Pure Water.....	80
Robert Junaidi ¹ , Abu Hasan ² , dan Muhammad Yerizam ³ , Indah Purnamasarii ⁴	80
Concentrations of Dissolved Oxygen in Drinking Water	81
Erwana Dewi ^{1(a)} , Aisyah Suci N ¹ and Elina M ¹	81
Growth Kinetics of <i>Saccharomyces Cerevisiae</i> and Tape Yeast on the Cassava Pulp Fermentation	82



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



Beni Hidayat, Udin Hasanudin, Muhamad Muslihudin, Syamsu Akmal, Siti Nurdjanah, Neti Yuliana	82
Distillation of Patchouli Oil Using Firewood and Liquefied Petroleum Gas as Fuel: Effects of Yield, Quality and Cost Analyses.....	83
Mahlinda and M. Dani Supardan	83
Evaluation of Main Parameter Process of Anaerobic Digestion of Cow Dung in Fixed Dome Biogester on Methane Gas Quality	84
Leila Kalsum, Abu Hasan, Rusdianasari, A.Husaini Yohandri Bow	84
Re-Design Pyrolysis Reactor Prototype for The Conversion of Plastic Waste into Liquid Fuel.....	85
Arizal Aswan, IrawanRusnadi, Fatria, Zurohaina, Rima Daniar	85
Value Added Analysis of Beef Floss with Fillers of Papaya Fruits And Banana Blossom's.....	86
Sri handayani, Chandra utami wirawati, Saroni saroni, Dwi eva nirmagustina.....	86
Marketing Efficiency of Organic Rice in Lampung Province	87
Sri Handayani, Dwi Eva Nirmagustina, Muhammad Irfan Affandi.....	87
Simple design of pyrolysis tool for making liquid smoke from shells and rubber seeds as a food preservative	88
Farida Ali, ¹ Roval Al Fiqri ²	88
Industrial Mapping in Java-Kalimantan-Nusa Tenggara Corridor	89
M A Berawi ¹ , P Miraj ^{2,3} , H Sidqi ² , G R Gaffara ^{2,4} and Gunawan ²	89
Revenue Analysis of Port-City Conceptual Design	90
M A Berawi ¹ , P Miraj ^{2,3} , E R Islamiah ² , and Gunawan ²	90
The Utilization of Plastics Waste in Flexible Pavement Hot Rolled Sheet and Asphalt Concrete Wearing Course With Marshall Immersion and Cantabro Test.....	91
Adhitya B B ¹ , Pataras M ² , and Kadarsa E ³	91
Characteristics Comparison of Refinery Asphalt, Rubberized Asphalt, and Buton Asphalt in Stone Matrix Asphalt Pavement with Marshall and Cantabro Method.....	92
Kurnia A Y ¹ , Dewi R ² , Permata D Y ³ , and Pataras M ⁴	92
The Effect of Polycarboxylate Addition towards The Workability and High Strength Concrete	93
Sumiati ¹ , Mahmuda ² , Andi Herius ³ dan Agus Subrianto ⁴	93



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference



Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918

Stabilization of Peat Soils Using Petrasoil with Cement Viewed from CBR Value and Free Compressive Strength Value of Soils	94
Ibrahim, S.T.,M.T. ¹ , Andi Herius, S.T.,M.T. ² , Julian Fikri, S.S.T., M.Sc. ³ , M. Shaid Ramadhinata ⁴ , Maryani ⁵	94
The Utilization of Crushed Clay Brick as Coarse Aggregate on Eco-Green Lightweight Foamed Concrete.....	95
Sumiati ¹ , Mahmuda ² , Sukarman ³ , Siswa Indra ⁴ , and Darma prabudi ⁵	95
Performance analysis of Patal - Pusri Intersections after underpass operated	96
Arfan Hasan ¹ , Indrayani ¹ , Ridho Adrian ¹ , Dwiki Syamanda ¹ , Darma Budi ¹ , and Akhmad Mirza ¹ .	96
Utilization of Coconut Shells as a Replacement of Some Coral Stone in Concrete Making	97
Raja Marpaung, Kosim, Zainuddin, Darma Prabudi	97
Public Transportation Service Bus Rapid Transit (BRT) Trans Musi Sustainable in Palembang City.....	98
A. Latif, Yusri, Moch.Absor, A. Fuad Z.	98
Transportation Needed of Bus Rapid Transit (BRT) Corridor in Palembang	99
Herlinawati, Puryanto, Sudarmadji, Sazili	99
Effect of Groundwater Table on Slope Stability and Design of Retaining Wall	100
R Ahmad ^{1*} , A B Mardhanie ¹ , P Suroso ¹ , T E Sutarto ¹ and R Alfajri ²	100
Falisa ^{1*} , Hendri Chandra ^{2*} , Harnani ^{3*}	108
^{1,3} Teknik Geologi, Universitas Sriwijaya, Indralaya.....	108
² Teknik Mesin, Universitas Sriwijaya, Indralaya	108
* <i>Corresponding author</i> : falisa@unsri.ac.id.....	108
Information System of Small And Medium Business in Palembang City	112
Hetty Meileni, Cindy Indah Pratiwi, Ienda Meiriska, and Desi Apriyanty	112
Inventory of Goods Data Processing Using The Economic Order Quantity (EOQ) Method	113
Hetty Meileni, Diky Juniansyah Putra, Desi Apriyanti, Indra Satriadi, Sony Oktapriandi	113
Internet of Thing for the Command Robot Command System.....	114
Emilia Hesti ¹ , Sholihin ² , Adewasti ³ , Sarjana ⁴	114
The Effect Of Addition Of High Density Poly Ethylene (Hdpe) As Binder On Hebel Light Brick (Celcon)	115



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Sriwijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



The Effect Of Addition Of High Density Poly Ethylene (Hdpe) As Binder On Hebel Light Brick (Celcon)	116
Implementation of Fingerprint Control in Majors Electrical Engineering Using Arduino	117
Ibnu Ziad ¹⁾ , Ali Nudin ²⁾ , Jon Endri ³⁾ , Ciksadan ⁴⁾	117
Biodiesel Production From Bintaro (Cerbera Manghas L) Seeds With Potassium Hydroxide As Catalyst	118
The Copper Fiber On Compressive Strength And Elastic Modulus On Concrete Fc'25	119
Information System Feature Development Of Telecommunications Engineering Study Program To Support The New Accreditation And The New Curriculum System	120
Grip Tool Cnc Mill 3a To Get 12 Sides Of The Elbow On Results Induction Electrical Furnance Casting	121
Implementation Of Parking Portal Door Security System Using Rfid And Password Based On Microcontrollers In Sriwijaya State Polytechnic	122
Technique Automatic For Detection And Segmentation Of Optic Disc Area In Retinal Image	125
Erwin ¹ , B Cania ² , I K Larasati ³	125
New Techniques For Segmentation And Extraction Retinal Blood Vessels	126
Erwin, A Rohman, L A Nurjanah, Yurika, D Sinta, Q Al'afwa	126
Optimization of City Bus Routes in Surabaya Using Memetic Algorithm as a Solution to Solve Orienteering Problem	127
Fauzi Rakhmad Firdausi, Arif Djunaidy, Ahmad Muklason	127
A Form of Preprocessing For Social Media Data Extraction	128
Dodo Zaenal Abidin, Siti Nurmaini, Reza Firsandaya Malik, Jasmir Jasmir	128
Factors Affecting Knowledge Sharing Capability of Doctors in Palembang	129
Nining Ariati, Dana Indra Sensuse, Putu Wuri Handayani	129
Serious Game Supply Chain Management Agribusiness as a Production Planning using Cournot Model	130
Saiful Bukhori	130
Smart Cup for Visual Impaired People Based on Arduino	132
Aryanti Aryanti ¹² , Lin Wei-cong ¹ , Lin chih-yi ¹ , Billy Brian Henriquez ⁴ , Ikhthison Mekongga ³ , Aaron Raymond See ^{1*}	132
Challenges of Teaching in Massive Open Online Course	133



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



M A Ahmad ¹ , A R C Hussin, H M Dahlan ¹ , J Mahmood	133
Analysis of Service Oriented Architecture and Enterprise Architecture Alignment for Loan Financing System.....	134
Ahmad Nurul Fajar	134
Analysis of Service Oriented Architecture and Enterprise Architecture Alignment for Loan Financing System.....	135
Ahmad Nurul Fajar	135
Analysis of Server Virtualization Service Performance Using Citrix Xenserver”	136
Surahmat, Alfred Tenggono	136
The Pattern of The Marketing Ground Coffee Beans Using Decision Support System	137
Suparto Darudiato, Eliando Eliando	137
The Pattern of The Marketing Ground Coffee Beans Using Decision Support System	138
Suparto Darudiato, Eliando Eliando.....	138
The Utilization of Ontology in Association Rule.....	139
Dewi Wardani, Achmad Khusyaini	139
The Evaluation of Semantic Mapping	140
Dewi Wardani ¹	140
Measurement of User Satisfaction Level on Implementation of SISKEUDES Application	141
¹ Mardiana and ² Eka Hartati	141
Garbage Collector Robot (GACOBOT) Design for Dry Waste Distribution.....	142
Aditya P. P. Prasetyo, Rendyansyah, Sri Desy Siswanti, Siti Nurmaini, Abdurahman.....	142
Use of Haversine Formula in Finding Distance Between Temporary Shelter and Waste End Processing Sites.....	143
Rezania Agramanisti Azdy, Febriyanti Darnis.....	143
Geographic Information Systems Search Test Location For Admission Of New Students In Sriwijaya State Polytechnic Using Location Based Service (LBS) Method.....	144
Book Catalog Information System in The Reading Room (Library) Web-Based at Informatics Management Department in State Polytechnic of Sriwijaya.....	145
Henny Madora ¹ , Yusniarti ² , Ida Wahyunigrum ³ , Muhammad Noval ⁴	145
Pull-down Fitness Technique Analysis using Motion Capture	146



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Sriwijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



R Passarella, A S Nugroho, and F N Arsyad	146
Analysis of EDFAT Methods in Photography Techniques	147
Meiyi Darlies, Ema Laila, Ali Firdaus, Muhamad Erwin.....	147
Predicting Cost Recovery Rate of Ischemic Stroke Patients: A Potential Application of Big Data Analysis in Hospital	148
^{1*} Heru Fahlevi, ² Teuku Roli Ilhamsyah Putra and ³ Rina Suryani Oktari.....	148
Development Analysis For Numbers And Colors Learning Media	149
Yesi Sriyeni and Maria Veronica.....	149
Animation Design as an Educational Media of Adolescents’ Social Behavior Deviation” has been accepted with major revision	150
Heki Aprianto and Alan Saputro	150
Designing Mobile Based User Interface for Promotion of Lakeur Craft Art Application at Balaputra Dewa State Museum.....	151
Syahrul, Pertiwi	151
Prototype of RFID –Based Parking Slot Availability Detection System	152
Lindawati ¹ , I Salamah ¹ , Asriyadi ¹ , M Fadhli ¹	152
Mobile Robot Motion Control Based on Static Hand Gesture.....	153
DS Sri , FP Rian , Z Ahmad	153
Object-Based Design and Modeling Batik Nusantara Catalog Wibatara.com	154
Adelin Adelin, Febria Sri Handayani.....	154
Genetic Algorithm Based Feature Selection With Ensemble Methods For Student Academic Performance Prediction	155
Al Farissi, Halina Mohamed Dahlan, Samsuryadi.....	155
Information System Strategy Planning In The Private Universities Of South Sumatera.....	156
Engine Replacement Scheduling Optimization Using Data Mining	158
Farizal1 and Albert Joelian	158
User Experience Analysis on Class I LPKA Palembang Filial E-School	159
D. Tri Octafian, Febrianty, Hendra Hadiwijaya	159
Information System of Student’s Final Report And Final Assignment At State Polytechnic of Sriwijaya with Android Based.....	160



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Sriwijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



Rika Sadariawati, A. Ari Gunawan, Meivi Kusnandar.....	160
Design of Semester Exam Scheduling at The State Polytechnic of Sriwijaya Application	161
Nita Novita, M. Aris Ganiardi, Indri Ariyanti, Delta Khairunnisa.....	161
Augmented Reality in the Registration Flow for Entrance Examination at State Polytechnic of Sriwijaya Based on Android	162
Rike Sucihati,Ahmad Bahri Joni Malyan, Ervi Cofriyanti	162
Design and Build Application of Campus Parking Area for State Polytechnic of Sriwijaya Based on Smartphone	163
Leni Novianti, Devi Sartika , Dewi Irmawati, Ienda Meiriska	163
Implementation of Biometric Fingerprint Barbasis Security Doors with Attendance Database on Sriwijaya State Polytechnic	164
A.Bahri Joni M , Herlambang Saputra , Ahyar Supani , Indarto	164
Designing and Applying Flood Early Warning System with Fuzzy Logic Based on Rainfall and Water Level for Special of Palembang City	165
Ahyar Supani, Yuli Adriani.....	165
Performance of RUS and SMOTE Method on Twitter Spam Data Using Random Forest.....	166
Huda Ubaya and Ria Siti Juairiah	166
Mobile Android Based Geographic Information System (GIS) Software Development for Tourist Destination Seekers in Palembang City Using RASCH Model Measurements.....	167
Sanjaya, Kurniawan, Saputra, Azhar	167
GIS Android Mobile Based Software Development for Tourism Objects, Public Places List, Transportations List, and Culinary Places List Using Usability Measurement	168
M. Rudi Sanjaya, Dedy Kurniawan, Ariansyah Saputra, Iman Saladin B Azhar	168
TRACK 3	172
MANAGEMENT ECONOMICS, BUSINESS ADMINISTRATION, ACCOUNTING	172
Impact of Learning, Socialization and Financial Lifestyle on Student' Intention to Invest in Capital Market.....	172
Dewi Fadila, Hendra Satrawinata, Mariskha Z, Riska Maulana.....	172
The Effect Of Capital Readiness And E-Commerce Utilization On The Competitiveness Of Micro Small And Medium Enterprises (Msmes) Woven Palembang.....	173
Dimensions of Village Expenditure in Development Sector	174



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Srijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



Zulkifli Zulkifli, Rita Martini, Sukmini Hartati, Endah Widyastuti.....	174
Comparison Analysis of Organic Rice and an Organic Rice Added Value Approach.....	175
Dwi Eva Nirmagustina, Sri Handayani and Luluk Irawati	175
Analysis of Political Connection, Profitability and Capital Intensity Against Tax Avoidance in Coal Companies on The Indonesia Stock Exchange.....	176
Rizki Fitri Amalia.....	176
Human Resource Role and Application of Technology in the Fourth Industrial Revolution	177
Relationship Model among Employee Engagement, Organizational Commitment and Employee Performance	178
Munparidi, L.Suhairi Hazizma & A.Jalaludin Sayuti.....	178
The Effect of Customer Orientation and Service Quality on Trust and Customer Loyalty	179
Gst Ayu Oka Widarti, Esya Alhadi, Elvia Zahara, Titi Andriani.....	179
Fetty Maretha, Yulia Pebrianti, Rini, Lisnini.....	180
E-government Policy, Leadership Commitment, Apparatus Resources Development, and Their Implications on Public Service Performance.....	181
Koesharijadi, Hardiyansyah and Muhamad Akbar.....	181
Industrial Clasterization to Improve The Competitiveness of Small and Medium Industries in The City of Palembang	182
Evada Dewata, Yuli Antina Aryani, Yuliana Sari, Aladin	182
The Influence Of Competence, Leadership, Motivation Work Impact On The Commitment Of Civil State Apparatus In The Office Of The Governor South Sumatera Province	183
Sopian.A.R, Periansya, Ardiyan Natoen, Indra Satriawan.....	183
Analysis Method Economic Value Added (EVA) of Cosmetics Companies Listed on the Stock Exchange Period 2013-2017.....	184
Lupikawaty, Alhamdari, Bustan	184
Anggeraini Oktarida, Eka Jumarni Fithri, Lambok Vera Riama, Sri Hartati	185
The Effect of Hospital Image And Service Quality on Customer Loyalty Through Customer Satisfaction as Intervening Variables in Siti Khadijah Hospital in Palembang City.....	186
Susi Ardiani, Sarikadarwati, Henny Yulsiati, Sandrayati.....	186
The Impact of Village Fund Program Implementation towards Society Welfare in Indonesia	187



The 3rd FIRST 2019
(FORUM IN RESEARCH, SCIENCE, AND TECHNOLOGY)
International Conference

Jl. Sriwijaya Negara Bukit Besar Palembang 30139 South Sumatera – Indonesia
phone +62711 353414 Fax: +62711 355918



Yevi Dwitayanti, Maria Maria, Nurhasanah Nurhasanah, Rosy Armaini	187
Determinants of Village Financial Management Accountability (Study of Villages in Pampangan Sub-District, OKI Regency and Rambutan Sub-District, Banyuasin Regency)	188
Desi Indriasari, Kartika Rachma Sari, Kiagus Zainal Arifin, Choiruddin	188
Evaluation of Sales Price within Calculation Cost of Good Production SMEs Pempek Ilir Barat I and Bukit Kecil District Palembang	189
Elisa, Marieska Lupikawaty, Yusleli Herawati, Purwati.....	189
The Effect of Taxpayer Awareness and Tax Sanctions on Compliance In Paying Land And Building Taxes in Bukit Kecil Sub-District of Palembang.....	190
M. Husni Mubarak, Faridah, Nelly Masnila.....	190
The Environmental Compliance Management of Palm Oil Plantation in Ogan Komering Ilir Regency, Sumatera Selatan, Indonesia	191
M. Yusuf, Yusnizal Firdaus, Markoni Badri, AlHusori	191
Attitude, Motivation, and Parental Involvement towards Students' Reading Comprehension Achievement	192
Nurul Aryanti, Welly Ardiansyah, Murwani Ujihanti	192
Relationship between GPA, Length of Study, and Competence with The Length of Time to Get A Job at Alumni of The Mathematics and Natural Sciences, University of Sriwijaya.....	193
Ali Amran ¹ , Irmeilyana ¹ * and Anita Desiani ¹	193
Testing the Role of Charismatic Leadership, Psychological Climate, and OCB on Resilience	194
Wustari L. Mangundjaya	194
Individual Readiness For Change and Affective Commitment To Change: The Mediation Effect Of Technology Readiness On Public Sector	195
Hermina Agustina Mahendrati, Wustari Mangundjaya.....	195
Leader-Member Exchange and Affective Commitment to Change: Mediating Role of Change Self-Efficacy	196
Dwi Andriani Puspitasari, Wustari L Mangundjaya.....	196
Testing Mediation of Psychological Empowerment, Work Engagement to Affective Commitment to Change	197
Susilo ¹ , Wustari L. Mangundjaya ²	197
Aim, Concept, and Objectives of Education in Islam	198



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Suroso ¹ , Wasitoh Meirani ² , Muhammad Erwin ³ , Ayu Puspasari ⁴	198
Testing the Impacts of Organizational Justice on Affective Commitment to Change with Work Engagement as Mediator.....	199
Yurnalis, Wustari Mangundjaya	199
The Effect of Directed Reading - Thinking Activity on Students' Critical Thinking Abilities.....	200
Eliyeny, Herman, Sunani, Muhammad Nadjmuddin	200
The Development of Teaching Material Speaking 2 Based on Communicative Approach for Students in English Department of State Polytechnic of Sriwijaya.....	201
Darmaliana, Risnawati, Risa, Sri Endah Kusmartini.....	201
Exploring Linkage among Experiential Value, Destination Image and Revisit Intention in Natural-based Tourism.....	202
Heri Setiawan, Taufiq Marwa, Zakaria Wahab, Muchsin Sagaf	202
Students' Perception of English Blended Learning in State Polytechnic of Sriwijaya.....	203
Munaja Rahma, Zakaria, Moehammad Ridhwan.....	203
Online Transportation Technology and Women's Driver Communication Skills.....	204
Pridson Mandiangan, Desloehal Djumrianti, Hanifati	204
The Importance of The Language Experience Approach (LEA) in Teaching Reading Comprehension to The Third Semester of Engineering Students in State Polytechnic of Sriwijaya	205
Zulkifli zulkifli, nian evawati, koryati koryati.....	205
The Effect of Organization Climate on Performance with Job Satisfaction as an Intervening Variable	206
Paisal Paisal, Afrizawati Afrizawati, Divianto Divianto, Yahya	206
The Clustering of Paddy Fields in The Province of South Sumatera as an Input for The Government in Determining Policy.....	207
Suryati, Ahmad Sanmorino	207
The Public Service Quality of The Library Services at The Library Unit of State Polytechnic of Sriwijaya	208
Deri Darfin, Zulkarnaini, Ridwan Effendi, Robinson,.....	208
The Effectiveness of Blended Learning Approach on Essay Writing Subject.....	209
Sri Gustiani, Yusri, Tiur Simanjuntak, Evi Agustinasari.....	209



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Analysis of Student Services at State Polytechnic of Sriwijaya	210
Hadi Winarko, Zaliah, Aimi.....	210
The Effect of Culinary Knowledge and Culinary Experience on Local Culinary Attractiveness.....	211
Heri Setiawan ¹ , Abd. Hamid ² , Ummasyroh ³ & Jusmawi Bustan ⁴	211
Criminal Law Policy In The Crime Of Persecution Carried Out By People Who Come From Outside Orang Rimba Group Against Members Of Orang Rimba Tribe Around The Bukit Duabelas National Park, Jambi Province, Indonesia	212

Optimal Design of Plasticizing Screw Using Artificial Intelligent Approach

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Abstract. This study integrated plasticizing screw analysis software with neural-network in the design of a screw for injection molding application. The qualities of the plasticizing screw selected in this study are output rate, melt temperature variation at the end of metering zone, the specific mechanical energy (SME), and the melting distance. The Taguchi orthogonal array is implemented to carry out the experiment and to obtain the test data for training the neural network. The Back-propagation Neural Network (BPNN) was then used for screw quality predictor, and optimal design was solved with Genetic Algorithm (GA). The optimal screw design for a diameter of 25 mm screw for molding PC resin in this study is 5.37D in solid conveying zone, 9D in compression zone, metering zone depth of 2.44 mm, and flight width of 3 mm. The performance of this screw with the preset processing condition can have the temperature difference at the end of metering (ΔT) of 5.67°C, the output rate Q of 20.12 kg/h, the SME of 520.80 (kJ/kg), and the plastics completely melted at 17.39D.

1. Introduction

A plasticizing screw is an important part of an injection molding machine as it is responsible for melting, mixing, metering, and conveying the plastic material inside the barrel. Thus, plasticizing screw should be the heart of an injection molding machine. The standard three-zone plasticizing screw, as shown in Figure 1, is the most common screw in the injection molding machine. Four different objectives should be considered in the design of a plasticizing screw and they are dispersive mixing, distributive mixing, plasticizing capacity, and the consistency of melting temperature of plastic material [1]. Energy is one of the most concerned issues in the molding industry, and the design of the plasticizing should as well consider the energy consumption [2].



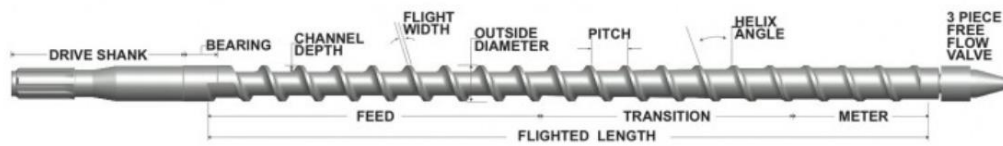


Figure 1. General Scheme of an Injection Molding Screw [3]

Since there is no standardized and integrated theory in designing plasticizing screw, the screw design was done by experienced engineers through trial and error process in the past. In recent years, with the advancement of computing technology and the development of plasticizing screw analysis software, computer-aided screw design becomes realistic. Altmann et al. [4] used a simulation software to study the standard three-zone plasticizing screw. Wagner et.al [5] used FLOW 2000 simulation software and experimental design to study extrusion screw performance and to search for the response of extruder system. Instead of trial and error method, Wang and Lin [6] have demonstrated an optimal screw design process with Taguchi method using Moldex3D ScrewPlus injection molding screw analysis software. The use of Taguchi Method can reduce the practice of experiments compared to the conventional trial and error method, because it's more efficient and time and cost saving [7-9]. Zhang et al. [10] and Wang and Lin [6] have applied Taguchi method to design injection screws for molding PMMA and PC materials. A design with preferable quality within the preset range of parameters can be obtained but the Taguchi Method cannot obtain continuous and global optimum design. Unlike the Taguchi Method, the neural network optimization method can reach continuous and global optimum design in problem analysis, and it is used to resolve the problem in optical design and parameter analysis in injection molding [11]. A back propagation neural network (BPNN), shown in Figure 2, was first built and trained as a quality predictor, then Genetic Algorithms (GA) was successfully applied in developing an LED lens and also finding the optimal molding parameters [12][13].

This study proposes an optimal design process integrating BPNN, GA, and screw analysis software for injection screw design. To demonstrate this optimal design process, an injection screw design for compact disk (CD) molding application will be carried out in this study.

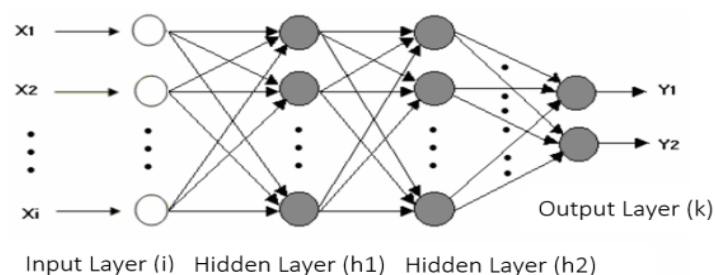


Figure 2. Architecture Diagram of Back Propagation Neural Network

2. Method and Procedure

Moldex3D ScrewPlus is a plasticizing screw simulation software that can provide the plastics

properties during plasticizing process with given screw design and the processing parameters, and the user can estimate the performance of the screw with the simulation results. In this study, the ScrewPlus simulation will be used to observe the performance of the screw for molding compact disks (CD). The material for this study is a PC resin (GE plastics). The design parameters of a standard three-zone screw generally are its diameter, pitch, length of the three zones, flight width, feed depth, and compression ratio (the ratio of feed depth to metering depth) [6]. Though all the parameters have effects on the screw performance, four different parameters (feeding zone length, compression zone length, metering zone depth, and flight width) are chosen in this experiment. For a CD molding machine, the tonnage is around 50 tons and with a screw of ϕ 25 mm and 20 in L/D. To train the BPNN, 27 sets of simulations will be prepared first, L27 orthogonal array is chosen to devise the experimental plan, each of the four selected design parameters with 3 different levels as shown in Table 1. Four quality characteristics selected to measure the overall performance of the screw in this study are melt temperature difference (ΔT) at the end of the metering zone, output rate of the screw (Q), specific mechanical energy (SME), and the distance that plastics melted completely (MD). Some of the screw design parameters and the molding parameters are kept the same as previous research done by Wang and Lin [6]. The pitch of the screw is 26.5 mm, compression ratio is 3. The processing parameters are 140 rpm, feeding zone temperature 300°C, back pressure 0.45 MPa, injection volume 18.379 cc, and injection stroke 37.443 mm. The parameter combinations of the 27 experiments are listed in Table 2.

Table 1. Design Parameters and Values at Different Levels

Standard Parameter	1	2	3
Feed zone length W (D)*	4	5	6
Compression zone length X (D) *	9	10	11
Metering zone depth Y (mm)	1.69	2.03	2.54
Flight width Z (mm)	3	3.5	4

*: the length is presented is D, diameter of the screw

Table 2. L27 Orthogonal Array Combination

Number	W	X	Y	Z	Number	W	X	Y	Z	Number	W	X	Y	Z
1	1	1	1	1	10	2	1	1	1	19	3	1	1	1
2	1	1	2	2	11	2	1	2	2	20	3	1	2	2
3	1	1	3	3	12	2	1	3	3	21	3	1	3	3
4	1	2	1	2	13	2	2	1	2	22	3	2	1	2
5	1	2	2	3	14	2	2	2	3	23	3	2	2	3
6	1	2	3	1	15	2	2	3	1	24	3	2	3	1
7	1	3	1	3	16	2	3	1	3	25	3	3	1	3
8	1	3	2	1	17	2	3	2	1	26	3	3	2	1

9 1 3 3 2 18 2 3 3 2 27 3 3 3 2

3. Result and Discussion

The parameters setting of the BPNN and the GA for this experiment is listed in Table 3 and Table 4. The four selected screw design parameters and the four quality characteristics obtained from ScrewPlus simulation are fed into the BPNN to train the neural network. Figure 3 shows the BPNN training convergent map. After BPNN training is completed, the GA is applied to obtain the optimal parameters with the following objective function:

$$Obj = (\Delta T - \Delta T_{min})^2 + (Q - Q_{max})^2 + (SME - SME_{min})^2 + (MD - MD_{min})^2$$

where ΔT is the melt temperature difference at the end of metering zone, ΔT_{min} is the minimum melt temperature of the 27 sets training data, Q is the output rate, Q_{max} is the maximum output rate of the 27 sets, SME is the specific mechanical energy, SME_{min} is the minimum specific mechanical energy of the 27 sets, MD is the complete melted distance and MD_{min} is the minimum complete melted distance of the 27 sets. Through BPNN and GA search, the values of the design parameters as well as the quality characteristics are listed in Table 5. The quality characteristics of the 27 training sets and those of the optimal design are shown in Figure 4.

Table 3. Arrangement of the Neural Network Parameters

The input layer	4 Neurons
Hidden layer	1 Layer, 10 Neurons
Output layer	4 Neurons
The transfer function	Double bend function
Learning rate	0.7 Decreasing by batch
Normalized range	0.1~0.9
Stop condition	Iteration 15000 Times or error threshold
Training materials	27 Pieces
Test data	5 Times

Table 4. Search Parameters for Genetic Algorithm

	Feeding zone length (D)	Compression zone length (D)	Metering zone depth (mm)	Flight width (mm)
Upper bound	6	11	2.54	4
Lower bound	4	9	1.69	3

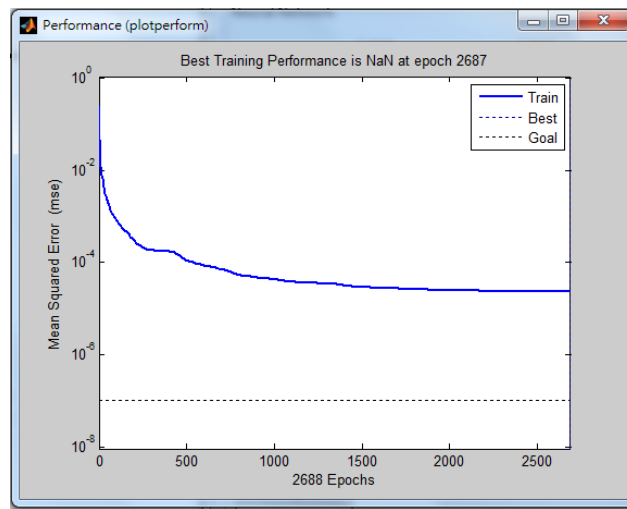
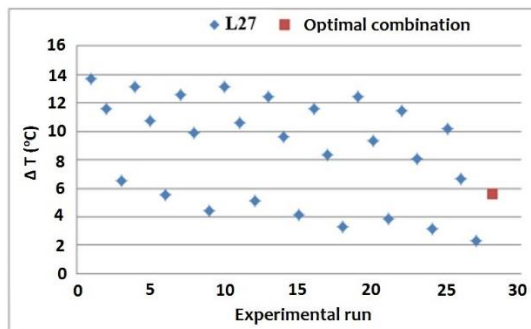


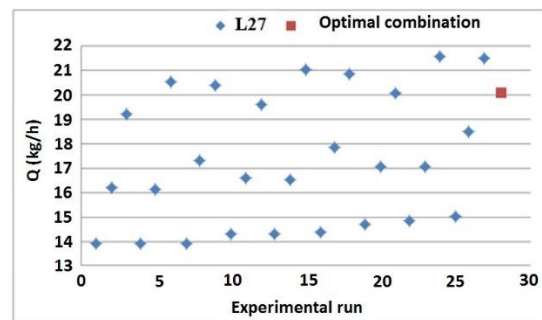
Figure 3. Back Propagation Neural Network Training Convergence Map

Table 5. Best Combination of Design Parameters

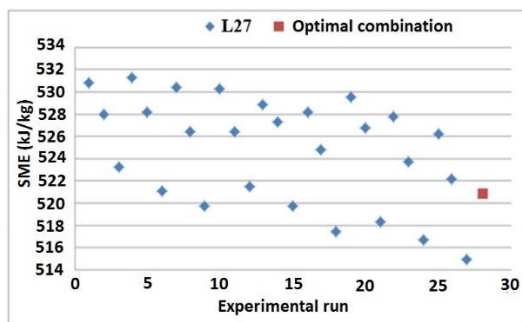
Design parameters					Quality characteristics		
A	B	C	D	ΔT	Q	SME	Melted distance
5.37	9.00	2.44	3	5.67	20.12	520.80	17.39



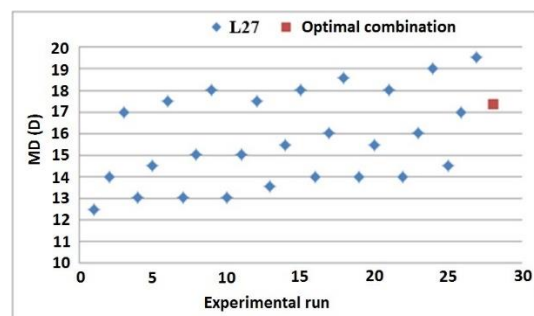
a. Temperature Difference at the End of Metering



b. The Output Rate



c. Specific Mechanical Energy



d. Complete Melted Distance

Figure 4. Screw Performance

The optimal performance of the screw considered all the four quality characteristics, each of the quality characteristic is not the maximum or the minimum compared to the other 27 runs shown in

Figure 4. The best design parameter values of this PC screw design for CD molding example are as follows: feeding zone length of 5.37D, compression zone length of 9D, metering zone depth of 2.44 mm, and flight width of 3 mm.

4. Conclusion

This study has proposed and demonstrated technology integration in computer-aided plasticizing screw design. The ScrewPlus can provide meaningful details of the plastics properties inside the barrel during plasticizing process, that will help engineers to estimate the performance of the screw before actually making it. Besides, design plasticizing screws with simulation software together with Taguchi experimental method or neural network optimization methods can save a lot of time and cost. Unlike experimental method with real screws, no screws have to be made before the best performance screw is designed using computer-aided simulation.

Unlike the Taguchi Method, the optimal design values of the four parameters studied in this experiment are not limited in the combination of the preset levels, it shows again that the neural network optimization method can create continuous and global optimum design in problem analysis.

This study considers four screw quality characteristics in the optimal design process as a demonstration and any quality characteristics combination can be selected to modify the objective function to come up with the best performance screw design for the specific applications.

Acknowledgment

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