CONFERENCE BOOK

BURSA
1. ULUSLARARASI
MATEMATİK VE MÜHENDİSLİK
KONGRESİ

18 - 20 Ağustos 2023
Bursa

YÜZYÜZE ve ONLINE

BURSA
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING SCIENCES
August 18 - 20, 2023 - Bursa

ISBN : 978-625-6830-23-3

ACADEMY GLOBAL PUBLISHING HOUSE

BURSA
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING SCIENCES
AUGUST 18 - 20, 2023

BURSA

Edited By

PROF. DR. ELİF AKPINAR KÜLEKÇİ

Issued: 10.09.2023

ISBN: 978-625-6830-23-3

CONFERENCE ID

BURSA
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING SCIENCES

DATE – PLACE
AUGUST 18 - 20, 2023
BURSA

ORGANIIZATION
ACADEMY GLOBAL CONFERENCES

EVALUATION PROCESS
All applications have undergone a double-blind peer review process.

PARTICIPATING COUNTRIES
Turkey – India – Australia – Malaysia – USA- Kuwait - Egypt

PRESENTATION
Oral presentation

PERCENTAGE OF PARTICIPATION
45% FROM Turkey And 55% From Other Counteries

LANGUAGES
Turkish, English, Russian, Persian, Arabic

Scientific & Review Committee

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023
Bursa

Join Zoom Meeting
https://us02web.zoom.us/j/88193707664?pwd=MEZBL3M0SlArNWVsMjV0YUJkR3lIQT09

Meeting ID: 881 9370 7664
Passcode: 123456

ÖNEMLİ AÇIKLAMA (Lütfen okuyunuz)

- ZOOM bağlantısı için yukarıda verilen bağlantıyı veya yine yukarıda verilen giriş bilgilerini kullanabilirsiniz.
- Moderatörün oturum düzenini gözetmesi, akademisyen adaylarını yönlendirmesi beklenmektedir.
- Zoom'a bağlanırken isminizin önüne salon numaramızı yazmanız rica ederiz. (isminiz programda olduğu gibi tam olarak yazılmalıdır. Sadece isim, kısaltılımış isim veya soyisim, cihaz adı OLMAMALIDIR)
- Sunum süresi 10 ve soru cevap süresi maximum 5 dakikadır. Bu sürenin aşılmamasını moderatörler temin edecektir.
- Sunumlar TÜRKÇE veya İNGİLİZCE yapılabilmektedir.
- Kameralar, oturum süresince toplam % 70 oranında açık olmak zorundadır.
- Sunum yapan katılımcının kamerası açık olmak zorundadır.
- Sunum yapmak zorunludur. Herhangi bir nedenle sunum yapmamış olan katılımcıya sertifika verilmesi ve çalışmasının yayınlanması sözkonusu olamaz.
- Katılımcı, bulunduğu oturumda, oturum bitene kadar bulunmak zorundadır.
- Katılımcıların kendi oturumları dışındaki oturumlara katılma zorunluluğu yoktur.
- ZOOM platformunun kapasite sınırı nedeniyle, DİNLEYİCİ, sadece kapasite izin verdiği sürece kabul edilebilmektedir.

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:00 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı / Session Chair		Bildiri No ve Başlığı / Paper ID and Title	Authors
Salon 1	Dr. Öğr. Üyesi Tuğba Bilgehan	1	CONSUMING KIWI FRUIT HAS HEALTH BENEFITS, AND USING CARBON DOTS IN CANCER NANOMEDICINE PRESENTS OPPORTUNITIES AND CHALLENGES IN RELATION TO PHARMACOLOGICAL ACTIONS	Assist. Prof. Dr. K.R.Padma K.R.Don Assist. Prof. M. Reshma Anjum Assist. Prof. M. Sankari
		2	GELENEKSEL VE TAMAMLAYICI TIP YÖNTEMLERİNDEN HACAMATIN HİPERTANSİYON ÜZERİNE ETKİSİ	Hülya TÜRKÇAPAR Dr. Öğr. Üyesi Tuğba Bilgehan
		3	TİP 1 DİYABET VE DİJİTAL SAĞLIK OKURYAZARLIĞI	Adife Ahsen Çetin Dr. Öğr. Üyesi Tuğba Bilgehan
		4	TIP EĞİTİMİNDE KÖTÜ HABER VERME YETENEĞİ	Ferhat Coşkun
		5	PROFESYONEL FUTBOLCULARIN OYUN POZİSYONLARINA GÖRE FİZİKSEL UYGUNLUKLARIN İNCELENMESİ	Yusuf Buzdağlı
		6	BAKIM VERME YÜKÜ: ETKİLEYEN FAKTÖRLER VE ÇÖZÜM ÖNERİLERİ	Rukiye DEMİR DİKMEN
		7	EGZERSİZ TERAPİLERİ: SAĞLIK ÜZERİNE ETKİLERİ	Rukiye DEMİR DİKMEN

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:00 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
SALON 2	Assoc. Prof. Dr. Bünyamin SARİKAYA	1	A Semiotic Theory of Language in EFL Context	Dr. Öğretim üyesi Serda Güzel
		2	MİLLİ EĞİTİM BAKANLIĞI'NA BAĞLI OKULLARDA ERASMUS+KA2 STRATEJİK ORTAKLIK PROJELERİNE KATILAN ÖĞRETMENLERİN KÜLTÜRLERARASI İLETİŞİM YETERLİLİKLERİNE İLİŞKİN GÖRÜŞLERİ	Mustafa Oruç Dr. Öğr. Üyesi Şule KARADAĞ ALÇI
		3	THE PRESENCE OF SPEAKING METHODS AND TECHNIQUES IN TURKISH TEXTBOOK ACTIVITIES	Doç. Dr. Bünyamin SARİKAYA
		4	CREATIVE WRITING IN TEXTBOOKS: GRADE 7 TURKISH TEXTBOOK SAMPLE	Assoc. Prof. Dr. Bünyamin SARİKAYA
		5	MÜZİK EĞİTİMİ YAZILIMLARINDA UNITY OYUN MOTORU	Yusuf Özgül
		6	INVESTIGATION OF GRADUATE THESES RELATED TO STEM IN PRESCHOOL IN TÜRKİYE	İlknur ADIYAMAN Doç. Dr. Bünyamin HAN
			YENİ NESİL ENDÜSTRİDE İŞ SAĞLIĞI VE GÜVENLİĞİ	Evren Çağlarer
		7	OSMANLI TARİHİNDE "KARDEŞ KATLİ" KAVRAMI HAKKINDA	Doç.Dr. Sevinç RUİNTAN
		8	TURKISH LANGUAGE CONTACTS	Prof. Hajar Huseynova

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:00 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
SALON 3	Assist. Prof. Dr. Olcay TİRE	1	Z KUŞAĞININ VATANDAŞLIK OKURYAZARLIĞI	Mehmet Kapusızoğlu Selda Uçar
		2	Political and economic relations between Azerbaijan and the European Union	Assoc. Yeqana Aliyeva
		3	SÜRDÜRÜLEBİLİR KALKINMA İÇİN BİR ALTERNATİF: CİTTASLOW HAREKETİ	YL Öğr. Hatice ARSLANPARÇASI Prof. Dr. Ersan ÖZ
		4	İBN TEYMİYYE DÜŞÜNCESİNDE TAŞIYICI-NİTELİK BÜTÜNLÜĞÜ	Arş. Gör. Cihan Özaykan
		5	THE EFFECT OF RELIGIOSITY TENDENCY ON GENDER PERCEPTION	Assist. Prof. Dr. Olcay TİRE
		6	INVESTIGATION OF THE RELATIONSHIP BETWEEN WORK-FAMILY CONFLICT AND BURNOUT LEVELS AMONG SOCIAL WORKERS WORKING IN PRIVATE CARE CENTERS	Öğr. Gör. Cezmi ERVÜZ Öğr. Gör. Ahmet TÜRK
		7	DAİRƏVİ İQTİSADİYYAT- DAVAMLI İNKİŞAFIN YENİ YOLU	Pərvin Verdiyeva
		8	KURAN İSLAMCILARININ TASAVVUFUN KAYNAKLIĞINA İLİŞKİN ÖZCÜ BAKIŞI	Filiz Orhan

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:00 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
SALON 4	Dr. Öğr. Üyesi Oğuzhan ÖZÇELİK	1	DÜNYA'DA KADINLARIN ÇALIŞMA HAYATINI ETKİLEYEN FAKTÖRLERİN K-ORTALAMALAR ALGORİTMASIYLA ANALİZİ	Dr. Şebnem KOLTAN YILMAZ
		2	ƏRZAQ TƏHLÜKƏSİZLİYİNİN TƏMİN OLUNMASINDA BEYNƏLXALQ TİCARƏTİN ROLU	Jalə Dadaşova
		3	DİJİTAL PAZARLAMADA CHATGPT TEKNOLOJİSİ VE MÜŞTERİ DENEYİMİ	Muhammed Fatih CEVHER
		4	ARTAN PETROL FİYATLARI OPEC+ ÜLKELERİNDE HOLLANDA HASTALIĞINA SEBEP OLUYOR MU? EKONOMETRİK BİR ANALİZ	Dr. Öğr. Üyesi Oğuzhan ÖZÇELİK
		5	KENT MARKALAMA STRATEJİSİ OLARAK TURİZM	Öğr. Gör. Cihad DOĞAN
		6	ANALYSIS OF VIOLENCE AGAINST WOMEN IN TURKISH TELEVISION SERIES: THE THREE SISTERS TV SERIES	Dr. Şebnem CEYLAN APAYDIN
		7		

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:00 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
SALON 5	Prof. Dr. Erol Feyzullahoğlu	1	ALÜMİNYUM ESASLI YATAK MALZEMELERİNİN ABRAZİV AŞINMASINA ALAŞIM ELEMENTLERİNİN ETKİLERİNİN İNCELENMESİ	Prof. Dr. Erol Feyzullahoğlu
		2	SULU ORTAMLARDAKİ SALİSİLİK ASİTİN STRES KOŞULLARI ALTINDA DEGRADASYONUNUN İNCELENMESİ	Burçin Yıldız
		3	BLENDS OF POLYLACTIC ACID POLYMERS: PROPERTIES, FUNCTIONAL APPLICATION	Nihayet KOÇYİĞİT
		4	A MINI-REVIEW ON ROPE TECHNOLOGIES IN THE MARINE INDUSTRY	Ph.D. Candidate, Ömer Fırat TURŞUCULAR Ph.D. Candidate, Elif Dicle TURŞUCULAR Assistant Professor, Alhayat Getu TEMESGEN
		5	YÜKSEK DEVİR SAĞLAYICI KULLANILARAK FREZELEME OPERASYONLARINDA KESME PARAMETRELERİNİN YÜZEY PÜRÜZLÜLÜĞÜ VE GÜÇ TÜKETİMİNE ETKİSİNİN İNCELENMESİ	Hüseyincan SAĞIR Barkın BAKIR
		6		

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 1	Ketan Christi	1	THE ALTERATIONS OF SOME PANCREAS GLAND HORMONES AFTER AN AEROBIC STRENUOUS EXERCISE IN MALE STUDENTS	M. Javad Pourvaghar, A. Reza Shahsavar
		2	INFLUENCE OF SOCIAL FACTORS AND MOTIVES ON COMMITMENT OF SPORT EVENTS VOLUNTEERS	Farideh Sharififar, Zahra Jamalian, Reza Nikbakhsh, Zahra Nobakht Ramezani
		3	FOOD HABİTS AND NUTRİTİONAL STATUS OF FİJİ RUGBY PLAYERS	Jimaima Lako, Subramaniam Sotheeswaran, Ketan Christi
		4	INFLUENCE OF STRENGTH ABILITIES ON QUALITY OF THE HANDSTAND	P. Hedbávný, G. Bago, M. Kalichová
		5	DİSTİNGUİSHİNG PLAYİNG PATTERN BETWEEN WİNNİNG AND LOSİNG FİELD HOCKEY TEAM İN DELHİ FIH ROAD TO LONDON 2012 TOURNAMENT	Sofwan N., Norasrudin S., Redzuan P., Mubin A.
		6	OBJECTİVİTY, RELİABİLİTY AND VALİDİTY OF THE 90º PUSH-UPS TEST PROTOCOL AMONG MALE AND FEMALE STUDENTS OF SPORTS SCİENCE PROGRAM	Ahmad Hashim, Mohd Sani Madon
		7	BİOMECHANİCAL ANALYSİS OF THE BASİC CLASSİCAL DANCE JUMP – THE GRAND JETÉ	M. Kalichová
		8	ON THE ANALYSİS OF A COMPOUND NEURAL NETWORK FOR DETECTİNG ATRİO VENTRİCULAR HEART BLOCK (AVB) İN AN ECG SİGNAL	Salama Meghriche, Amer Draa, Mohammed Boulemden

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 2	Asst. Prof. Philip T. Roundy	1	AN APPROACH FOR INTEGRATION OF INDUSTRIAL ROBOT WITH VISION SYSTEM AND SIMULATION SOFTWARE	Ahmed Sh. Khusheef, Ganesh Kothapalli, Majid Tolouei-Rad
		2	PEOPLE CRITICAL SUCCESS FACTORS OF IT/IS IMPLEMENTATION: MALAYSIAN PERSPECTIVES	Aziz, Nur Mardhiyah, Salleh, Hafez
		3	Thics İn The Technology Driven Enterprise	Bobbie Green, James A. Nelson
		4	STUDIES ON THE FEASIBILITY OF COW DUNG AS A NON-CONVENTIONAL ENERGY SOURCE	Raj Kumar Rajak, Bharat Mishra
		5	REFİNİNG WASTE SPENT HYDROPROCESSİNG CATALYST AND THEİR METAL RECOVERY	Meena Marafi, Mohan S. Rana
		7	OİL RECOVERY STUDY BY LOW TEMPERATURE CARBON DİOXİDE INJECTİON İN HİGH-PRESSURE HİGH-TEMPERATURE MİCROMODELS	Zakaria Hamdi, Mariyamni Awang
		8	IMPACT OF EGYPT’S ENERGY DEMAND ON OİL AND GAS POWER SYSTEMS ENVİRONMENT	Moustafa Osman Mohamed

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 3	Chanokporn Angsuviriya	1	READING STRATEGY AWARENESS OF ENGLISH MAJOR STUDENTS	Hsin-Yi Lien
		2	THE COMPARATIVE ANALYSIS OF MICRO-READING AND TRADITIONAL READING BASED ON SCHEMA THEORY	Haiyan Wang
		3	STUDENTS´ KNOWLEDGE, OR RANDOM CHOICE IN ESP?	Ivana Šimonová
		4	A DEVELOPMENT OF ENGLISH PRONUNCIATION USING PRINCIPLES OF PHONETICS FOR ENGLISH MAJOR STUDENTS AT LOEI RAJABHAT UNIVERSITY	Pongthep Bunrueng
		5	EFL TEACHERS’ METACOGNITIVE AWARENESS AS A PREDICTOR OF THEIR PROFESSIONAL SUCCESS	Saeedeh Shafiee Nahrkhalaji
		6	LINGUISTIC DEVICES REFLECTING VIOLENCE IN BORDER–PROVINCES OF SOUTHERN THAILAND ON THE FRONT PAGE OF LOCAL AND NATIONAL NEWSPAPERS	Chanokporn Angsuviriya
		7	GRADING AND SEQUENCING TASKS IN TASK-BASED SYLLABUS: A CRITICAL LOOK AT CRITERION SELECTION	Hossein Ahmadi, Ogholgol Nazari
		8	THE IMPACT OF GENDER DIFFERENCES ON THE EXPRESSIONS OF REFUSAL IN JORDANIAN ARABIC	Hanan Yousef, Nisreen Naji Al-Khawaldeh

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 4	Ilkka J. Virtanen	1	COGNITIVE EMOTION REGULATION IN CHILDREN IS ATTRIBUTABLE TO PARENTING STYLE, NOT TO FAMILY TYPE AND CHILD'S GENDER	AKM Rezaul Karim, Tania Sharafat, Abu Yusuf Mahmud
		2	MULTI-VIEW NEURAL NETWORK BASED GAIT RECOGNITION	Saeid Fazli, Hadis Askarifar, Maryam Sheikh Shoaie
		3	HOW VALID ARE OUR LANGUAGE TEST INTERPRETATIONS? A DEMONSTRATIVE EXAMPLE	Masoud Saeedi, Shirin Rahimi Kazerooni, Vahid Parvaresh
		4	EXPLORING LIFE MEANINGFULNESS AND ITS PSYCHOSOCIAL CORRELATES AMONG RECOVERING SUBSTANCE USERS – AN INDIAN PERSPECTIVE	Fouzia Alsabah Shaikh, Anjali Ghosh
		5	TOWARDS BETTER UNDERSTANDING OF THE CONCEPT OF TACIT KNOWLEDGE – A COGNITIVE APPROACH	Ilkka J. Virtanen
		6	DEVELOPMENT OF ORGANIZATIONAL JUSTICE IN INCENTIVE ALLOCATION OF THE THAI PUBLIC SECTOR	Kalayanee Koonmee
		7	ON THE NEED TO HAVE AN ADDITIONAL METHODOLOGY FOR THE PSYCHOLOGICAL PRODUCT MEASUREMENT AND EVALUATION	Corneliu Sofronie, Roxana Zubcov
		8	TREATMENT OR RE-VICTIMIZING THE VICTIMS	Juliana Panova
		9	CULTURAL ANXIETY AND ITS IMPACT ON STUDENTS- LIFE: A CASE STUDY OF INTERNATIONAL STUDENTS IN WUHAN UNIVERSITY	Nadeem Akhtar, Shan Bo

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 5	J. Samuel Jesudoss	1	ATTACHMENT STYLES OF CHILDREN RAISED IN NURSERY VS. THOSE WHO ARE RAISED IN THE FAMILY IN IRAN	Narges Razeghi
		2	DETERMINANTS OF AGGRESSION AMONG YOUNG ADOLESCENTS	Rita C. Ramos
		3	TALENT IN AUTISM: COGNITIVE STYLE BASED ON WEAK CENTRAL COHERENCE AND SPECIAL SENSORY CHARACTERISTICS IN STATE OF KUWAIT: CASE STUDY	Mariam Abdulaziz Y.Esmaeel
		4	THE DETERMINANTS AND OUTCOMES OF PATHOLOGICAL INTERNET USE (PIU) AMONG URBAN MILLENNIAL TEENS: A THEORETICAL FRAMEWORK	Pressca Neging, Rosidah Musa, Rabiah Abdul Wahab
		5	USE OF A LEARNER'S LOG FOR EFFECTIVE SELF-DIRECTED LEARNING IN PBL	Amudha Kadirvelu, Sivalal Sadasivan
		6	NEGATIVE EMOTIONS AND WAYS OF OVERCOMING THEM IN PRISON	Katarzyna Czubak
		7	EVALUATION OF INTERNET ANXIETY IN SRBIAU HIGHER EDUCATION STUDENTS IN RESEARCH PROCESS	Nima Babazadeh Gashti, Nazanin Pilevari
		8	THE DEVELOPMENT OF POSITIVE EMOTION REGULATION STRATEGIES SCALE FOR CHILDREN AND ADOLESCENTS	Jia-Ru Li, Ching-Wen Lin
		9	EFFICACY OF SELECTED MOBILITY EXERCISES AND PARTICIPATION IN SPECIAL GAMES ON PSYCHOMOTOR ABILITIES, FUNCTIONAL ABILITIES AND GAME PERFORMANCE AMONG INTELLECTUALLY DISABLED CHILDREN OF UNDER 14 AGE	J. Samuel Jesudoss

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 6	Analiza Acuña-Villacorte	1	PROJECT AND EXPERIMENT-BASED FLUID DYNAMICS EDUCATION	Etsuo Morishita
		2	A STUDY OF PRIMARY SCHOOL PARENTS’ INTERACTION WITH TEACHERS’ IN MALAYSIA	Shireen Simon
		3	STUDENTS’ PERCEPTIONS OF MOBILE LEARNING: CASE STUDY OF KUWAIT	Rana AlHajri, Salah Al-Sharhan, Ahmed Al-Hunaiyyan
		4	THE IMPACT OF COOPERATIVE LEARNING ON NUMERICAL METHODS COURSE	Sara Bilal, Abdi Omar Shuriye, Raihan Othman
		5	MECHANISMS IN REGULATING LANGUAGE PRACTICES IN ELECTRONICS ENGINEERING: A PROGRAM PLAN FOR OUTCOMES-BASED EDUCATION	Analiza Acuña-Villacorte
		6	EXPERIMENTING THE INFLUENCE OF INPUT MODALITY ON INVOLVEMENT LOAD HYPOTHESIS	Mohammad Hassanzadeh
		7	A PROPOSED PROGRAM FOR POSTGRADUATES IN EGYPT TO ACQUIRE THE SKILLS AND TECHNIQUES FOR PRODUCING CONCEPT CARTOONS FOR KINDERGARTEN CHILDREN	Ahmed Amin Mousa, M. Abd El Salam
		8	THE MANAGEMENT AND FUNDING OF EDUCATION IN NIGERIA	Teryima Oralu, Babatunde Kasim Oladele
		9	THE EFFECT OF THE ANDALUS KNOWLEDGE PHASES AND TIMES MODEL OF LEARNING ON THE DEVELOPMENT OF STUDENTS’ ACADEMIC PERFORMANCE AND EMOTIONAL QUOTIENT	Sobhy Fathy A. Hashesh

BURSA
1ST INTERNATIONAL CONFERENCE ON HEALTH AND SPORT SCIENCES
1ST INTERNATIONAL CONFERENCE ON MATHEMATIC AND ENGINEERING
1ST INTERNATIONAL CONFERENCE ON HUMANITY AND SOCIAL SCIENCES
August 18 - 20, 2023

19 Ağustos/ August 19, 2023 / 11:30 – 13:00 Time zone in Turkey (GMT+3)

Salon / Hall	Oturum Başkanı		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL 7	Heba Mustafa Abdullah	1	MILLENNIAL TEACHERS OF CANADA: INNOVATION WITHIN THE BOXED-IN CONSTRAINTS OF TRADITION	Lena Shulyakovskaya
		2	EMPLOYING QR CODE AS AN EFFECTIVE EDUCATIONAL TOOL FOR QUICK ACCESS TO SOURCES OF KINDERGARTEN CONCEPTS	Ahmed Amin Mousa, M. Abd El-Salam
		3	SERVICES-ORIENTED MODEL FOR THE REGULATION OF LEARNING	Mohamed Bendahmane, Brahim Elfalaki, Mohammed Benattou
		4	IMPROVING LISTENING COMPREHENSION FOR EFL PRE-INTERMEDIATE STUDENTS THROUGH A BLENDED LEARNING STRATEGY	Heba Mustafa Abdullah
		5	GRAPHIC ANIMATION: INNOVATIVE LANGUAGE LEARNING FOR AUTISTIC CHILDREN	Norfishah Mat Rabi, Rosma Osman, Norziana Mat Rabi
		6	EXPLORATION OF INFLUENTIAL FACTORS ON FIRST YEAR ARCHITECTURE STUDENTS' PRODUCTIVITY	Shima Nikanjam, Badiossadat Hassanpour, Adi Irfan Che Ani
		7	QUALITY AND QUANTITY IN THE STRATEGIC NETWORK OF HIGHER EDUCATION INSTITUTIONS	Juha Kettunen
		8	DIFFERENT ROLES FOR MENTORS AND MENTEES IN AN E-LEARNING ENVIRONMENT	Nidhi Gadura
		9	DESIGNING INFORMATION SYSTEMS IN EDUCATION AS PREREQUISITE FOR SUCCESSFUL MANAGEMENT RESULTS	Vladimir Simovic, Matija Varga, Tonco Marusic

Contents

IMPACT OF EGYPT'S ENERGY DEMAND ON OIL AND GAS POWER SYSTEMS ENVIRONMENT

Moustafa Osman Mohamed

Alexandria University. Egypt

Abstract:

This paper will explore the influence of energy sector in Arab Republic of Egypt which has shared its responsibilities of many environmental challenges as the second largest economy in the Middle East (after Iran). Air and water pollution, desertification, inadequate disposal of solid waste and damage to coral reefs are serious problems that influence environmental management in Egypt. The intensive reliance of high population density and strong industrial growth are wearing Egypt's resources, and the rapidly-growing population has forced Egypt to breakdown agricultural land to residential and relevant use of commercial ingestion. The depletion effects of natural resources impose the government to apply innovation techniques in emission control and focus on sustainability. The cogeneration will be presented to control thermal losses and increase efficiency of energy power system.

Keywords: Cogeneration, energy indicators, power plant, electricity, environmental loads, environmental impact assessment.

SULU ORTAMLARDAKİ SALİSİLİK ASİTİN STRES KOŞULLARI ALTINDA DEGRADASYONUNUN İNCELENMESİ

Burçin Yıldız

Van Yüzüncü Yıl Üniversitesi – ORCID ID: 0000-0001-9750-7278

ÖZET

Farmasötikler, tamamen metabolize edilmeden büyük oranda vücuttan atılmakta ve klasik biyolojik arıtım prosesleri ile tamamen giderilememektedir. Alıcı su ortamlarına ulaşan bu aktif maddeler sudaki organizmaları olumsuz etkilemekte, toksisiteye ve ilaca karşı dirençli genlerin gelişmesine sebep olmaktadır. Bu bileşikler için alternatif arıtım teknolojilerinin geliştirilmesi önem arz etmektedir. İlaç moleküllerinin kimyasal stabilitesi, bahsedilen arıtım yöntemlerinin geliştirilmesinde oldukça önemlidir. Bu çalışmada 100 mg/L başlangıç derişimine sahip salisilik asitin stabilitesi, hidroliz için pH 2, 4, 6, 8 ve 1 M HCl ortamında; oksidasyon için, % 0.1, % 0.5, % 1, % 2 ve % 3 H_2O_2 mevcudiyetinde, fotoliz için 18, 24 ve 42 W ışık varlığında ve sıcaklık için 25, 37 ve 60 °C'de saf su ve musluk suyu için ayrı ayrı incelenmiştir. Hidroliz çalışması sırasında 1 M HCl mevcudiyetinde daha hızlı ve yüksek degradasyon meydana gelmiştir ve pH değişimlerinde çok büyük degradasyon farklılıkları gözlenmemiştir. 5 günün sonunda saf suda molekülün maksimum %12'si musluk suyunda ise %27'si parçalanmıştır. Oksidasyon çalışmasında H_2O_2 konsantrasyonu arttıkça degradasyon artmış ve 5 günün sonunda %3 H_2O_2 varlığında salisilik asitin saf su ve musluk suyu için sırasıyla %19 ve %51'i degrade olmuştur. Fotoliz şartlarında saf suda kısmi verim artışı meydana gelirken musluk suyunda 42 W'da yüksek bir artış gözlenmiştir. 42 W için saf suda salisilik asitin %11'i, musluk suyunda %97'si degrade olmuştur. Sıcaklığın etkisi 60 °C'de daha belirgin olarak gözlenmiş ve 5 günün sonunda saf suda %18, musluk suyunda %32 degradasyon gerçekleşmiştir. Musluk suyunda elde edilen daha yüksek degradasyon verimleri, salisilik asitin degradasyonunun yabancı iyonların varlığından daha çok etkilendiğini göstermiştir.

Anahtar Kelimeler : stres koşulları, degradasyon, salisilik asit, stabilite

BLENDS OF POLYLACTIC ACID POLYMERS: PROPERTIES AND FUNCTIONAL APPLICATION

Nihayet KOÇYİĞİT

Batman Üniversity, Chemistry Department, **ORCID ID:**0000-0002-3472-1127

ABSTRACT

Polylactic acid is a semicrystalline aliphatic thermoplastic polyester. With a variety of uses from industrial to civilian, polylactic acid has tremendous economic value and extremely good market prospects. It is suited for a variety of processing methods, including melt-extrusion moulding, injection moulding, blown film moulding, foam moulding, vacuum moulding, film extrusion, thermoforming due to its high tensile strength and flexibility.

Innate deficiencies of polylactic acid such as high stiffness, poor ductility, brittleness limit its use in engineering applications. Thus, it is critically needed to modify the properties of polylactic acid (PLA) to compete with other commodity polymers, particularly polypropylene (PP), polyethylene (PE), poly(vinyl chloride) (PVC) or polyethylene terephthalate (PET). In this context, a number of techniques, such as copolymerization, polymer compositing, and polymer blending, have been used to get overcome drawbacks of PLA materials. Polymer blending is one of these processes that has generated a lot of interest due to its simplicity and cost-effectiveness for producing materials for a variety of uses.

Different blends, particularly those including non-biodegradable polymers that can reduce PLA's mechanical and thermal problems, can enhance its features. Polyolefins, vinyl polymers, polyolefin elastomer, acrylonitrile-butadiene rubber and isoprene rubber are examples of non-biodegradable polymers that could be blended with PLA. Polyanhydrides, aliphatic polyesters, aliphatic-aromatic copolyesters, elastomers, and rubbers are biodegradable polymers that have been suggested for blending with PLA.

Keywords: Aliphatic polyester, amorphous polymer, polylactic acid, improvement, blends

1. INTRODUCTION

Modern life is heavily reliant on synthetic plastics. Synthetic plastics have a great resistance to chemical, physical, and biological degradation; nevertheless a worldwide production of over 288 million tonnes per year supplies the ecosystem with a large amount of waste [1]. The progress and optimization of high polymer materials play an important role in industrial production, especially in the fields of electronics, chemical and medical treatment

[2]. In light of waste management and the depletion of crude oil, biobased and biodegradable polymers have grown increasingly attractive [1]. There have been several biopolymers researched, but Polylactic acid (PLA) appears to have the most promising.

PLA is a biocompatible polymer with thermal flexibility, a semicrystalline nature with good processing capabilities, and mechanical properties approaching those of polystyrene [3]. It is entirely biodegradable and is a type of lactic acid (LA) derivative made from renewable resources such wheat, straw, corn, and sorghum [4]. It can be broken down by bacteria into water and carbon dioxide, making it an environmentally friendly polymer. Consequently, it is regarded as the market's most promising biodegradable polymer material [5]. Despite the fact that the polylactic acid monomer (lactic acid) is readily available in nature, it is typically made by fermenting carbohydrates and hydrolyzing the resulting monomers. Although numerous synthetic techniques have been researched for industrial and commercial usage, none of them are easy to use or cost-effective. With a variety of uses from industrial to civilian, polylactic acid has tremendous economic value and extremely good market prospects. It is suited for a variety of processing methods, including melt-extrusion moulding, injection moulding, blown film moulding, foam moulding, and vacuum moulding, due to its high tensile strength and flexibility [2], film extrusion, thermoforming [6]. Due to its high biocompatibility, it is frequently utilised in the practise of biochemical medicine. The degree of crystallinity of PLA affects how easily it dissolves. Acetone, acetonitrile, and methylene chloride are just a few of the organic solvents that amorphous polymers are soluble in. A high temperature is also required to dissolve crystalline PLA in dichloromethane or benzene. The thermal stability of polylactic acid is sufficient to prevent degradation and preserve molecular weight and functionality. Polylactic acid undergoes hydrolysis, lactide recombination, oxidative main-chain scission, and inter- or intramolecular transesterification at temperatures above 200°C [2].

2. HISTORY AND COMMON PROPERTIES OF POLYLACTIC ACID (PLA)

Applications for PLA include the biomedical, pharmaceutical, environmental applications, agriculture, food packaging, and furniture industries. Cast and blown films are just two of the various processing applications where it is widely employed. Due to its outstanding shaping and moulding capabilities, great mechanical strength, and numerous other benefits, PLA has a wide range of applications especially in the medical industry, used for sutures, screws for bone fractures, and drug delivery systems [3].

Although PLA was initially developed in 1845, it wasn't until the early 1990s that it was made commercially available by the Cargill and Dow Chemical Companies (TDCC), who opened the first PLA facility in the world in Nebraska (Cargill Dow LLC) [7]. After Cargill acquired TDCC in 2005, the manufacturing firm was renamed NatureWorks. The major PLA manufacturers nowadays are NatureWorks (Ingeo), Synbra (BioFoam), Total Corbion (Luminy), Futero, Hisun, Danimer Scientific LLC, and Weforyou. The total annual production of PLA is currently estimated to be 200 kton/year. The PLA market was valued at USD 2.23 billion globally in 2017, and it is projected to expand at a steady compound annual growth rate of more than 20.5% from 2018 to 2026. Although packaging is the main application for PLA in terms of volume, a report published in 2019 forecasted that the global market for PLA in 3D printing will expand at a compound annual growth rate of 19.3 % from 2018 to 2028 [8].

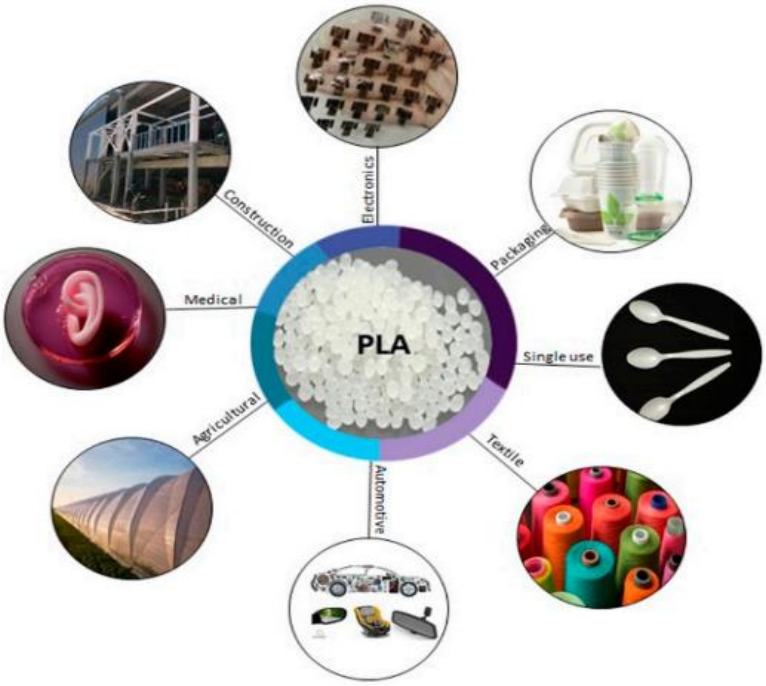


Fig. 1. PLA applications in end-use industries and its' global market consumption.

The thermal and mechanical properties of PLA: **1)** Glass transition temperature (Tg) is 50–70 °C; **2)** Melting temperature (Tm) is 170–190°C; **3)** Crystallinity (χc) is ∼35%; **4)** Intrinsic viscosity (η, in chloroform) is 3.8–8.2 dL g−1; **5)** Tensile strength (film) is 28–50 MPa; **6)** Tensile modulus (film) is 1200–3000 MPa; **7)** Shear strength is 54.5 MPa; **8)** Share modulus is 1210–1430 MPa; **8)** Bending strength is 132 MPa; **9)** Bending modulus is 2800 MPa; **10)** Elongation at break (film) is 2.0–6.0% [1].

Compared to petroleum-based polymers like polyethylene (PE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), and polyethylene terephthalate (PET), PLA has properties that are similar to or even superior to those materials. For instance, PLA outperforms PS in terms of strength and toughness as well as low permeability performance when it comes to the transfer of many gases, including methane and water vapour [9].

3. BIOMEDICAL APPLICATIONS OF POLYLACTIC ACID

The class of biomaterials known as poly-hydroxy acids, poly-esters, or aliphatic polyesters includes the hydrophobic polymer known as polylactic acid. It is made from lactic acid, also known as 2-hydroxypropanoic acid, which has two enantiomeric forms, L-(+)-LA and D-(-)-LA. Lactic acid is a water-soluble monomer. A "family" of polymers known as PLA consists of the homopolymers PLLA (poly(l-lactic acid)) and PDLA (poly(d-lactic acid)), which are produced from mixtures of pure L- or D-lactic acid, respectively, and the copolymer PDLLA (obtained from the racemic mixture). Since PLLA and PDLA are semicrystalline polymers but PDLLA is typically amorphous, this has a surprising impact on the material properties. The final crystallinity is also influenced by the mechanical and thermal history, primarily as a result of production methods. The degree of crystallinity in a polymer affects its tensile strength, stiffness, melting temperature, hardness, and other mechanical and physical properties. Lower quantities (and a lower optical purity) lead to an amorphous polymer, which is a semicrystalline polymer if the amount of PLLA is greater than 90%. Because material properties can be altered in a variety of ways, PLA's success also stems from its adaptability. They can be modified, for example, by adding suitable plasticizers, which are frequently used to increase the processability and flexibility of polymers [10].

PLA which is categorised as an aliphatic polyester due to the ester linkages connecting its monomer units. Due to its vast range of uses in the biomedical industry, including suture threads, bone fixation screws, and drug administration devices has become increasingly important. PLA is a great choice for biological applications since it combines a number of interesting characteristics. PLA naturally degrades in situ through hydrolysis mechanism: water molecules break the ester bonds that constitute polymer backbone. This reduces the need for additional procedures to remove the device, enhancing patient rehabilitation and lowering expenses for the healthcare system. Because of its biocompatibility and processability, PLA is frequently used in the biomedical industry. It can be processed using a variety of methods, including extrusion, injection moulding, injection stretch blow moulding, extrusion blow film, film and sheet casting, thermoforming, fibre spinning, foaming, electro spinning, compounding, blending, and nanocompositing [10].

4. FOOD PACKAGING WITH POLYLACTIC ACID

When designing a packaging solution to match the characteristics of a food product, the packaging material and the product it will be used to package should be viewed as a single system. The environmental effects of food packaging can be reduced by developing sustainable, green packaging that uses plant extracts, edible or biodegradable materials, and their composites, as well as nanomaterials [11]. Both flexible and hard forms of a large variety of these polymers have been utilised in packaging. These plastics can be classified as thermoplastic or thermosets. Heat can be used in the processing and recycling various thermoplastics. Since they can be easily shaped into various forms and are recyclable, this class of polymers is more suited for use in food packaging. Thermoplastics most widely used in food packaging materials are low-density polyethylene (LDPE), polyvinyl chloride (PVC), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), high-density polyethylene (HDPE), and expanded polystyrene [12]. On the other hand, once thermosets are produced, heat cannot be used to reprocess them. As a result, they cannot be recycled and are rarely employed as food packaging [13].

The substance with the biggest research potential is polylactic acid (PLA). It offers packaging applications for a wider range of goods, including films, forms, food containers, and coatings, among many other applications. PLA has several advantages that make them perfect for use in food contact packaging materials, including: 1) Excellent transparency. 2) Compared to the majority of traditional plastics made from fossil fuels, permeability to carbon dioxide is higher than permeability to oxygen (perm selectivity). This is crucial in food packaging applications where a high oxygen barrier is needed. 3) Relatively strong resistance to water. 4) Strong chemical resistance to fats and oils. 5) Greater thermal processability when compared to other bioplastics, as seen from its low melting temperature and comparatively high glass transition temperature. 6) Films seal well at temperatures below their melting point. 7) Low density polyethylene (LDPE) films are not as effective at blocking UV radiation as PLA films [13].

According to numerous reports, PLA degrades in compost environments more quickly than in soil [14]. However, PLA has performed poorly in the marine environment and even compares to plastics made from fossil fuels. One study found that while PLA disintegrated 20 times more quickly on land, but HDPE's surface degradation rate in the marine environment was comparable with PLA [13].

5. BLENDS OF POLYLACTİC ACID

Due to its susceptibility to humidity, PLA has its limitations for applications requiring longevity. Water sorption, dry matter loss, molecular weights (number-average and weight-average), glass transition temperature (Tg), melting temperature (Tm), percentage of crystallinity (Xc), percentage of amorphous region (rigid fraction (XRAF), and mobile phase (XMAP), are the PLA parameters that are impacted by humidity [15]. It has been discovered that many of the characteristics of PLA are equal to those of conventional petrochemical-based polymers, including strength, stiffness, and gas permeability. However, PLA-based materials exhibit a number of limitations for specific applications, such as slow biodegradation rate, high cost, and low toughness. Although the toughness of PLA is higher than PS, it is still lower than that of PET and PC, which may restrict its use as a structural material. In addition, PLA's poor biodegradation rate and hydrophobicity typically limit its use in biomedical applications [9].

Additionally, PLA is intrinsically flammable, which prevents it from being used in construction, electrical appliances, and automotive applications due to the risk of fire [16]. According to Vadori et al. [17], PLA's brittleness, which prevents polymeric chains from mobilising relative to one another and, as a result, their inability to absorb energy, is usually related to the material's low impact strength. It is possible to increase crystallinity either by using nucleating chemicals that do not alter the natural crystal structure or by applying stress to the polymer during processing [18].

In this context, a number of techniques, such as copolymerization, polymer compositing, and polymer blending, have been used to get overcome PLA materials' drawbacks. Polymer blending is one of these processes that has generated a lot of interest due to its simplicity and cost-effectiveness for producing materials for a variety of uses. Over the past few years, a lot of attention has been paid to the modification of PLA utilising the polymer mixing approach to develop features that are acceptable for various applications [9].

The addition of fillers or additives can be used to improve PLA's durability. Plasticizers like PEG were added to the PLA in order to combat its brittle character. But it causes a loss of stiffness or a reduction in elastic modulus, which is one of the desired qualities for structural applications [15]. A few researchers incorporated nanoclay into the PLA, which very well gets dispersed due to the hydrogen bonding formation linking the carbonyl group of PLA and ammonium group of clay into the polymer without the addition of compatibilizers and results in the formation of PLA nanocomposites [19]. When compared to other filled polymeric systems, it has been found that plasticized PLA/MMT (montmorillonite) nanocomposites at least preserve toughness. Toughener was incorporated into the materials to combat the brittle characteristic of PLA nanocomposite [15].

In order to modify or enhance the properties of a polymeric material or to add new features, various polymers are frequently blended [20]. The high molecular weight of polymers makes it difficult to achieve compatibility and miscibility. The combined polymers often go through phase separation because decreasing the interfacial area minimises the system free energy. Phase separated immiscible polymer blends can be categorised into one of four morphologies: 1) globular inclusions (of the minor phase) in a continuous matrix, 2) fibers (of the minor phase) in a continuous matrix, 3) alternating superimposed lamellae of the two phases, and 4) bicontinuity. The addition of fillers to polymer blends is another significant technological feature with the goal of lowering overall cost or giving the materials beneficial properties. Nanocomposites belong to this last category, and they can be obtained by adding nanosized particles with specific property to one or more polymer with the objective of conferring these properties to the final material [20].

In order to produce composite materials, PLA can be mixed with biodegradable or non-biodegradable polymers (such as polyethylene, polypropylene, chitosan, polystyrene, polyethylene terephthalate, and polycarbonates) or with natural fibres, cellulose, carbon nanotubes, and ceramic nanoparticles [21,9,22]. Another is the formation of stereocomplexes, which can be achieved by combining PLLA and PDLA (i.e., the homopolymer made up of just D-lactide units) or by using PLLA/PDLA block copolymers [23]. The stereocomplex crystallisation that results in the production of the PDLA and PLLA blocks has strong interactions that enhance mechanical and thermal stability, reduce degradation rate, and strengthen PLA barrier characteristics. According to Corneillie and Smet [1], PLA-based materials can also be built into complex molecular structures that result in branching polymer chains, star-shaped structures, grafted chains, and cross-linked matrices. Stereocomplexation can also be accomplished with these complex structures if they are synthesised using both PLLA and PDLA blocks [24]. Copolymerization with glycolic acid, which produces the well-known polylactic-co-glycolic random copolymer (PLGA), is another common method for adjusting a material's characteristics. Caprolactone is used in copolymerization as well, resulting in polylactic-co-caprolactone (PLCL). The production of PLA and polyethylene glycol (PEG) block copolymers is another method for enhancing material hydrophilicity [10].

Composites made of fibre mixtures contain the beneficial properties of several fibres. Future PLA composites research should focus more on the role of the reinforcing fibre. By experimenting with various fibre properties, composite properties can be generated. Examples of fibers used in PLA hybrid composites are: **1)** Banana/Sisal Fiber, **2)** Flax/Jute, **3)** Polycaprolactone/Oil Palm Mesocarp, **4)** Montmorillonite nanoclay/short kenaf, **5)** Corn stover/wheat straw/soy stalks, **6)** Hemp/Sisal, 7**)** Coir/Pineapple leaf, **8)** Banana/Kenaf, **9)** Cotton gin waste/flax, **10)** Bamboo/microfibrillated cellulose, **11)** Hemp/yarn, **12)** MMT clay/aloe vera, **13)** Softwood flour/cellulose, **14)** PBSA/Starch, **15)** Clay/RCF, **16)** Hydroxyapatite/Membrane mat, **17)** Graphene oxide/CNT, **18)** Chitosan/Basalt [6].

The PLA-based blends or composites that were prepared are as follows: **1)** PLA/ABS [25]; **2)** PLA-PEG [26]; **3)** PLA-PC [27]; **4)** PLA-CF [28]; **5)** PLA-PCL [29]; **6)** PLA-PET [30]; **7)** PLA-nylon [31]; **8)** PLA-nanoclay [32]; **9)** PLA-LDPE [33]; **10)** PLA-HDPE [34]; **11)** PLA-ABS [35]; **12)** PLA-chitosan [36]; 1**3)** PLA-talc [37]; **14)** PLA-hydroxyapatite [38]; **15)** PLA-cellulose [39]; **16)** PLA-polysaccharide gum [40]; **17)** PLA-silk [41];**18)** PLA-soy straw [42]; **19)** PLA-flax [43]; **20)** PLA/ABS/SAN-GMA [25]; **21)** PLA/NBR19; **22)** PLA/NBR33; **23)** PLA/NBR5 [44]; **24)** PLA/PA; **25)** PLA/PP/PTW; **26)** PLA/PP [45]; **27)** PLA-poly(glycerol succinate-co-maleate)(PGSMA) [46]; **28)** PLA-poly-PTT (trimethylene terephthalate) [47]; **29)** PLA-poly(butylene terephthalate) (PBT) [48]; and **30)** PLA-poly(amide elastomer) (PAE) [49].

Various types and quantities of additives were used to formulate blends and composites that crucially determine the desired properties of polymers for durable applications in different research studies by international researchers. The additives used in these studies were **1)** Luperox (2,5-bis(tert-butyl peroxy)-2,5-dimethylhexane); **2)** acryl copolymer (Biostrength 99) [46]; **3)** trichloromethyl terminated PLA (PLA-Cl), **4)** LAK-301; **5)** magnesium oxysulfate; **6)** precipitated calcium carbonate [18]; **7)** poly(ethylene-n-butylene acrylateglycidyl methacrylate) (EBA-GMA); **8)** poly(styreneacrylic-co-glycidyl methacrylate) (SA-GMA) [50]; **9)** EMA-GMA (Elvaloy) [51]; **10)** ethylene butyl acrylate-maleic anhydride (EBA-MaH); **11)** ethylene methyl acrylate-glycidyl methacrylate (EMA-MaH) [52]; **12)** maleic anhydride-graft-polypropylene (MA-g-PP) [53]; **13)** L-lysine ethyl ester diisocyanate (LDI); **14)** hydrogenated dimer acid (HDA) [54]; **15)** N,N-dimethylstearylamine (DMSA) [55]; **16)** stannous octanoate (Sn(Oct)2) [56]; **17)** dibutyltin dilaurate [57]; **18)** poly(L-lactic acid)-block-poly- (methyl methacrylate) (PLLA-b-PMMA) [56].

Processing techniques for fibers used PLA hybrid composites are: **1)** Injection molding, **2)** Compression molding, **3)** Mold blending, **4)** Extrusion + injection molding, **5)** Melt blending, **6)** Double extrusion, **7)** Melt mixing, **8)** Solution casting, **9)** Molding, **10)** Extrusion + melt blending, **11)** Reactive blending + injection molding, **12)** Milling, **13)** Compression molding/prepreg, **14)** Extrusion, **15)** Air jet spinning [58, 59, 60, 6].

In PLLA/PDLA blends or stereoblock copolymers, the strong connection between the l-lactic acid segments and the d-lactic acid segments improves the mechanical characteristics, hydrolytic/thermal degradation-resistance, and gas barrier properties. It is preferable to employ high molecular weight (HMW) PLLA and PDLA for high mechanical performance. For HMW PLLA/PDLA blends, homo-crystallization comes superior over SC crystallisation. To solve this issue low molecular weight (LMW), medium molecular weight (MMW), and HMW are generally used for weight-averaged molecular weight (Mn) values below 1 × 104 g mol−1, between 1 × 104 and 1 × 105 g mol−1, above 1 × 105 g mol−1, respectively. Moreover, numerous block or graft copolymers having PLLA, PDLA, or both PLLA and PDLA blocks or chains and various random copolymers with l- or d-lactic acid units have been synthesized for a wide variety of applications [23].

Typically, overnight drying of the polymer precursors can stop moisture-induced processing-induced breakdown. Further processing is performed on the dried precursors with a moisture sensitivity of less than 1%. The modification, functionalization, or grafting of PLA to make it hydrophobic is another technique for lowering the moisture sensitivity of PLA before processing. However, this procedure won't be economical and could alter the properties of PLA. To further reduce moisture sensitivity and hydrolytic instability in PLA-based products, additives like initiators, nucleating agents, and chain extenders have been added; this has been observed with silane cross-linking, carbodiimide, silicon carbide, nanoclays, graphene nanoplatelets, and antihydrolysis agents [61, 62].

The key obstacles to PLA's performance in durable applications are its brittleness, poor toughness, and low HDT. PLA can be made stiffer, more HDT-resistant, and more chemically resistant by increasing the amount of crystallinity in it generally. The areas that need to be improved in order for PLA to be employed in engineering applications by achieving durability are these shortcomings in PLA [15].

PLA has an HDT value of about 55 °C. Increasing the mould temperature and adding an organic nucleating agent are two practical and proven methods for improving PLA's crystallisation capacity and the effectiveness of HDT. Because PLA's hardness is less than that of PET and polycarbonate (PC), it cannot be used in structural applications. Additionally, it is frequently observed that the relationship between toughness and stiffness and strength is inverse. By adding plasticizers, PLA's low elongation at break and brittleness have been solved [9].

Recently, it has been shown that a number of PLA mixes based on synthetic or natural components are particularly successful at enhancing PLA characteristics. Studying blend stability in various ageing circumstances, such as in diverse habitats, during storage, or during reprocessing, has, however, received very little attention. This section is crucial, and greater focus should be placed on the objective assessment of these new compositions' advantages over previously reported compositions (PLA: PGA, PLA: PCL, etc.) in terms of durability and application [6].

6. MILITARY AND AEROSPACE EQUIPMENTS AND PARTS PRODUCTION WITH PLA

Several areas emerge to contribute and enhance the capabilities of military weaponry, contingency resupply, and wartime preparations. The use of projectiles, propulsion, artificial intelligence, and computer and communication technology has revolutionised military systems. 3D printing and additive manufacturing are the most widely applicable technologies over the next two decades. Via using FDM technology, Balasubramaniam et al. [63], studied an observation quadcopter with PLA parts. Additionally, electrochemical deposition is used to PLA pieces manufactured using FDM. They discovered a 22% component reduction and an 18% weight decrease. The electrochemical coating was also claimed to have increased tensile, flexural, and impact characteristics by 10%. According to Booth et al. [64], AM systems offer the potential for developing smaller, lighter weapons for military aircraft, missile research, and autonomous air/ground systems. Specimens were generated utilising FDM technology in accordance with ASTM (D3846-02 and ASTM D5379). Specimens include PLA, ABS, and HIPS materials subjected to in-plane and out-plane shear properties characterization.

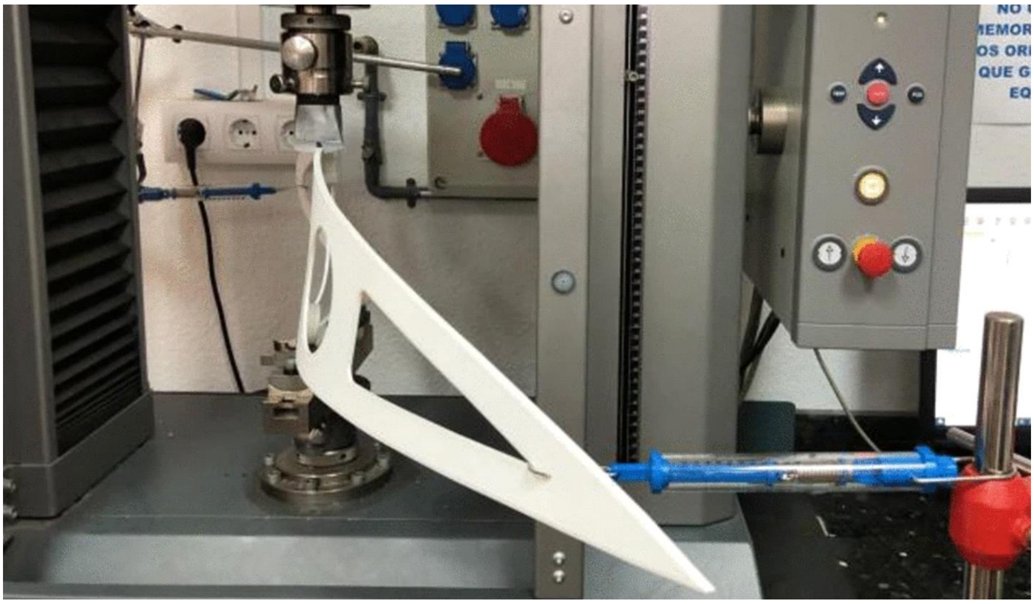


Fig. 2. Testing and evaluation of the structural performance of a 3D-printed polylactic acid aircraft wing rib [65].

Accumulation of the Earth's "space debris" has become a huge obstacle to human aerospace activities. The growth of the aerospace sector will be restricted by space debris, which will also contribute to cosmic disasters. It has emerged as a fresh issue for civilization and will soon pose an additional threat to human security. Research on the degradation of ecologically acceptable aerospace materials in microgravity is necessary in this area. Sugar-, water-, and non-toxic, starch-polylactic acid molecules are the end breakdown products. They can be used to degrade or reuse them in spacecraft and space stations. Aerospace materials, taking the first step to voluntarily reduce and reuse aerospace materials, develop new theories and technologies for the functional enhancement and regulation of biodegradable materials under space conditions, and govern the pollution of near-earth space [66].

7. 4D PRINTING WITH POLYLACTIC ACID

Innovative designs and fabrication tactics that were previously impractical to realise with conventional methods are now possible via the precise layer-by-layer patterning of materials. Four-dimensional (4D) printing is the name given to this technology since the 3D printed pieces can either change their shape over time to a pre-programmed three-dimensional shape or revert to an earlier design. In this regard, the commonly used polylactic acid (PLA) polymer has been acknowledged as a compelling material candidate for 4D printing as it is a biobased polymer with outstanding shape memory behaviour that may be used in the design and manufacturing of a wide range of smart devices [8]. Although a wide range of materials, including plastics, metals, and even ceramics, have been successfully 3D printed, most materials cannot be used for 4D printing because they do not undergo enough shape change in response to stimuli like humidity, temperature change, or an external magnetic field [67].

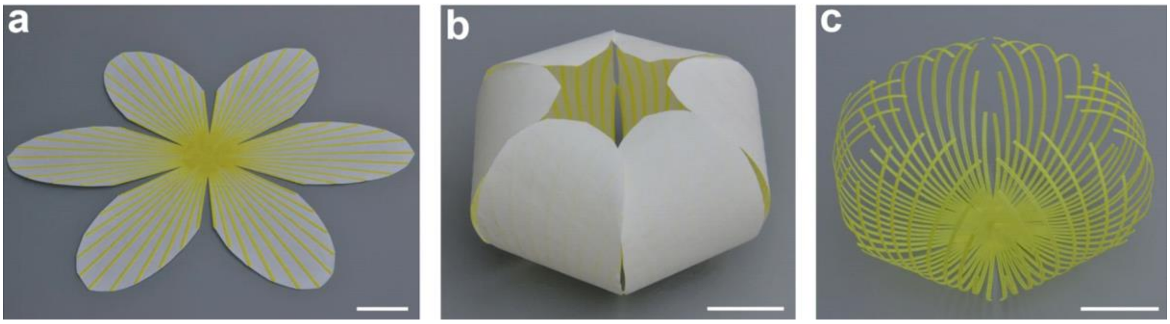


Fig. 3. 4D printing with PLA. Formation of flower-like 3D structure from initial planar sheet. (a) The initial planar shape of the 3D-printed composite sheet. (b) The final flower-like 3D shape after a process of heating and cooling. (c) A complex lightweight structure fabricated by tearing off the paper from the flower-like 3D structure. Scale bar is 2 cm [68].

In 4D printing concept, before shape recovery is initiated by an external stimulus, shape memory polymers (SMPs) have the capacity to deform from an initial shape into a stress-free, temporally maintained shape [69]. Particularly, throughout the programming phase, internal stress is built up, and the stored energy can be released and serves as the driving force in the form recovery step. Changing temperature through a process known as transformation temperature is a common method for achieving these shape changes. 'Programming' is the part-specific process of changing from a primary shape to an altered shape (and vice versa) in the presence of a stimulus [70]. In this aspect, choosing the right polymer is essential for producing programmable 4D printed structures. PLA polymer has emerged as an attractive option for 4D printing due to its numerous 3D printing uses and affordable price. Many works that have already been published in this area combine PLA with other polymers, such as polyurethane (PU), to improve form recovery and lower PLA's glass transition temperature (Tg), improving its sensitivity to thermal programming [71]. The primary property of polymers that allows them to recover from a distorted condition is viscoelasticity. When subjected to an external force, polymer chains often display a certain behaviour. The ability to customise polymer topologies for regulating shape memory features has been made available by current fabrication technology [72]. In general, heat-responsive shape memory polymers can be described by one of three fundamental mechanisms, including the (I) dual-state (DSM), (II) dual-composite (DCM), and (III) partial-transition (PTM) mechanisms. The shape memory response of polymers is mostly determined by Tg and melting temperature (Tm), two inherent features. Supramolecular interactions and partially reversible covalent connections are necessary for polymers to exhibit shape memory behaviour [73]. By enhancing thermal conductivity the time to induction of shape recovery can be reduced. The elaborate material design may also yield shape memory polymers that respond to alternative impulses such as electricity, light, magnetism, and moisture [74].

Different blends, particularly those including non-biodegradable polymers that can reduce PLA's mechanical and thermal problems, can enhance its features. Polyolefins, vinyl polymers, elastomers (like polyolefin elastomer), and rubbers (like acrylonitrile-butadiene rubber, isoprene rubber) are examples of non-biodegradable polymers that could be blended with PLA. Polyanhydrides, aliphatic polyesters, aliphatic-aromatic copolyesters, elastomers, and rubbers are biodegradable polymers that have been suggested for blending with PLA [8]. Nanofillers such nanoclays, carbon nanotubes, nanocellulose, and inorganic nanoparticles can help overcome PLA's natural disadvantages [75]. As an example, silver (Ag) and cellulose nanocrystals (CNC) nanoparticles have enhanced antibacterial activity and gas barrier characteristics in PLA-based films [76]. Nanoclays and carbon nanotubes have also been shown to improve thermal and mechanical properties [77]. The characteristics of PLA-based polymer composites can be impacted by the geometry of the nanofillers. In order to support piezoelectric sensing, Bodkhe and Ermanni [78] researched materials that incorporated PLA with polyesteramide (PEA) for shape-memory. For deposition using electric poling-assisted additive manufacturing (EPAM), the composite material was prepared as ink that was injected into a syringe barrel. Wei et al. [79] used an inkjet 3D printer followed by UV curing to insert Fe_3O_4 nanoparticles in PLA ink for enabling remote component heating through an externally provided, alternating magnetic field. This alternate composite also contained nanoparticles. Parts were printed through direct-write techniques using inks prepared from PLA with Fe_3O_4 nanoparticles introduced.

REFERENCES

[1] Corneillie, S., & Smet, M. (2015). PLA architectures: the role of branching. Polymer Chemistry, 6(6), 850-867.

[2] Li, G., Zhao, M., Xu, F., Yang, B., Li, X., Meng, X., ... & Li, Y. (2020). Synthesis and biological application of polylactic acid. Molecules, 25(21), 5023.

[3] Michaelski, A., Brzezinski, M., Lapienis, G., & Biela, T. (2019). Star-shaped and branched polylactides: Synthesis, characterization, and properties. Progress in Polymer Science, 89, 159-212.

[4] Singhvi, M., Joshi, D., Adsul, M., Varma, A., & Gokhale, D. (2010). d-(−)-Lactic acid production from cellobiose and cellulose by Lactobacillus lactis mutant RM2-2 4. Green Chemistry, 12(6), 1106-1109.

[5] Abdel-Rahman, M. A., Tashiro, Y., Zendo, T., & Sonomoto, K. (2013). Improved lactic acid productivity by an open repeated batch fermentation system using Enterococcus mundtii QU 25. RSC advances, 3(22), 8437-8445.

[6] Ilyas, R. A.,Zuhri, M. Y. M.,Aisyah, H. A., Asyraf, M. R. M., Hassan, S. A., Zainudin, E. S., ... & Sari, N. H. (2022). Natural fiber-reinforced polylactic acid, polylactic acid blends and their composites for advanced applications. Polymers, 14(1), 202.

[7] Auras, R. A., Lim, L. T., Selke, S. E., & Tsuji, H. (Eds.). (2011). Poly (lactic acid): synthesis, structures, properties, processing, and applications (Vol. 10). John Wiley & Sons.

[8] Mehrpouya, M., Vahabi, H., Janbaz, S., Darafsheh, A., Mazur, T. R., & Ramakrishna, S. (2021). 4D printing of shape memory polylactic acid (PLA). Polymer, 230, 124080.

[9] Hamad, K., Kaseem, M., Ayyoob, M., Joo, J., & Deri, F. (2018). Polylactic acid blends: The future of green, light and tough. Progress in Polymer Science, 85, 83-127.

[10] Casalini, T., Rossi, F., Castrovinci, A., & Perale, G. (2019). A perspective on polylactic acid-based polymers use for nanoparticles synthesis and applications. Frontiers in bioengineering and biotechnology, 7, 259.

[11] Han, J. W., Ruiz-Garcia, L., Qian, J. P., & Yang, X. T. (2018). Food packaging: A comprehensive review and future trends. Comprehensive Reviews in Food Science and Food Safety, 17(4), 860-877.

[12] Jacob, J., Lawal, U., Thomas, S., & Valapa, R. B. (2020). Biobased polymer composite from poly (lactic acid): processing, fabrication, and characterization for food packaging. In Processing and development of polysaccharide-based biopolymers for packaging applications (pp. 97-115). Elsevier.

[13] Ncube, L. K., Ude, A. U., Ogunmuyiwa, E. N., Zulkifli, R., & Beas, I. N. (2020). Environmental impact of food packaging materials: A review of contemporary development from conventional plastics to polylactic acid based materials. Materials, 13(21), 4994.

[14] Rajesh, G., Prasad, A. R., & Gupta, A. V. S. S. K. S. (2019). Soil degradation characteristics of short sisal/PLA composites. Materials Today: Proceedings, 18, 1-7.

[15] Tripathi, N., Misra, M., & Mohanty, A. K. (2021). Durable polylactic acid (PLA)-based sustainable engineered blends and biocomposites: Recent developments, challenges, and opportunities. ACS Engineering Au, 1(1), 7-38.

[16] Zhang, Y., Xiong, Z., Ge, H., Ni, L., Zhang, T., Huo, S., ... & Fang, Z. (2020). Core–shell bioderived flame retardants based on chitosan/alginate coated ammonia polyphosphate for enhancing flame retardancy of polylactic acid. ACS Sustainable Chemistry & Engineering, 8(16), 6402-6412.

[17] Vadori, R., Misra, M., & Mohanty, A. K. (2016). Sustainable biobased blends from the reactive extrusion of polylactide and acrylonitrile butadiene styrene. Journal of applied polymer science, 133(45).

[18]Nagarajan, V., Zhang, K., Misra, M., & Mohanty, A. K. (2015). Overcoming the fundamental challenges in improving the impact strength and crystallinity of PLA biocomposites: influence of nucleating agent and mold temperature. ACS applied materials & interfaces, 7(21), 11203-11214.

[19]Banerjee, R., & Ray, S. S. (2021). An overview of the recent advances in polylactide-based sustainable nanocomposites. Polymer Engineering & Science, 61(3), 617-649.

[20]Nasti, G., Gentile, G., Cerruti, P., Carfagna, C., & Ambrogi, V. (2016). Double percolation of multiwalled carbon nanotubes in polystyrene/polylactic acid blends. Polymer, 99, 193-203.

[21] Saini, P., Arora, M., & Kumar, M. R. (2016). Poly (lactic acid) blends in biomedical applications. Advanced Drug Delivery Reviews, 107, 47-59.

[22] Murariu, M., & Dubois, P. (2016). PLA composites: From production to properties. Advanced drug delivery reviews, 107, 17-46.

[23] Tsuji, H. (2016). Poly (lactic acid) stereocomplexes: A decade of progress. Advanced drug delivery reviews, 107, 97-135.

[24] Fan, X., Wang, M., Yuan, D., & He, C. (2013). Amphiphilic conetworks and gels physically cross-linked via stereocomplexation of polylactide. Langmuir, 29(46), 14307-14313.

[25] Jo, M. Y., Ryu, Y. J., Ko, J. H., & Yoon, J. S. (2012a). Effects of compatibilizers on the mechanical properties of ABS/PLA composites. Journal of Applied Polymer Science, 125(S2), E231-E238.

[26] Abebe, D. G., & Fujiwara, T. (2012). Controlled thermoresponsive hydrogels by stereocomplexed PLA-PEG-PLA prepared via hybrid micelles of pre-mixed copolymers with different PEG lengths. Biomacromolecules, 13(6), 1828-1836.

[27] Yuryev, Y., Mohanty, A. K., & Misra, M. (2017). Novel biocomposites from biobased PC/PLA blend matrix system for durable applications. Composites Part B: Engineering, 130, 158-166.

[28] Chen, J., Lu, L., Wu, D., Yuan, L., Zhang, M., Hua, J., & Xu, J. (2014). Green poly (ε-caprolactone) composites reinforced with electrospun polylactide/poly (ε-caprolactone) blend fiber mats. ACS Sustainable Chemistry & Engineering, 2(9), 2102-2110.

[29] Chen, R., Misra, M., & Mohanty, A. K. (2014). Injection-moulded biocomposites from polylactic acid (PLA) and recycled carbon fibre: Evaluation of mechanical and thermal properties. Journal of Thermoplastic Composite Materials, 27(9), 1286-1300.

[30] Wang, F., Liu, H., Li, Y., Li, Y., Ma, Q., Zhang, J., & Hu, X. (2020). Tunable biodegradable polylactide–silk fibroin scaffolds fabricated by a solvent-free pressure-controllable foaming technology. ACS Applied Bio Materials, 3(12), 8795-8807.

[31] Kim, J. W., Kim, H., & Ko, J. (2020). Effect of changing printing parameters on mechanical properties of printed PLA and Nylon 645. Journal of Advanced Mechanical Design, Systems, and Manufacturing, 14(4), JAMDSM0056-JAMDSM0056.

[32] Das, K., Ray, D., Banerjee, I., Bandyopadhyay, N. R., Sengupta, S., Mohanty, A. K., & Misra, M. (2010). Crystalline morphology of PLA/clay nanocomposite films and its correlation with other properties. Journal of applied polymer science, 118(1), 143-151.

[33] Arslan, F., & Dilsiz, N. (2020). Flame resistant properties of LDPE/PLA blends containing halogen-free flame retardant. Journal of Applied Polymer Science, 137(32), 48960.

[34] Alsabbagh, A., Abu Saleem, R., Almasri, R., Aljarrah, S., & Awad, S. (2021). Effects of gamma irradiation on 3D-printed polylactic acid (PLA) and high-density polyethylene (HDPE). Polymer Bulletin, 78, 4931-4945.

[35] Rigoussen, A., Raquez, J. M., Dubois, P., & Verge, P. (2019). A dual approach to compatibilize PLA/ABS immiscible blends with epoxidized cardanol derivatives. European Polymer Journal, 114, 118-126.

[36] Pal, A. K., & Katiyar, V. (2016). Nanoamphiphilic chitosan dispersed poly (lactic acid) bionanocomposite films with improved thermal, mechanical, and gas barrier properties. Biomacromolecules, 17(8), 2603-2618.

[37] Yu, W., Wang, X., Ferraris, E., & Zhang, J. (2019). Melt crystallization of PLA/Talc in fused filament fabrication. Materials & Design, 182, 108013.

[38] Zhou, S., Zheng, X., Yu, X., Wang, J., Weng, J., Li, X., ... & Yin, M. (2007). Hydrogen bonding interaction of poly (D, L-lactide)/hydroxyapatite nanocomposites. Chemistry of Materials, 19(2), 247-253.

[39] Gitari, B., Chang, B. P., Misra, M., Navabi, A., & Mohanty, A. K. (2019). A comparative study on the mechanical, thermal, and water barrier properties of PLA nanocomposite films prepared with bacterial nanocellulose and cellulose nanofibrils. BioResources, 14(1), 1867-1889.

[40]Tripathi, N., & Katiyar, V. (2016). PLA/functionalized-gum arabic based bionanocomposite films for high gas barrier applications. Journal of Applied Polymer Science, 133(21).

[41] Wang, G., Zhao, J., Wang, G., Zhao, H., Lin, J., Zhao, G., & Park, C. B. (2020). Strong and super thermally insulating in-situ nanofibrillar PLA/PET composite foam fabricated by high-pressure microcellular injection molding. Chemical Engineering Journal, 390, 124520.

[42] Pradhan, R., Misra, M., Erickson, L., & Mohanty, A. (2010). Compostability and biodegradation study of PLA–wheat straw and PLA–soy straw based green composites in simulated composting bioreactor. Bioresource technology, 101(21), 8489-8491.

[43] Zhang, L., Li, Z., Pan, Y. T., Yáñez, A. P., Hu, S., Zhang, X. Q., ... & Wang, D. Y. (2018). Polydopamine induced natural fiber surface functionalization: A way towards flame retardancy of flax/poly (lactic acid) biocomposites. Composites Part B: Engineering, 154, 56-63.

[44] Maroufkhani, M., Katbab, A., Liu, W., & Zhang, J. (2017). Polylactide (PLA) and acrylonitrile butadiene rubber (NBR) blends: The effect of ACN content on morphology, compatibility and mechanical properties. Polymer, 115, 37-44.

[45] Ebadi-Dehaghani, H., Khonakdar, H. A., Barikani, M., & Jafari, S. H. (2015). Experimental and theoretical analyses of mechanical properties of PP/PLA/clay nanocomposites. Composites Part B: Engineering, 69, 133-144.

[46] Valerio, O., Misra, M., & Mohanty, A. K. (2017). Sustainable biobased blends of poly (lactic acid)(PLA) and poly (glycerol succinate-co-maleate)(PGSMA) with balanced performance prepared by dynamic vulcanization. RSC advances, 7(61), 38594-38603.

[47] Nagarajan, V., Mohanty, A. K., & Misra, M. (2016). Reactive compatibilization of poly trimethylene terephthalate (PTT) and polylactic acid (PLA) using terpolymer: Factorial design optimization of mechanical properties. Materials & Design, 110, 581-591.

[48] Zhou, J., Jiang, Z., Wang, Z., Zhang, J., Li, J., Li, Y., ... & Gu, Q. (2013). Synthesis and characterization of triblock copolymer PLA-b-PBT-b-PLA and its effect on the crystallization of PLA. RSC advances, 3(40), 18464-18473.

[49] Li, Z., Li, K., He, H., Zhou, Y., & He, Z. (2019). Tough and tunable shape memory PLA/PAE melt-blends actuated by temperature. Iranian Polymer Journal, 28(5), 371-378.

[50] You, X., Snowdon, M. R., Misra, M., & Mohanty, A. K. (2018). Biobased poly (ethylene terephthalate)/poly (lactic acid) blends tailored with epoxide compatibilizers. ACS omega, 3(9), 11759-11769.

[51]Zhang, K., Nagarajan, V., Misra, M., & Mohanty, A. K. (2014). Supertoughened renewable PLA reactive multiphase blends system: phase morphology and performance. ACS applied materials & interfaces, 6(15), 12436-12448.

[52] Nagarajan, V., Mohanty, A. K., & Misra, M. (2018). Blends of polylactic acid with thermoplastic copolyester elastomer: effect of functionalized terpolymer type on reactive toughening. Polymer Engineering & Science, 58(3), 280-290.

[53] Anstey, A., Codou, A., Misra, M., & Mohanty, A. K. (2018). Novel compatibilized nylon-based ternary blends with polypropylene and poly (lactic acid): fractionated crystallization phenomena and mechanical performance. ACS omega, 3(3), 2845-2854.

[54] Liu, H., Chen, N., Shan, P., Song, P., Liu, X., & Chen, J. (2019). Toward fully bio-based and supertough PLA blends via in situ formation of cross-linked biopolyamide continuity network. Macromolecules, 52(21), 8415-8429.

[55] Deng, S., Bai, H., Liu, Z., Zhang, Q., & Fu, Q. (2019). Toward supertough and heat-resistant stereocomplex-type polylactide/elastomer blends with impressive melt stability via in situ formation of graft copolymer during one-pot reactive melt blending. Macromolecules, 52(4), 1718-1730.

[56] Jiang, H., Ding, Y., Liu, J., Alagarsamy, A., Pan, L., Song, D., ... & Li, Y. (2020). Supertough Poly (Lactic Acid) and Sustainable Elastomer Blends Compatibilized by PLLA-b-PMMA Block Copolymers as Effective A-b-C-Type Compatibilizers. Industrial & Engineering Chemistry Research, 59(31), 13956-13968.

[57] Lu, X., Wei, X., Huang, J., Yang, L., Zhang, G., He, G., ... & Qu, J. (2014). Supertoughened poly (lactic acid)/polyurethane blend material by in situ reactive interfacial compatibilization via dynamic vulcanization. Industrial & Engineering Chemistry Research, 53(44), 17386-17393.

[58] Asaithambi, B., Ganesan, G., & Ananda Kumar, S. (2014). Bio-composites: Development and mechanical characterization of banana/sisal fibre reinforced poly lactic acid (PLA) hybrid composites. Fibers and Polymers, 15, 847-854.

[59] Manral, A., Ahmad, F., & Chaudhary, V. (2020). Static and dynamic mechanical properties of PLA bio-composite with hybrid reinforcement of flax and jute. Materials Today: Proceedings, 25, 577-580.

[60] Sanchez-Garcia, M. D., & Lagaron, J. M. (2010). On the use of plant cellulose nanowhiskers to enhance the barrier properties of polylactic acid. Cellulose, 17, 987-1004.

[61] Limsukon, W., Auras, R., & Selke, S. (2019). Hydrolytic degradation and lifetime prediction of poly (lactic acid) modified with a multifunctional epoxy-based chain extender. Polymer Testing, 80, 106108.

[62] Kakanuru, P., & Pochiraju, K. (2020). Moisture ingress and degradation of additively manufactured PLA, ABS and PLA/SiC composite parts. Additive Manufacturing, 36, 101529.

[63] Balasubramanian, E., Sagar, N. V. S. S., Chandrasekhar, U., & Salunkhe, S. (2019). Development of light weight multi-rotor UAV structures through synergistic application of design analysis and fused deposition modelling. International Journal of Materials and Product Technology, 59(3), 229-238.

[64**]** Booth, J., Edwards, E., Whitley, M., Kranz, M., Seif, M., & Ruffin, P. (2018, March). Military comparison of 3D printed vs commercial components. In Nano-, Bio-, Info-Tech Sensors, and 3D Systems II (Vol. 10597, pp. 52-66). SPIE.

[65] Dogea, R., Yan, X. T., & Millar, R. (2023). Testing and evaluation of the structural performance of a 3D-printed polylactic acid aircraft wing rib. Discover Mechanical Engineering, 2(1), 1-17.

[66] Zhang, T., Liu, Z., & Chen, G. (2018). Microgravity Degradation of the Starch-Polylactic Acid Aerospace Environmental Materials. Journal of Aerospace Science and Technology, 6(2), 11-16.

[67] Kuang, X., Roach, D. J., Wu, J., Hamel, C. M., Ding, Z., Wang, T., ... & Qi, H. J. (2019). Advances in 4D printing: materials and applications. Advanced Functional Materials, 29(2), 1805290.

[68] Zhang, Q., Zhang, K., & Hu, G. (2016). Smart three-dimensional lightweight structure triggered from a thin composite sheet via 3D printing technique. Scientific reports, 6(1), 22431.

[69] Patel, K. K., & Purohit, R. (2018). Future Prospects of shape memory polymer nano-composite and epoxy based shape memory polymer-A review. Materials Today: Proceedings, 5(9), 20193-20200.

[70] Senatov, F. S., Niaza, K. V., Zadorozhnyy, M. Y., Maksimkin, A. V., Kaloshkin, S. D., & Estrin, Y. Z. (2016). Mechanical properties and shape memory effect of 3D-printed PLA-based porous scaffolds. Journal of the mechanical behavior of biomedical materials, 57, 139-148.

[71] Zhang, Q., Yan, D., Zhang, K., & Hu, G. (2015). Pattern transformation of heat-shrinkable polymer by three-dimensional (3D) printing technique. Scientific reports, 5(1), 1-6.

[72] Fang, T., Fang, L., Chen, S., Li, L., Huang, H., Lu, C., & Xu, Z. (2017). Synthesis and study of shape-memory polymers selectively induced by near-infrared lights via in situ copolymerization. Polymers, 9(5), 181.

[73] Lewis, C. L., & Dell, E. M. (2016). A review of shape memory polymers bearing reversible binding groups. Journal of Polymer Science Part B: Polymer Physics, 54(14), 1340-1364.

[74] Shie, M. Y., Shen, Y. F., Astuti, S. D., Lee, A. K. X., Lin, S. H., Dwijaksara, N. L. B., & Chen, Y. W. (2019). Review of polymeric materials in 4D printing biomedical applications. Polymers, 11(11), 1864.

[75] Kim, H. W., Lee, H. H., & Knowles, J. C. (2006). Electrospinning biomedical nanocomposite fibers of hydroxyapatite/poly (lactic acid) for bone regeneration. Journal of Biomedical Materials Research Part A: An Official Journal of The Society for Biomaterials, **[33]** The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials, 79(3), 643-649.

[76] Fortunati, E., Armentano, I., Zhou, Q., Iannoni, A., Saino, E., Visai, L., ... & Kenny, J. M. (2012). Multifunctional bionanocomposite films of poly (lactic acid), cellulose nanocrystals and silver nanoparticles. Carbohydrate polymers, 87(2), 1596-1605.

[77] Aghjeh, M. R., Nazari, M., Khonakdar, H. A., Jafari, S. H., Wagenknecht, U., & Heinrich, G. (2015). In depth analysis of micro-mechanism of mechanical property alternations in PLA/EVA/clay nanocomposites: A combined theoretical and experimental approach. Materials & Design, 88, 1277-1289.

[78] Bodkhe, S., & Ermanni, P. (2020). 3D printing of multifunctional materials for sensing and actuation: Merging piezoelectricity with shape memory. European Polymer Journal, 132, 109738.

[79] Wei, H., Zhang, Q., Yao, Y., Liu, L., Liu, Y., & Leng, J. (2017). Direct-write fabrication of 4D active shape-changing structures based on a shape memory polymer and its nanocomposite. ACS applied materials & interfaces, 9(1), 876-883.

A MINI-REVIEW ON ROPE TECHNOLOGIES IN THE MARINE INDUSTRY

Ph.D. Candidate, Ömer Fırat TURŞUCULAR*
Textile Engineering, Bursa Uludağ University, Bursa, TURKEY - 0000-0003-1162-0742
Ph.D. Candidate, Elif Dicle TURŞUCULAR
Mechanical Engineering, Bursa Uludağ University, Bursa, TURKEY- 0000-0001-9339-2688
Assistant Professor, Alhayat Getu TEMESGEN
Textile Engineering, Wollo University, Kombolcha, ETHIOPIA - 0000-0001-7841-2281
Correspond author: omerfiratturssucular@gmail.com*

ABSTRACT

In this mini compilation study on rope technologies in the maritime sector; a compilation has been made on the history of the rope, design criteria, applied tests, raw materials used, production methods, and various experimental performance tests (DIN and VDI) belonging to many previous studies. In conclusion that the ropes used in the maritime industry are generally produced by twisting or braiding production methods, which started with natural fibers 3300 years ago, continued with natural fibers such as linen in 80 AD, and thanks to the technologies developed in the process until today, various conventional or high performance (technical) yarns. Depending on the type of yarn used, yarn number, braid diameter, twist angle, braid angle, braiding geometry, braiding layer number, braiding construction, the values of various mechanical performance tests such as bending, twisting, sliding, creep, fatigue, and tensile strength and wear It changes the values of various physical and chemical performance tests such as corrosion, chemical, and UV resistance. The highest various mechanical performance values; With high performance (technical) yarns, high yarn counts (dtex), high twist amount, high filament count, optimum (close to short fiber length such as 6 mm) filament length, high number of braiding layers used, use of braiding construction such as Three-strand, low braiding angle (- 45°), low drafting speed, 3D braiding geometry will enable the observation of various mechanical performance values at the maximum level in various experimental studies to be carried out in this field in the future.

Keywords: Marine, Ropes, Design criteria, Braiding technologies, Raw materials, Mechanical properties

1. INTRODUCTION

1.1. Historical background and world marketing for rope structures

The oldest rope was discovered 3300 years ago during excavations in Egypt. At that time, depictions of people climbing mountains, trees, and rocks with rope-like structures were found in the drawings in the caves. [one]. In the 500 BC, boats also pulled and fixed with ropes were found. **[1,6].** The sails are plain woven canvas fabrics, presumably from flax yarn. Lots of designs of ancient vessels, which are made of natural fibers have been found in Ecuador and Peru abosince ut 500 A.D. **[10].** In Thor, Heyerdahl's (1950) classic Kon-Tiki expedition (Pacific by raft) was made by tying logs of sal balsa tightly together by knotting them with quarter-inch diameter hemp threads. Decks woven with split bamboo reeds were made. The boat part was made of braided bamboo straws, the pole part was covered with bamboo slats, and the ceiling part was covered with banana leaves. Moreover, masts and rudders were made of mangrove wood. **[10].**

Moreover, the construction of the Egyptian pyramids could not have been done without ropes. It was reported for the first production methods records that it was produced by hand-bending leather or papyrus in 1450 BC. It has been reported that ropes with a tensile strength of 70 kN were also used in the construction of the Colosseum in Rome. **[1,6].** It was reported that linen yarn was used in 80 AD for the yarns used in the ropes. Moreover, it has been reported that the most commonly used yarn in rope production in the Middle Ages was linen. **[1].** It has also been reported that steel structures were widely used in the industrial revolution. After the 19th century, the use of cotton increased significantly. **[1].** PET was used in Petrobras' first engineering application for rope in 1997 and is still in production. **[7,12].** Worldwide annual rope production is not easily quantified but was estimated to be worth around $1.6 billion in 2004. **[4].**

1.2. Design criteria and applied standard tests for rope structures

The design criteria to be considered in rope design are their mechanical properties such as yarn types, yarn counts (dtex), yarn count, yarn elasticity modulus, shear modulus, bending modulus, bending modulus, abrasion resistance, corrosion resistance, UV resistance, bending, bending, tensile, shear, creep and fatigue strength, Crimp behavior, dimensional stability, yarn tension, filament number, filament length, filament cross-section, friction coefficient of filaments, force (kN) value needed depending on the application area, lubrication, twist amount, twist angle, cavitation and fill factors, floating (pitch) length, twisting angle, braiding angle, braiding geometry, drawing speed, braiding construction, ability to accommodate sensors, rope diameter (mm), rope covering, production in layers. **[1-4,6,7,12,15,16].** Nominal rope diameter (dN) is produced according to EN ISO 1968 standard. For ropes made of steel, the nominal rope diameter (dN) by the bending diameter ratio (D/d) is produced according to the DIN EN 12385-4 standard. Moreover: other standards used for ropes are; They are DIN EN ISO 2307, DIN EN ISO 9554, and VDI 2500. In a specific standard (DIN EN 564) for mountaineering equipment only), it is declared as a minimum dN 0.2 mm and a maximum dN + 0.5 mm. **[1].**

1.3. Manufacturing processes and braiding technology for rope structures

It is known about ropes that many yarns with many filaments can be produced by twisting and combining thanks to the braiding production method for ropes nowadays. **[1,6].** In the production methods of ropes; laying, twisting, or braiding methods are used. **[1-4,6-8,10,12,13,14,16].** The braiding production method is a textile structure formed by combining the yarns they carry on the road to which the yarn carriers are connected (by the desired braiding construction) depending on the braiding angle (°) by bringing the yarns they carry to each other at 180° angles opposite and in contact. The types of Braiding machines are; maypole (2D or 3D), rotary (2D or 3D), lace, and triaxial. In addition, braiding structures can be changed by playing with the profiles of the gears that provide the rotational movement of the yarn carriers, thanks to CAE systems. The number of yarns (braid yarns) and directions carried by yarn carriers also change braiding constructions. **[2,3,6].** Braided structures can be classified as diamond (1/1 repeat), regular (2/2 repeat) and Hercules (3/3 repeat) based on the weave pattern. **[3].** The rope, which was produced for the first time in history, was produced in Three-strand construction and is a very common braiding construction. **[1,12].** Four-strand is a very common braiding construction. **[13].** The first single-point mooring (SPM) in the maritime industry was established in 1959. A tanker ship anchors at a large buoy to transfer oil to the port. The diameters of the ropes used here are 150 mm and 200 mm. **[12].**

(18-inch-24-inch diameter, sizes 18 and 24). **[12].** Ropes are produced in 1.5-inch and 2-inch diameters. **[7].** Plaited and single or double braid constructions comprising 3x, 4x, 8x, 7x, 12x, and x16 strands are widely used in ropes in the maritime industry to prevent twisting when force is applied due to their high torque balance. **[4,6,12-16].** It has a high tensile strength in the axial direction thanks to its low braiding angle, and wear resistance can be improved by coating. It is usually PU or PMMA coating material. **[4,15].** Various mechanical properties of braiding structures produced by changing the braiding production parameters can also be changed. 2D, and 3D structures are formed according to the yarn feeding (3D) or not (2D) to the center of the braiding structure. Moreover, 3D structures in various geometries can be produced with the help of mandrels. **[2,3].** The rope foundation structure is presented in Figure 1. **[1].** Technora® ropes with different braid angles, and twist angles have been presented in Figure 2. **[1].** The Maypole braiding machine has been presented in Figure 3. **[2].** The Wardwell rotary braiding machine has been presented in Figure 4. **[2].** The lace braiding machine is presented in Figure 5. **[2].** The triaxial braiding machine has been presented in Figure 6. **[2].**

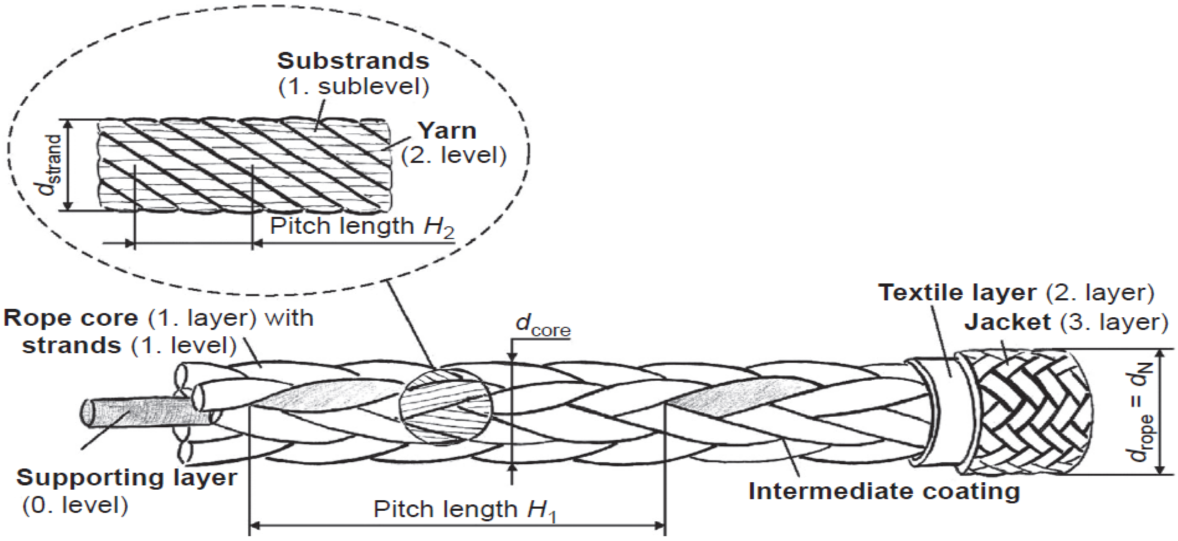


Figure 1. Rope foundation structure **[1]**

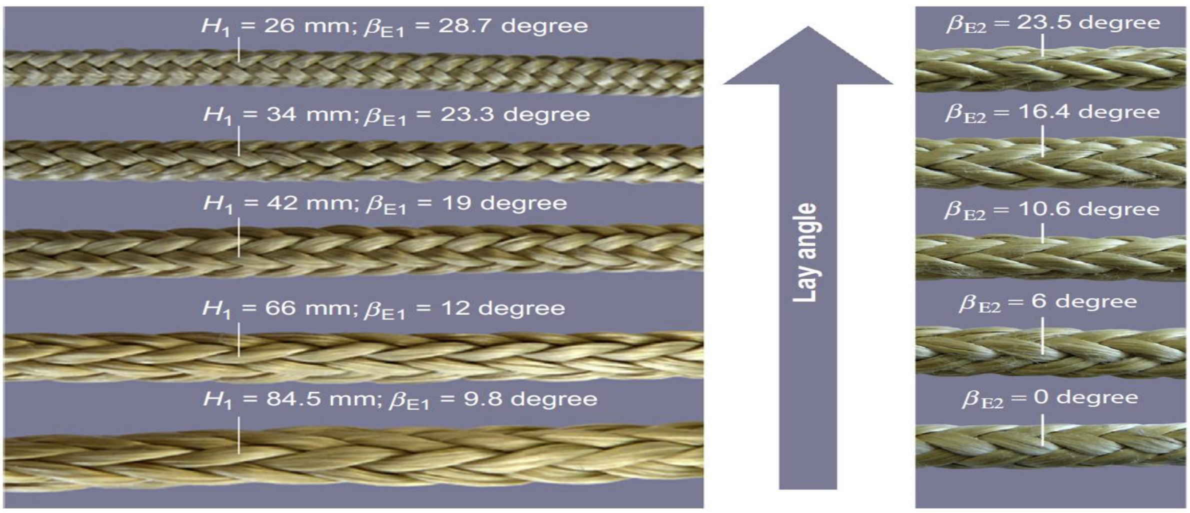


Figure 2. Technora® ropes with different braid angles, and twist angles **[1]**

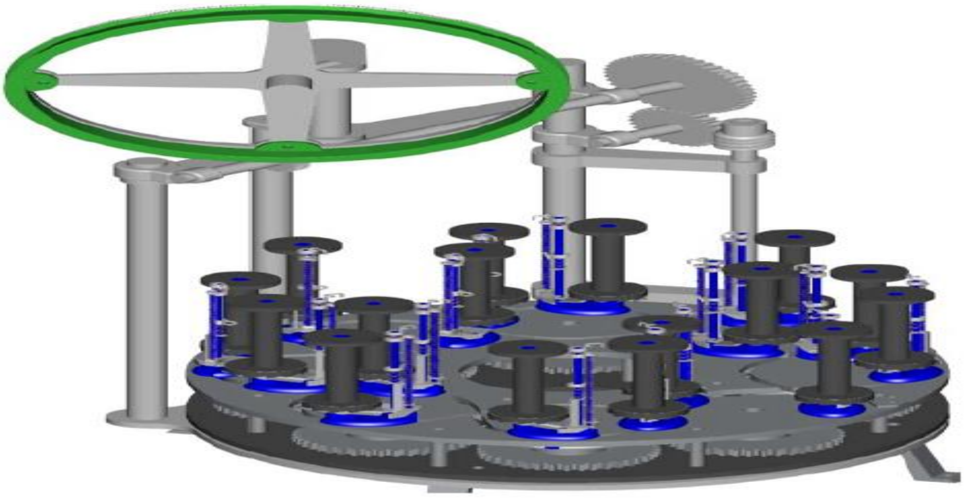


Figure 3. Maypole braiding machine **[2]**

Figure 4. Wardwell rotary braiding machine **[2]**

Figure 5. Lace braiding machine **[2]**

Figure 6. Triaxial braiding machine **[2]**

1.4. Raw materials for rope applications

Natural fibers in traditional marine technology played an important role in the primitive for the shape of ropes, moorings, hulls, and sails. Wooden rafts have been produced using available fiber resources together with ropes and twine. **[10].** It is used in ropes produced from natural fibers. **[9,11-13].** Among natural fibers; There are flax, hemp, jute, sisal, bamboo, ramie, kenaf, coconut, kapok, banana, and others. **[9-11].** Natural fibers compared to glass; have features such as ecological, biodegradable, lightness, low cost, flexibility, stiffness, and modulus of elasticity. **[9-11].** Most sisal fibers are grown in East Africa, Haiti, Brazil, India, and Indonesia. The name "Sisal" comes from a port town in Mexico so it is BT stands for "cold water". The diameter and length of the sisal fiber vary between about 100 μm - 300 μm and 1 m - 1.5 m. Each sisal fiber contains a group of small hollow fibers. The cell wall is composed of cellulose, lignin, and hemicellulose. The surface of each cell wall consists of a waxy (cuticle) layer and a large number of adjacent cell walls. This ensures that the breaking strength of the sisal fiber is good. This fiber is hydrophilic and therefore difficult to achieve strong interfacial adhesion with the hydrophobic polymer matrix. In this case, it leads to a decrease in moisture resistance. The cross-section of the sisal fiber is not uniform throughout its length. **[11].** For hundreds of years, sisal; rope, mattress, bag, etc. Composites made from natural fibers for applications such as consumer goods, low-cost residential, civil structures, and low-cost reinforced plastics are widely used in applications. **[9].** It was emphasized that PA 6.6 and PET yarns were generally used by the 20th century. **[1,12].** Synthetic ropes have been used since the 1980s until today due to their viscoelastic and viscoplastic behavior. **[4,6,7,12,13,16].** Some advantages of synthetic fibers are strong and durable. They can keep the wrinkle longer. They do not crease easily. They are resistant to most chemicals. They are resistant to insects, fungi, and rot. They have low moisture absorbency and are therefore easy to dry. They do not shrink when washed. **[8,11].** It has high corrosion resistance. It is also resistant to high tensile forces in the axial direction. Moreover, it has higher torsional strength performance compared to steel. **[4,11].** PA, polyolefin (PE and PP), PAN, and PET fibers constitute 98% of synthetic fiber production and are used in fiber production. Moreover, it is used in almost every field of fiber and textile applications. PET is the main type of synthetic fiber produced (60%) and consumed (24 million metric tons) worldwide. **[8].**

PA and PET yarns are widely used in rope types where moderate tensile strength and ductility are required. **[4].** PET absorbs very little water, but about 10% of PA's tensile strength is reduced by water absorption. **[4].** PE and PP, which are polyolefin group yarns, are similar to PET and PA (ductile materials), but they have easy processability, high wear resistance thanks to the low friction coefficient, low UV resistance, and low fatigue strength values compared to them. **[4,5,16].** PA, PET, PE, and PP raw materials; In the maritime sector, it is widely used as rope materials, thanks to the conversion of the yarn form into braiding structures. **[1.3-5,7,8,12-14,16].** The advantages of PA fibers are excellent tensile strength, good elastic recovery, low initial modulus, excellent abrasion resistance, high breaking energy work required to break the fiber, and excellent resistance to most chemicals. **[8].** Moreover, high-performance yarns developed in the 1970s; HMPE, Basalt (BF), Carbon (CF), Glass (GF), Aramid (Meta (Nomex®) and Para (PPD-T – Kevlar®)), UHMWPE (Dyneema®), Technora®, M5, LCAP (Vectran®), Pentax, Spider silk, PTFE and PBO (Zylon) yarns are widely used today due to their high mechanical properties. **[1-4,5,7-12,15,16].** In cases where high mechanical properties of steel are desired; high modulus high tenacity materials (HM-HT), high modulus polyethylene (HMPE), liquid crystal polymer (LCP, eg Vectran®), and aramid yarns are used. **[4,16].** Textile fibers have been presented in Figure 7. **[8].** Some rope samples used in the maritime industry have been presented in Figure 8. **[7].** An example of basalt (BF) rope used in the maritime industry has been presented in Figure 9. **[15].**

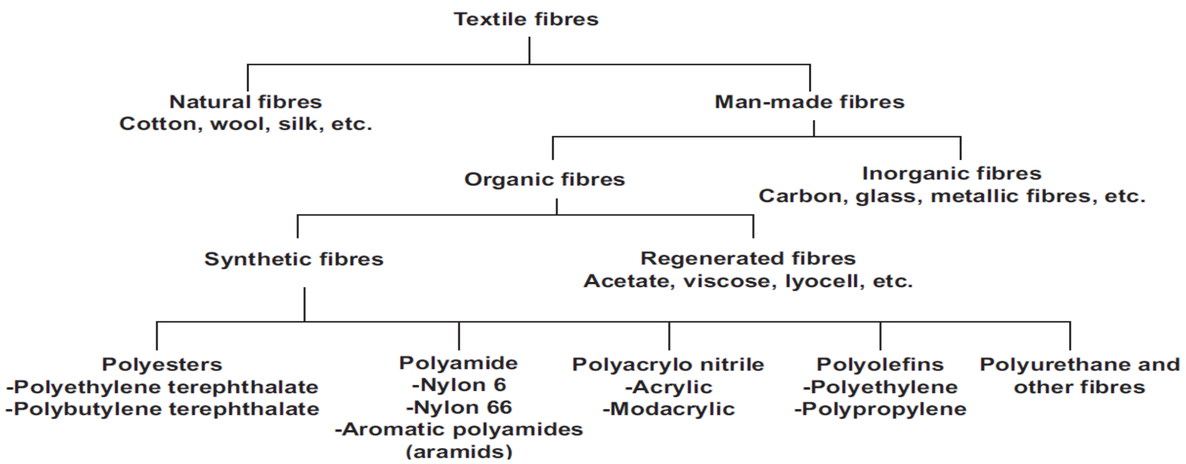


Figure 7. Textile fibers **[8]**

Figure 8. Some samples of ropes used in the maritime industry **[7]**

Figure 9. Example of basalt (BF) rope used in the maritime industry **[15]**

1.5. Mechanical properties for rope structures

The tensile strength of PA fibers is 0.5 N/tex and the % elongation at break is approximately 25%. **[8].** The advantages of PET fibers are hydrophobic and have a low moisture recovery value of 0.4%. It is water-repellent and dries quickly due to its hydrophobicity. They have excellent tensile strength, resistance to stretching, negligible shrinkage, non-wrinkling, excellent abrasion resistance, easy maintenance, chemical resistance, and mildew resistance. The tensile strength of PET fibers is in the range from 0.4 N/tex to 0.5 N/tex and the % elongation at break is between 15% and 25%. **[8,16].** The advantages of Aramid (Meta and Para) fibers are so strong. They have excellent resistance to heat, abrasion, and chemicals. They are not electrically conductive. Above 500 °C, they do not melt, but they begin to decompose. Meta-aramids (brands Nomex®, Tenjin conex®, New star®, X-fiber®, Kermel®) have a particularly tensile property. The tensile strength of meta-aramid fibers is about 0.5 N/tex. Moreover, it is comparable to high-strength synthetic fibers such as PA and PET. The uniqueness of meta-aramid fibers is that they have tensile stress, abrasion, and chemical resistance during exposure to flames and high temperatures up to 400 °C. The moisture recovery of meta-aramid fibers is 5% and the elongation at break is 15%. **[8,16].** Para-aramids (PPD-T) have high tensile strength and high modulus of elasticity behavior. PPD-T fibers are available in low-modulus, high-modulus, and very high-modulus variants. The low modulus (LM) of PPD-T fibers (Kevlar 29®) generally has a tensile strength of 2 N/tex, a modulus of elasticity of 490 N/tex, and an elongation at a break of 3.6%. The high modulus (HM) of PPD-T fibers (Kevlar 49®, Twaron®, Technora®) generally has a tensile strength of 2.1 N/tex, a modulus of elasticity of 780 N/tex, and an elongation at break of 2.8%. The very high modulus (UHM) of PPD-T fibers (Kevlar 149®) generally has a tensile strength of 2.1 N/tex, a modulus of elasticity of 1000 N/tex, and an elongation at a break of 2%. **[8,16].** The physical properties of natural fibers have been presented in Table 1. **[9].** The properties of various synthetic-based yarns at 65% relative humidity and 20 °C temperature have been presented in Table 2. **[4].** The chemical and mechanical properties of synthetic-based raw materials used as ropes in the maritime industry have been presented in Table 3. **[4].**

Table 1. Physical properties of natural fibers **[9]**

Fibers	Tensile Strength (MPa)	Young's modulus (GPa)	Elongation at break (%)	Density (g/cm^3)
Abaca	400	12	3-10	1.5
Bagasse	350	22	5.8	0.89
Bamboo	290	17	-	1.25
Banana	529-914	27-32	5.9	1.35
Coir	220	6	15-25	1.25
Cotton	400	12	3-10	1.51
Curaua	500-1150	11.8	3.7-4.3	1.4
Flax	800-1500	60-80	1.2-1.6	1.4
Hemp	550-900	70	1.6	1.48
Jute	410-780	26.5	1.9	1.48
Kenaf	930	53	1.6	-
Pineapple	413-1627	60-82	14.5	1.44
Ramie	500	44	2	1.5
Sisal	610-720	9-24	2-3	1.34
E-glass	2400	73	3	2.55

Table 2. Properties of various synthetic-based yarns at 65% relative humidity and 20 °C temperature **[4]**

Properties	PA 6	PET	Vectran® HT	Aramid	HMPE	Steel
Density (g/cm^3)	1.14	1.38	1.40	1.45	0.97	7.85
Modulus (N/tex)	7	11	54	60	100	20
Tenacity (mN/tex)	840	820	2286	2000	3500	330
Break extension (%)	20	12	3.8	3.5	3.5	(2 yield points)
Moisture (%)	5	<1	<0.1	1-7	0	0

Table 3. Chemical and mechanical properties for synthetic-based raw materials used as ropes in the maritime industry **[4]**

Properties	PA 6	PET	Vectran®	Aramid	HMPE
UV resistance	Good	Good	Poor	Average	Average
Chemicals	Good	Good	Good	Good	Good
Temperature	Good	Good	Good	Average	Poor
Abrasion	Average	Good	Good	Average	Good
Creep	Average	Good	Good	Good	Poor
Tension fatigue	Good	Good	Good	Good	Good
Compression fatigue	Good	Good	Good	Poor	Good

1.6. Mechanical behaviors of raw materials for rope applications

Synthetic rope test specifications defined in API RP 2SM such as load bearing capacity, torque, and rotation, static load extension, axial compression fatigue, dynamic load extension, creep and relaxation, and tension-tension fatigue. Brittle and hard yarns such as aramid and HMPE can tire quickly in compression under 0 or low forces. In this case, the filaments of the yarns bend and thus cause rapid fatigue. **[4].** In addition, the rope used in the maritime industry wears out quickly due to friction with other components or the contact of filaments/yarns with each other. This situation can be prevented by covering it with a material such as PU. Creep behavior in extreme cases is unsuccessful for HMPE yarn. The wetting and drying cycles of partially submerged ropes should be determined. **[4].** It has been reported that a PET-structured rope had 50 times higher fatigue strength compared to steel-structured rope and its densities were extremely low. It was also extremely low cost considering the cost. **[4].** They can accumulate between them due to the contact between the salt crystals and filaments/yarns, and in this case, they get tired quickly due to the abrasive effect. The development of marine polishes and micron-level filtration screens (to prevent the ingress of abrasive material) has led to significant increases in the fatigue performance of synthetic ropes. Moreover; as the rope diameter (dN) increases, the strain (%) values also increase. **[4].** PA and PET ropes with 1.5-inch and 2-inch diameters and double braided construction are extremely strong and have a very high modulus of elasticity and tensile strength values and are widely used in applications where high tensile strength is required. In addition, it has been reported that the 1.27 cm diameter PET rope has a breaking force of 150 tons. **[7].** An experimental study on ropes produced with high-performance yarns included 3-stranded PET ropes with 6 mm and 8 mm diameters, 16×2 double braided PPD-T (Kevlar 49®) ropes, and 12-stranded HMPE (Dyneema SK75®) ropes were produced. In conclusion; For 6 mm and 8 mm diameter PET ropes, 14.0% and 14.6% elongation at break are available, respectively. Elongation at break of 3.0% and 2.0% is available for 6 mm and 8 mm diameter PPD-T ropes, respectively. For 6 mm and 8 mm diameter HMPE ropes, elongation at break of 2.9% and 2.2% is available, respectively. After 1000 cycles for all ropes, the hysteresis of the ropes stabilized and hardened. The heat energy stored by the ropes did not increase. This was because the hysteresis field was extremely small. **[7].** The permanent elongation gradually increased and became stable due to the force storage as the number of cycles increased. **[7].** Huntsman Advanced Materials has developed a product for boat racing in the marine industry. Consisting of composite material in a sandwich structure, this racing boat; reinforcement material structure was multi-layered, in the form of fabric and the sandwich structure consisted of 50% linen and 50% carbon. The matrix material was composed of 100% epoxy. 50% linen part was impregnated with 100% epoxy to ensure moisture absorption in production. Then, the 50% carbon fraction was included. The racing boat made of this composite material was produced by curing at 50 °C using the vacuum infusion production method. In conclusion; an ecological, low-cost, high-strength, and high damping capacity racing boat was produced. Moreover: this company; canoes, surfboards, sails for windsurfers, and sails and yachts for kitesurfers. In addition, composite materials reinforced with bamboo and flax fibers and natural fiber reinforced with PET or epoxy matrix are often used for surfboards. **[10].** An experimental study with sisal fiber included that the sisal-reinforced PET matrix material and the glass-reinforced PET matrix material were mechanically compared. The specific modulus values were so close to each other, but the sisal-reinforced PET matrix composite material had 3 times more impact strength compared to the glass-reinforced PET matrix composite material. **[10,11].**

In addition, the reinforcement element ratio in the composite material should be a minimum of 50% and the critical fiber length should be 6 mm. Because high-impact strength can only be achieved at this rate or above. Moreover; it significantly improves its mechanical properties such as energy absorption, moisture absorption, bending, tensile, shear, and impact strength when chemical and thermal pre-treatment processes are applied to sisal fiber, Applied chemicals, and heat process; H_2SO_4, NaOH, isocyanate, permanganate, peroxide, benzoyl alcohol dewax, zirconate, organotitanate, silane, N-substituted methacrylamide, and 150 °C thermal process. As reinforcement elements such as glass, C, PE, PP, PS, LDPE, and matrix elements such as epoxy, PET, and PP are using for producing composite materials. **[10,11].** An example of natural fiber (sisal) reinforced composite material used in the maritime industry has been presented in Figure 10. **[10].**

Figure 10. Example of natural fiber (sisal) reinforced composite material used in the maritime industry **[10]**

An experimental study included that 10 mm diameter 4-stranded ropes were produced from PA, PE, and PP yarns. In conclusion PP > PA > PE, respectively for their tensile (rupture) force. PE > PP > PA, respectively for their time-dependent tensile (rupture) force decrease rate. PE > PP > PA, respectively for their elongation at break. PE > PA > PP, respectively for their time-dependent tensile (breaking) elongation decrease rate. Elastic and plastic degradation rates were PE > PP > PA, respectively for a period of 8 months. **[13].** An experimental study included that ropes were produced from PET and PA yarns. In conclusion; as a result of wet abrasion resistance applied over 10,000 cycles, PET > PA, respectively. The chemical structure of PET was due to its hydrophobic nature. **[14].** An experimental study included that reinforced (80%) basalt (BF) yarns and impregnated (matrixed) with vinyl ester (VE) resin (20%) and as a result composite material ropes were produced. The composite material ropes were also produced as 8 strips with a diameter of 4 mm. They were processed as pre-treatment with H_2O, NaOH, and HCl chemicals. In conclusion; their dimensional stability as well. HCl > NaOH > H_2O, respectively for their mass losses. When the surface morphology of the BF ropes was examined after the aging test, NaOH > H_2O > HCl, respectively for their damages. H_2O > HCl > NaOH, respectively for their tensile (rupture) force. **[15].**

The reason for this situation was the VE resin (matrix element) was sensitive to alkalis, and could not protect the composite material rope against alkalis. It was resistant to seawater. It was also resistant to Cl, salt, or microorganisms in seawater. **[15].** An experimental study included that various ropes were produced from UHMWPE, HPPE, and PET yarns. When the creep behavior was examined that as the applied force, and temperature increased over time, the creep behavior increased significantly, and the elastic recovery behavior decreased for the UHMWPE rope. At the same time, the percentage of permanent elongation (%) increased. A very serious percentage permanent elongation of 25% was observed after 22 hours under 70 °C temperature, and 0.5 N/tex tension. A very serious percentage permanent elongation of 25% was observed after 40 days at 72°F at 72°F with a gradual decrease from 72°F to 55°F, and under stress from 11.19 g/m. A moderately severe persistent elongation of 13% was observed after 80 days at 55 °F. In addition, the comparative creep behavior of UHMWPE, and PET ropes was also investigated. **[16].** At the end of 100 days under tension of 0.6 N/tex, 13% permanent elongation was observed in PET-structured rope, while 25% permanent elongation was observed in UHMWPE-structured rope. The reasons for this situation were as soon as the force was applied, the amorphous regions of the filaments in the structure of the yarns forming the rope began to stretch. The stresses increased depending on time. Thus, the long molecular chains began to slide over each other without reversibility until they broke. Moreover, as the temperature (up to about 70 °C) increased in UHWMPE structured ropes, a slight increase in tightening, and breaking strength was observed in the structure. The reason for this situation was the reduction of the length differences of the filaments in the structure of the yarns that made up the rope, and the fact that the filaments increased the friction force with the effect of friction between each other, and provide some increase in the plucking force, but at temperatures above 70 °C this situation lost its effect and turned into a very serious percentage of permanent elongation (25%). Moreover, it will maintain its breaking force value for a very long time at 10% permanent elongation. The filaments with the shortest length in the structure of the yarns forming the rope due to the friction effect were exposed to the highest force values. Therefore, cause the highest percentage of permanent elongation to be observed. allowed the observation of force values. **[16].**

2. CONCLUSIONS

-The oldest rope production started in Egypt 3300 years ago by twisting natural yarns.
-Synthetic-based raw materials used in ropes, which are low cost and widely used throughout history and today; flax, hemp, sisal, and bamboo.
-Synthetic-based raw materials used in ropes that are low in cost and widely used today; PET, PA, PE, PP. The most widely used synthetic-based raw material is PET.
-The raw materials used in the ropes where high-performance mechanical properties are required such as HMPE, Carbon (CF), Glass (GF), Aramid (Meta (Nomex®) and Para (PPD-T - Kevlar®)), UHMWPE (Dyneema®), Technora®, M5, LCAP (Vectran®), Pentex®, Spider silk, PTFE and PBO (Zylon®).
-While the high-performance (technical) raw materials produced today (converted from yarn to braiding form) are in rope form, it has been determined that dimensional stability is provided in terms of fatigue strength in 1000 cycles (n) and the permanent elongation values are low due to the low hysteresis area. In terms of tensile strength, it provides resistance to the maximum tensile (rupture) force on the basis of kN. Moreover, the maximum elongation at break (%) values was found to be between 2% and 3% for high-performance (technical) raw materials and between 14% and 15% for conventional synthetic-based raw materials.

-The high-performance (technical) raw materials (converted from yarn to braiding) produced today usually have a significant amount of creep behavior at above 70 °C depending on the applied force value and temperature.
- Throughout history, laying, twisting, and braiding production methods have been used in terms of the production method of ropes. Today, the braiding production method is widely used in terms of the production method of ropes.
-Today, the most common braiding construction in terms of the braiding production method of ropes is three-strand. Other braiding constructions used are plaited and single or double braids. These braiding constructions are preferred because they prevent twisting and provide high torque balance.
-Covering the ropes used today with a coating material such as PU or PMMA will increase their abrasion resistance. For ropes made of steel, the nominal rope diameter (dN) is produced according to the DIN EN 12385-4 standard.
-Nominal rope diameters (dN) of mooring ropes used specifically in the maritime industry are between 150 mm and 200 mm (18 - 24 inch diameter, 18 and 24 numbers). Other standards used for ropes are DIN EN ISO 2307, DIN EN ISO 9554, and VDI 2500. In a special standard (DIN EN 564) only for mountaineering equipment, there is a requirement to manufacture diameters in the range of minimum dN 0.2 mm and maximum dN + 0.5 mm.
-To provide the highest various mechanical performance values in the ropes used today; with high performance (technical) yarns, high yarn counts (dtex), high twist amount, high filament count, high number of braiding layers used, use of braiding construction such as Three-strand, low braiding angle (-45°), low drawing speed, It is recommended to be produced in 3D braiding geometry.

REFERENCES

[1] Michael, M., C. Kern., and T. Heinze. (2016). Braiding processes for braided ropes. Advances in Braiding Technology, Woodhead Publishing, 225-243. https://doi.org/10.1016/B978-0-08-100407-4.00009-0./ (Erişim tarihi: 27.07.2023)
[2] Branscomb, D., Beale, D., and Broughton, R. (2013). New directions in braiding. Journal of Engineered Fibers and Fabrics, 8 (2). 11-24. https://doi.org/10.1177/155892501300800202./ (Erişim tarihi: 27.07.2023)
[3] Rawal, A., Saraswat, H., and Sibal, A. (2015). Tensile response of braided structures: a review. Textile Research Journal, 85 (19). 1-14. https://doi.org/10.1177/0040517515576331. / (Erişim tarihi: 27.07.2023)
[4] Weller, S. D., Johanning, L.Ü, Davies, P., and Banfield, S. J. (2015). Synthetic mooring ropes for marine renewable energy applications. Renewable Energy, 83 (1). 1268-1278. https://doi.org/10.1016/j.renene.2015.03.058./ (Erişim tarihi: 28.07.2023)
[5] Mathew, M. T., Novo, J., Rocha, L. A., Covas, J. A., and Gomes, J. R. (2010). Tribological, rheological, and mechanical characterization of polymer blends for ropes and nets. Tribology International, 43 (8). 1400-1409. https://doi.org/10.1016/j.triboint.2010.01.011./ (Erişim tarihi: 28.07.2023)
[6] Vu, T. D., Durville, D., and Davies, P. (2015). Finite element simulation of the mechanical behavior of synthetic braided ropes and validation on a tensile test. International Journal of Solids and Structures, 58 (1). 106-116. https://doi.org/10.1016/j.ijsolstr.2014.12.022./ (Erişim tarihi: 28.07.2023)
[7] Liu, H., Huang, W., Lian, Y., and Li, L. (2014). An experimental investigation on nonlinear behaviors of synthetic fiber ropes for deepwater moorings under cyclic loading. Applied Ocean

Research, 45 (1). 22-32. https://doi.org/10.1016/j.apor.2013.12.003./ (Erişim tarihi: 29.07.2023)
[8] Deopura, B. L., and N. V. Padaki. (2015). Synthetic textile fi: polyamide, polyester, and aramid fibers. Textiles and Fashion, Woodhead Publishing, 97-114. https://doi.org/10.1016/B978-1-84569-931-4.00005-2./ (Erişim tarihi: 29.07.2023)
[9] Sanjay, M. R., Arpitha, G. R., and Yogesha, B. (2015). Study on mechanical properties of natural-glass fiber reinforced polymer hybrid composites: A review. Materials Today: Proceedings 2 (4-5). 2959-2967. https://doi.org/10.1016/j.matpr.2015.07.264./ (Erişim tarihi: 29.07.2023)
[10] Ansell, M. P. (2014). Natural fiber composites in a marine environment. Natural Fibre Composites, Woodhead Publishing, 365-374. https://doi.org/10.1533/9780857099228.3.365./ (Erişim tarihi: 29.07.2023)
[11] Naveen, J., Jawaid, M., Amuthakkannan, P., and Chandrasekar, M. (2019). Mechanical and physical properties of sisal and hybrid sisal fiber-reinforced polymer composites Mechanical and physical testing of biocomposites, fiber-reinforced composites, and hybrid composites, Woodhead Publishing, 427-440. https://doi.org/10.1016/B978-0-08-102292-4.00021-7./ (Erişim tarihi: 30.07.2023)
[12] Flory, J. F., Hearle, J., McKenna, H., and Parsey, M. (2015). About 75 years of synthetic fiber rope history. MTS/OCEANS, IEEE, 1 (1). 1-13. DOI: 10.23919/OCEANS.2015.7404500./ (Erişim tarihi: 30.07.2023)
[13] Welden, N. A., and Cowie, P. R. (2017). Degradation of common polymer ropes in a sublittoral marine environment. Marine Pollution Bulletin, 118 (1-2). 248-253. https://doi.org/10.1016/j.marpolbul.2017.02.072./ (Erişim tarihi: 30.07.2023)
[14] Flory, J. F. (2013). Cordage Institute guidelines for marine grade nylon and polyester rope-making yarns. MTS/OCEANS, IEEE, 1-6. DOI: 10.23919/OCEANS.2013.6740956./ (Erişim tarihi: 30.07.2023)
[15] Quagliarini, E., Monni, F., Bondioli, F., and Lenci, S. (2016). Basalt fiber ropes and rods: Durability tests for their use in building engineering. Journal of Building Engineering, 5 (1). 142-150. https://doi.org/10.1016/j.jobe.2015.12.003./ (Erişim tarihi: 30.07.2023)
[16] Smeets, P., Jacobs, M., and Mertens, M. (2001). Creep as a design tool for HMPE ropes in long-term marine and offshore applications. MTS/OCEANS, IEEE, 2 (1). 685-690. DOI: 10.1109/OCEANS.2001.968205./ (Erişim tarihi: 30.07.2023)

YÜKSEK DEVİR SAĞLAYICI KULLANILARAK FREZELEME OPERASYONLARINDA KESME PARAMETRELERİNİN YÜZEY PÜRÜZLÜLÜĞÜ VE GÜÇ TÜKETİMİNE ETKİSİNİN İNCELENMESİ

Hüseyincan SAĞIR[1], Barkın BAKIR[2]

[1] Marmara Üniversitesi, Teknoloji Fakültesi, 0009-0005-1436-5056

[2] Marmara Üniversitesi, Teknoloji Fakültesi, 0000-0002-3031-1649

ÖZET

İnsanlığın küresel ısınma ve çevre kirliliği gibi önemli sorunlar ile yüzleşmesinden dolayı, enerji tüketimi giderek önem kazanmaktadır. Ayrıca yüksek teknolojiye sahip sanayilerde üretilen iş parçalarının, giderek artan kalite isterleri ile üretim için harcanan enerji miktarı arasındaki çekişme dikkat çekici hale gelmektedir. Bir iş parçasının en önemli isterleri, boyutsal doğruluk ve yüzey pürüzlüğü olup talaşlı imalat endüstrisinde takım tezgâhları, işlenecek malzeme, kesici takımlar ve kesme parametrelerinin verimliliği üzerine yıllardır araştırmalar yapılmaktadır. Bu çalışmalar sonucunda takım tezgâhlarının enerji tüketimini doğru bir şekilde karakterize etmek, üretim enerji verimliliğini artırmak ve bunlarla ilişkili parametrelerden en iyi sonuçların elde edilmesi için yapılan araştırmaların artırılmasına ihtiyaç duyulmaktadır.
Bu çalışmada, talaşlı imalat faaliyetlerinde yaygın bir uygulama alanı bulunan frezeleme operasyonun yüksek devir sağlayıcı kullanılarak malzemenin işlenmesi sonucunda, tezgahın enerji tüketimindeki karakterizasyonu incelenmiştir. CNC tezgahının işleme merkezine adapte edilecek yüksek devir sağlayıcının devir artış oranı 1:5 oranındadır. Bu oran sayesinde düşük devirlerde çekilen güç ile yüksek devir elde edilerek enerji tüketimindeki değişim ve ürün kalitesindeki durum belirlenmiştir.
Bu kapsamda gerçekleştirilecek işlemlerde optimum kesme parametrelerinin belirlenebilmesi için Taguchi Metodu kullanılmıştır. Taguchi yöntemi, imalat aşamalarında ürün maliyetini ve kalitesine etki eden kesme parametrelerini optimize edilmesinde etkili bir yöntemdir. Bu yöntemle deney sayısı önemli ölçüde azaltılmakta ve zaman kaybını en az seviyeye indirilmektedir. Bu nedenlerden dolayı yapılan çalışmada optimum kesme parametrelerinin belirlenmesi için Taguchi yöntemi tercih edilmiştir. Bu sayede frezeleme operasyonları gibi talaşlı imalat işlemlerin gerçekleştirildiği takım tezgâhlarındaki güç tüketiminin azaltılması, maliyet-etkin ürünler oluşturulması hedeflenmiştir.

Anahtar Kelimeler: Enerji Verimliliği, Güç Tüketimi, Yüksek Devir Sağlayıcı, Yüzey Pürüzlülüğü, Taguchi Yöntemi, Yeşil İmalat.

1. GİRİŞ

Sanayi sektörü en çok enerji tüketen sektör konumunda olup özelikle seri üretim hatlarına sahip sanayi kuruluşlarının ürün maliyetlerinin önemli bir kısmını enerji tüketimi oluşturmaktadır. Enerji kullanımında sürdürebilirlik; endüstri için güncel ekonomik koşullar, rekabet şartları gibi hususlar dikkate alındığında araştırması yapılması gereken en önemli konu başlıklarından birisini oluşturmaktadır.

Talaşlı imalat prosesleri, önemli miktarda enerji tüketimi nedeniyle çevre üzerinde ölçülebilir etkilere neden olur. Takım tezgâhlarının enerji verimliliğinin arttırılması, işleme sistemlerinin çevresel performansını önemli ölçüde iyileştirebilir. Çoğu konvansiyonel yaklaşımda, kesme gücünü tork sensörleri ya da dinamometrelerle doğrudan ölçerek enerji verimliliği takip edilmiştir. Bu yöntemde kullanılan ekipmanlar yerine uygulama maliyetini düşürmek yeni bir çevrimiçi yaklaşım önerilmiştir [1].

Talaşlı imalatta optimum yüzey kalitesini sağlamak ve üretim maliyetlerini düşürmek için, malzemelerin uygun kesme parametreleri kullanılarak işlenmesi üzerine çalışmalar gerçekleştirilmiştir [2-3]. Optimum işleme parametrelerinin seçimi önemlidir. Bu çerçevede gerçekleştirilen deneysel çalışmalar ile yüksek verimlilik elde etme üzerine etkili araştırmalar yapılmıştır [4-5]

Takım tezgâhları kullanılarak gerçekleştirilen talaşlı imalat operasyonları ile ilgili olarak, en uygun süreç parametrelerinin seçimi ile enerjiyi en aza indirgeme araştırmaları gerçekleştirilmiştir [6-7]. Uygun parametre seçimi ile % 6-40 arasında enerji tasarrufu sağlanabileceği belirlenmiştir [8-9].

Talaşlı imalat sistemindeki ihtiyaçlara bağlı olarak enerji tüketimini anlamak ve karakterize etmek, üretim süreçleri perspektifinden potansiyel enerji tüketiminin azaltılmasını keşfetmeye katkıda bulunulmuştur [10-11].

Kesici takım, işçilik ve takım tezgâhı ne kadar verimli kullanılırsa, işleme operasyonlarında kullanılan enerji verimli ve aynı zamanda daha uygun maliyetli olacağından, bu durumun takım tezgâhların kullanımında dikkate alınması üzerinde bir etkisi olacağı değerlendirilmiştir [12].

Verimli bir süreç sağlamak ve talaşlı imalatı başarılı bir şekilde etkinleştirmek için kesme parametrelerinin, kesici takımların, takım tezgâhlarının ve üretim ortamının ayrıntılı analizi ve adaptasyonunun zorunlu olduğu belirtilmiştir [13].

Eren ve arkadaşları tarafından, DIN 1.2367 sıcak iş takım çeliğinin sert tornalanmasında kesme parametrelerinin enerji tüketimine etkileri araştırılmış ve toplam güç tüketiminin matematiksel modeli oluşturulmuştur. Deneyler sonucunda, kesme parametrelerindeki artışın anlık akım değerini arttırdığı, ancak özellikle ilerleme miktarı ve kesme derinliğinin artmasıyla azalan işleme süresine bağlı olarak toplam güç tüketiminin azaldığı tespit edilmiştir [14].

Şahinoğlu ve arkadaşları tarafından, bir deneysel çalışmada, ray çeliği malzemesinin üç farklı talaş derinliği, üç farklı ilerleme miktarı ve sabit kesme hızında meydana gelen yüzey pürüzlülük ve enerji tüketim değerleri ölçülmüştür. Sonuç olarak: Artan ilerleme ve talaş derinliğiyle birlikte güç tüketiminin de arttığı, güç tüketimi üzerinde talaş derinliğinin en etkili parametre olduğu, artan ilerleme miktarı ve talaş derinliği ile anlık güç tüketiminin arttığı, fakat toplam işleme süresi kısaldığı, dolayısıyla bir parçanın işlenmesi için tüketilen toplam enerji tüketiminin düştüğü görülmüştür [15].

Zhou ve arkadaşları tarafından, malzemenin işlem süresini ve enerji tüketimini azaltarak minimize etmeyi amaçlayan çok maksatlı bir kesme parametresi optimizasyon modeli önerilmiştir. Bu kapsamda takım tezgâhların işleme kapasitesi, takım ömrü, malzemenin yüzey pürüzlülüğü ve boşa tüketilen enerji kriter olarak göz önünde bulundurulmuştur. Optimizasyon modelini oluşturmak maksadıyla genetik bir algoritma kullanılmış ve tanımlanan parametrelerin takım tezgâhlar üzerindeki enerji tüketim miktarı incelenmiştir. Önerilen yöntemi doğrulamak için Taguchi metodu yardımıyla bir frezeleme prosesi oluşturulmuştur [16].

Karabulut ve Şahinoğlu tarafından, Hadfield çeliğinin kesme davranışı ile birlikte işleme parametrelerinin yüzey pürüzlülüğü, makine gürültüsü ve güç tüketimine etkisi kuru işleme şartlarında yatay freze tezgâhı mağfiretiyle deneysel olarak araştırılmıştır. Bahse konu deneysel çalışmalar, sabit kesme hızı, dört farklı ilerleme hızı ve altı farklı talaş derinliğinde ve gerçek bir üretim ortamında gerçekleştirilmiştir. Anılan parametrelerin yüzey pürüzlülüğü, makine gürültüsü ve güç tüketimi üzerindeki etkisi varyans analizi kullanılarak irdelenmiştir. Bu kapsamda deneysel sonuçlar neticesinde, talaş derinliğinin yüzey pürüzlülüğü üzerinde en etkili kesme parametresi olduğu, talaş derinliğinin artmasıyla yüzey pürüzlülüğü değeri belirgin şekilde iyileştiği tespit edilmiştir. Ayrıca güç tüketimi ve makine gürültüsünün, artan ilerleme hızı ve talaş derinliği değerlerinin artmasından etkilendiği görülmüştür [17].

Bu tez kapsamında, yüksek devir sağlayıcıların freze operasyonlarında kullanılması durumunda takım tezgahlarındaki enerji tüketimi ve elde edilen ürünün kalitesi incelenerek bakım/onarım sürelerini, yedek parça ve enerji maliyetlerini azaltacak parametrelerin belirlenmesi ve bunun sonucunda ekonomik, kaliteli ve maliyet-etkin ürünler oluşturmak için optimum yöntemin tespit edilmesi amaçlanmıştır. Bu sayede frezeleme operasyonları gibi talaşlı imalat işlemlerin gerçekleştirildiği takım tezgâhlarında yüksek devir sağlayıcı kullanılması durumunda elde edilen verimin artırılması hedeflenmektedir.

2. DENEYSEL ÇALIŞMALAR

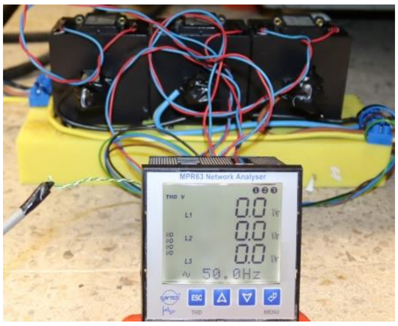
Bu çalışmada, numune olarak zırh çeliği malzemesi (Görsel 2.1.a), Johnford VMC 850 / 550 üç eksenli CNC freze tezgâhı (Görsel 2.1.b), DIN 844K kalitesinde Gühring marka 3428 numaralı kesici takım (Görsel 2.1.c), Nikken marka hız kafası (Görsel 2.1.ç), Dynoware ve Minitab yazılımları, güç analizörü (Görsel 2.1.d) ve portatif Mitoyoyo marka yüzey pürüzlülüğü ölçüm cihazı (Görsel 2.1.e) kullanılmıştır.

a)Deney Numunesi

b) Deneyde Kullanılan CNC Freze Tezgahı

c)Kesici Takım

ç)Hız Kafası



d)Güç Analizörü

e) Yüzey Pürüzlülüğü Ölçüm Cihazı

Görsel 2.1 Deney Tezgahı, İşlenen Numune ve Kullanılan Ölçüm Aletleri

Kesme parametreleri olarak devir sayısı (n), ilerleme miktarı (f) ve kesme derinliği (d) bağımsız değişken olarak kabul edilmiştir. Değişkenlerin her biri için 3 farklı seviye bulunmaktadır. Deney yönteminde, Taguchi metodunun L_9 dikey dizisi kullanılmıştır. Ayrıca deneyler yüksek devir sağlayıcı olan/olmayan frezeleme operasyonu için tekrar edilmiştir. Böylece, toplamda 18 farklı deney gerçekleştirilmiştir. Deneylerde zırh çeliği kullanılmış olup deneyler kuru ortam şartlarında soğutma sıvısı kullanılmadan icra edilmiştir. Uygulanan kesme parametreleri, değerleri ve sembolleri ile birlikte Çizelge 2.1'de belirtilmiştir.

Çizelge 2.1 Kesme Parametreleri ve Değerleri

Kesme Parametreleri	**Sembol**	**Birim**	**Kod**	**Değerler**		
				1	**2**	**3**
Devir	n	dev/dk	S	1500	2000	3000
İlerleme	F	mm/dk	F	150	200	250
Talaş Derinliği	a_p	mm	A	0,25	0,5	0,75

Taguchi metodunda yukarıda belirtilen 'en büyük en iyi', 'nominal en iyi' ve 'en küçük en iyi' amaç fonksiyonlarıdır. Bu tez kapsamında enerji tüketiminin azaltılması maksadıyla güç tüketiminin en küçük olması gerekmektedir. Bu nedenle S/N oranlarının hesaplanmasında "en küçük en iyi" amaç fonsiyonu seçilmiştir.

Deneysel tasarımda yer alan S/N oranının hesaplanmasında ortalama ve değişimi olabildiğince küçültmek için kullanılan “daha küçük daha iyi” ifadesini temsil eden denklem esas alınmıştır. Daha küçük daha iyi kriterine göre S/N oranı;

$$S/N_s\,(\eta) = -10log\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right) \qquad (2.1)$$

denklemiyle hesaplanır. Denklemde, y_i^2, ölçüm sonuçlarının toplamının karesi, n ise toplam deney sayısını ifade etmektedir [18].

3. SONUÇLAR VE DEĞERLENDİRME

Yapılan deneylerde zırh çeliği malzemesinin üç farklı kesme parametre ile üç farklı seviyede işlenmesi sonucunda güç tüketimi (W) ve yüzey pürüzlülüğü (Ra) değerlerinin elde edilmesi şeklinde gerçekleştirilmiştir. Bulgular, hız kafası kullanılmadan ve hız kafası kullanılarak olmak üzere iki aşamada incelenmiştir.

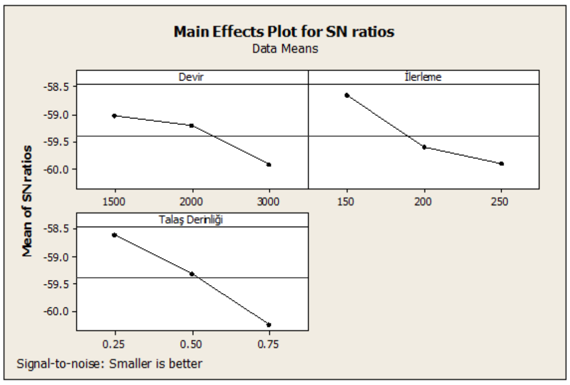
3.1. Güç Tüketimi Ölçümü

CNC freze tezgâhında zırh çeliği malzemesi üzerinde hız kafası kullanılarak/kullanılmadan her bir kesme parametresi üç farklı değerde ele alınarak gerçekleştirilen toplam on sekiz deneyde güç tüketim değerleri ölçülmüştür. Bu deneylerde hız kafası kullanılmadan güç tüketimi en düşük 744 W, en yüksek 1048 W olarak, hız kafası kullanıldığında güç tüketimi en düşük 476 W, en yüksek 704 W olarak ölçülmüştür. Ölçülen değerlen Çizelge 3.1’de verilmiştir.

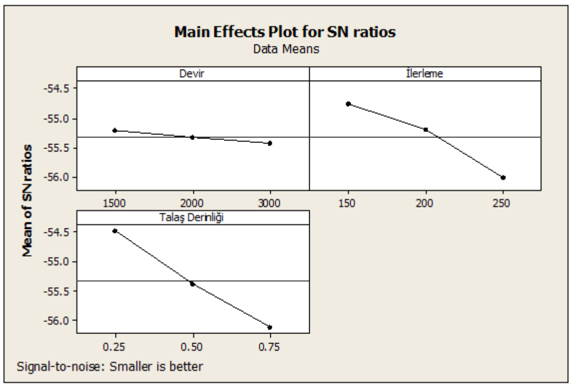
Çizelge 3.1 Güç Tüketimi Deney Sonuçları

Deney No	Parametreler	Devir (dev/dk)	İlerleme (mm/dk)	Talaş Derinliği (mm)	Güç Tüketimi (W)	Hız Kafası Kullanıldığında Güç Tüketimi
1	S1F1A1	1500	150	0,25	744	476
2	S1F2A2	1500	200	0,5	920	572
3	S1F3A3	1500	250	0,75	1048	704
4	S2F1A2	2000	150	0,5	832	568
5	S2F2A3	2000	200	0,75	1024	612
6	S2F3A1	2000	250	0,25	896	574
7	S3F1A3	3000	150	0,75	1016	608
8	S3F2A1	3000	200	0,25	928	544
9	S3F3A2	3000	250	0,5	1032	624

Görsel 3.1’de deneylerde kullanılan kesme parametrelerinin hız kafası kullanılmayan (Görsel 3.1a) ve hız kafası kullanılan (Görsel 3.1b) proseslerdeki güç tüketimi arasındaki ilişki gösterilmiştir. Burada görüldüğü üzere devir, ilerleme ve talaş derinliği arttıkça güç tüketimi artmış olup hız kafası kullanıldığında güç tüketiminin azaldığı tespit edilmiştir.



a)Hız kafası kullanılmayan



b)Hız kafası kullanılan

Görsel 3.1 Kesme Parametreleri ile Güç Tüketimi Arasındaki İlişki

Gerçekleştirilen deneylerde güç tüketimi değişiminin kesme parametrelerine göre S/N oranları Çizelge 3.2'de verilmiştir.

Çizelge 3.2 Güç Tüketimi Değerlerinin S/N Oranları

	Hız Kafası Kullanılmadığında			Hız Kafası Kullanıldığında		
Seviye	Devir (S) (dev/dk)	İlerleme (F) (mm/dk)	Talaş Derinliği (A) (mm)	Devir (S) (dev/dk)	İlerleme (F) (mm/dk)	Talaş Derinliği (A) (mm)
1	-59,04	-58,66	-58,61	-55,22	-54,77	-54,48
2	-59,22	-59,61	-59,32	-55,33	-55,20	-55,38
3	-59,92	-59,91	-60,25	-55,43	-56,01	-56,12
Fark	0,88	1,25	1,64	0,21	1,24	1,64
Rank	3	2	1	3	2	1

Çizelge 3.2'de görüldüğü üzere hız kafası kullanılan/kullanılmayan deneylerde en düşük güç tüketimi elde edilebilmesi için "S1F1A1" kesme parametrelerinin kullanılması gerektiği anlaşılmaktadır. Ayrıca güç tüketimini etkileyen en önemli parametrenin sırasıyla "talaş derinliği, ilerleme, devir" olduğu sonucuna ulaşılmıştır. Bunun yanı sıra frezeleme operasyonlarında hız kafası kullanıldığında güç tüketiminin önemli ölçü de azaldığı tespit edilmiştir.

3.1. Yüzey Pürüzlülüğü Ölçümü

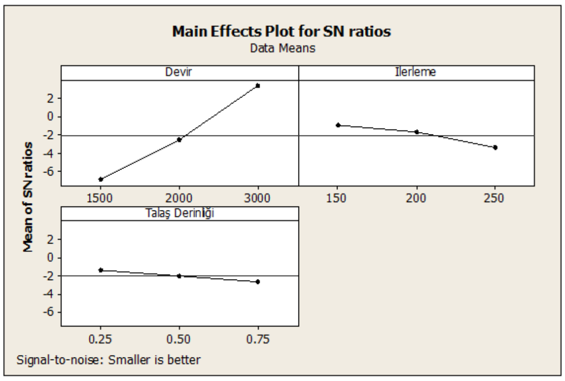
Hız kafası kullanılan/kullanılmayan frezeleme operasyonlarından elde edilen yüzey pürüzlülük verileri aşağıdaki Çizelge 3.3'de ve şekillerde belirtilmiştir.

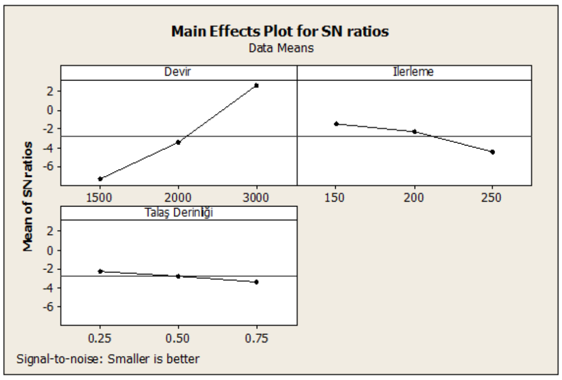
Çizelge 3.3 Yüzey Pürüzlülüğü Deney Sonuçları

Deney No	Parametreler	Devir (dev/dk)	İlerleme (mm/dk)	Talaş Derinliği (mm)	Yüzey Pürüzlülüğü Ra (µm)	Hız Kafası Kullanıldığında Yüzey Pürüzlülüğü, Ra (µm)
1	S1F1A1	1500	150	0,25	1,935	2,083
2	S1F2A2	1500	200	0,5	2,217	2,301
3	S1F3A3	1500	250	0,75	2,54	2,637
4	S2F1A2	2000	150	0,5	1,073	1,125
5	S2F2A3	2000	200	0,75	1,472	1,669
6	S2F3A1	2000	250	0,25	1,521	1,784
7	S3F1A3	3000	150	0,75	0,675	0,721

8	S3F2A1	3000	200	0,25	0,546	0,591
9	S3F3A2	3000	250	0,5	0,852	0,979

Görsel 3.2’de, deneylerde kullanılan kesme parametrelerinin hız kafası kullanılmayan (Görsel 3.1a) ve hız kafası kullanılan (Görsel 3.1b) proseslerdeki yüzey pürüzlülüğü üzerindeki etkisi gösterilmiştir. Burada görüldüğü üzere devir sayısı arttıkça yüzey pürüzlülüğünün azaldığı, ilerleme arttıkça yüzey pürüzlülüğünde de artış olduğu ve talaş derinliği arttıkça yüzey pürüzlülüğünün de arttığı ancak yüzey pürüzlülüğüne olan etkisinin diğer parametrelere göre daha az olduğu elde edilen veriler sonucunda tespit edilmiştir.





a)Hız kafası kullanılmayan **b)Hız kafası kullanılan**

Görsel 3.1 Kesme Parametreleri ile Yüzey Pürüzlülüğü Arasındaki İlişki

Gerçekleştirilen deneylerde yüzey pürüzlülüğü ile kesme parametreleri S/N oranları Çizelge 3.4’de verilmiştir.

Çizelge 3.4 Yüzey Pürüzlülüğü Değerlerinin S/N Oranları

	Hız Kafası Kullanılmadığında			**Hız Kafası Kullanıldığında**		
Seviye	**Devir (S) (dev/dk)**	**İlerleme (F) (mm/dk)**	**Talaş Derinliği (A) (mm)**	**Devir (S) (dev/dk)**	**İlerleme (F) (mm/dk)**	**Talaş Derinliği (A) (mm)**
1	-6.9152	-0.9772	-1.3734	-7.345	-1.519	-2.278
2	-2.5376	-1.6724	-2.0454	-3.500	-2.373	-2.692
3	3.3538	-3.4494	-2.6803	2.531	-4.422	-3.343
Fark	10.2690	2.4721	1.3069	9.876	2.903	1.066
Rank	1	2	3	1	2	3

Çizelge 3.4’de görüldüğü üzere hız kafası kullanılan/kullanılmayan deneylerde en düşük yüzey pürüzlülüğü elde edilebilmesi için “S3F1A1” kesme parametrelerinin kullanılması gerektiği anlaşılmaktadır. Bu neden doğrulama deneyi yapılması gerekmektedir. Deney bulgularından anlaşıldığı üzere yüzey pürüzlülüğünü etkileyen en önemli parametrenin sırasıyla “devir, ilerleme, talaş derinliği” olduğu sonucuna ulaşılmış olup talaş derinliğinin diğer parametrelere kıyasla yüzey pürüzlülüğünü daha az etkilediği, en etkili parametrenin devir olduğu değerlendirilmiştir. Bunun yanı sıra frezeleme operasyonlarında hız kafası kullanıldığında, hız kafası kullanılmayan işlemlere göre yüzey pürüzlülüğü değerlerinde çok fark oluşturan bir değişim görülmemiştir.

4. GENEL DEĞERLENDİRME VE SONUÇLAR

Yapılan deneyler neticesinde elde edilen sonuçlar aşağıda özetlenmiştir:

1. Devir, ilerleme ve talaş derinliği arttıkça güç tüketimi artmaktadır.
2. Güç tüketimini etkileyen en önemli parametrenin sırasıyla "talaş derinliği, ilerleme, devir" olduğu görülmüştür.
3. Hız kafası kullanıldığında güç tüketiminin önemli ölçüde azaldığı tespit edilmiştir.
4. Devir sayısı arttıkça yüzey pürüzlülüğünün azaldığı, ilerleme ve talaş derinliği arttıkça yüzey pürüzlülüğünde arttığı ancak talaş derinliği etkisinin diğer parametrelere göre yüzey pürüzlülüğüne etkisinin daha az olduğu anlaşılmıştır.
5. Deney bulgularından anlaşıldığı üzere yüzey pürüzlülüğünü etkileyen en önemli parametrenin sırasıyla "devir, ilerleme, talaş derinliği" olduğu sonucuna ulaşılmıştır.
6. Hız kafası kullanılmasının aynı ilerleme ve devirlerde yüzey pürüzlülüğüne etkisinin hız kafası kullanılmayan deneylerdeki değerlere yakın olduğu görülmüştür.

KAYNAKÇA

[1] Hu S., Liu F., He Y. ve Hu T., (2012). An on-line approach for energy efficiency monitoring of machine tools, Journal of Cleaner Production, cilt 27, pp. 133-140.

[2] Shi K., Zhang D., Ren J., Yao C. ve Huang X., (2016). Effect of cutting parameters on machinability characteristics in milling of magnesium alloy with carbide, Advances in Mechanical Engineering, cilt 8, no. 1, pp. 168-179.

[3] Gok A., Demir H. ve Yaka H., (2017). Optimization of the cutting parameters affecting the surface roughness on free form surface, Sigma Journal of Engineering and Natural Science,, cilt 35, no. 2, pp. 323-331.

[4] Yang J. L. ve Chen J. C., (2001). A systematic approach for identifying optimum surface roughness performance in end-milling operations, Journal of Industrial Technology, cilt 17, no. 2, pp. 1-8.

[5] Gok A., (2015). A new approach to minimization of the surface roughness and cutting force via fuzzy TOPSIS, multi-objective grey design and RSA, Measurement, cilt 70, pp. 100-109.

[6] Mativenga, P.T., Rajemi, M.F., (2011). Calculation of optimum cutting parameters based on minimum energy footprint. CIRP Annals – Manufacturing Technology, Vol.60, No.1, pp. 149 – 152.

[7] Kara, S., Li, W. (2011). Unit process energy consumption models for material removal processes. CIRP Annals–Manufacturing Technology, Vol.60, No.1, pp. 37–40.

[8] Newman, S.T., Nassehi, A., Imani-Asrai, R., Dhokia, V., (2012). Energy efficient process planning for CNC machining. CIRP Journal of Manufacturing Science and Technology 5 (2), 127-136.

[9] Jihong Y., Lin L., (2013). Multi-objective optimization of milling parameters e the tradeoffs between energy, production rate and cutting quality Journal of Cleaner Production 52, 462-471.

[10] Diaz, N., Redelsheimer, E., Dornfeld, D. (2011). Energy consumption characterization and reduction strategies for milling machine tool use. In: Glocalized Solutions for Sustainability in Manufacturing: Proceedings of the 18th CIRP International Conference on Life Cycle Engineering, pp. 263-267.

[11] He, Y., Liu, B., Zhang, X., Gao, H., Liu, X. (2012). A modeling method of task-oriented energy consumption for machining manufacturing system. Journal of Cleaner Production 23, 167-174.

[12] Anderberg, S.E., Kara, S., Beno, T., (2010). Impact of energy efficiency on computer numerically controlled machining. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 224, pp. 531-541.

[13] Weinert, K., Inasaki, I., Sutherland, J.W., Wakabayashi, T. (2004). Dry Machining and Minimum Quantity Lubrication. CIRP Annals 53 (2), pp. 511–537.

[14] Eren N., Hayat F., Günay M. (2020). Sertleştirilmiş 1.2367 Takım Çeliğinin İşlenmesinde Enerji Tüketiminin Analizi ve Modellenmesi. İmalat Teknolojileri ve Uygulamaları 1(3), 41-49.

[15] Şahinoğlu A., Erbaş M., Güllü A. (2021). Yatay Freze Tezgahında Yüksek Talaş Derinliklerinde Kesme Parametrelerinin Yüzey Pürüzlülük Değeri ve Güç Tüketimi Üzerindeki Etkilerinin İncelenmesi. Uluslararası Mühendislik Bilimleri ve Multidisipliner Yaklaşımlar Kongresi, 978-605-7594-91-4.

[16] Z. Zhou, C. Zhang, G. Tian, Y. Xie, W. Lin ve Z. Huang, (2016). Energy consumption modeling and prediction of the milling process: A multistage perspective, Journal of Engineering Manufacture, cilt 232, pp. 1973-1985.

[17] Karabulut Ş. ve Şahinoğlu A., (2018). R260 Çeliklerinin İşlenmesinde Kesme Parametrelerinin Yüzey Pürüzlülüğü, Güç Tüketimi ve Makine Gürültüsü Üzerine Etkileri, Politeknik Dergisi, 21(1) : 237-244.

[18] Bakır B., (2012). “Frezelemede Talaş Oluşumunun ve Geometrisinin Yüzey Pürüzlülüğüne Etkilerinin İncelenmesi”, Doktora Tezi, Marmara Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

AN APPROACH FOR INTEGRATION OF INDUSTRIAL ROBOT WITH VISION SYSTEM AND SIMULATION SOFTWARE

Ahmed Sh. Khusheef, Ganesh Kothapalli, Majid Tolouei-Rad

Edith Cowan University, Australia
Senior Lecturer in engineering school in Edith Cowan University, Australia
Senior Lecturer in engineering school in Edith Cowan University, Australia

Abstract:

Utilization of various sensors has made it possible to extend capabilities of industrial robots. Among these are vision sensors that are used for providing visual information to assist robot controllers. This paper presents a method of integrating a vision system and a simulation program with an industrial robot. The vision system is employed to detect a target object and compute its location in the robot environment. Then, the target object-s information is sent to the robot controller via parallel communication port. The robot controller uses the extracted object information and the simulation program to control the robot arm for approaching, grasping and relocating the object. This paper presents technical details of system components and describes the methodology used for this integration. It also provides a case study to prove the validity of the methodology developed.

Keywords: industrial robot, integration, simulation, vision system

PEOPLE CRITICAL SUCCESS FACTORS OF IT/IS IMPLEMENTATION: MALAYSIAN PERSPECTIVES

Aziz, Nur Mardhiyah, Salleh, Hafez

with University of Malaya, Malaysia

Abstract:

Implementing Information Technology/ Information System (IT/IS) is critical for every industry as its potential benefits have been to motivate many industries including the Malaysian construction industry to invest in it. To successfully implement IT/IS has become the major concern for every organisation. Identifying the critical success factors (CSFs) has become the main agenda for researchers, academicians and practitioners due to the wide number of failures reported. This research paper seeks to identify the CSFs that influence the successful implementation of IT/IS in construction industry in Malaysia. Limited factors relating to people issue will be highlighted here to showcase some as it becomes one of the major contributing factors to the failure. Three (3) organisations have participated in this study. Semi-structured interviews are employed as they offer sufficient flexibility to ensure that all relevant factors are covered. Several key issues contributing to successful implementations of IT/IS are identified. The results of this study reveal that top management support, communication, user involvement, IT staff roles and responsibility, training/skills, leader/ IT Leader, organisation culture, knowledge/ experience, motivation, awareness, focus and ambition, satisfaction, teamwork/ collaboration, willingness to change, attitude, commitment, management style, interest in IT, employee behaviour towards collaborative environment, trust, interpersonal relationship, personal characteristic and competencies are significantly associated with the successful implementations of IT/IS. It is anticipated that this study will create awareness and contribute to a better understanding amongst construction industry players and will assist them to successfully implement IT/IS.

Keywords: critical success factors, construction industry , IT/IS, people

ETHICS IN THE TECHNOLOGY DRIVEN ENTERPRISE

Bobbie Green, James A. Nelson

New Mexico State University, USA

Abstract:

Innovations in technology have created new ethical challenges. Essential use of electronic communication in the workplace has escalated at an astronomical rate over the past decade. As such, legal and ethical dilemmas confronted by both the employer and the employee concerning managerial control and ownership of einformation have increased dramatically in the USA. From the employer-s perspective, ownership and control of all information created for the workplace is an undeniable source of economic advantage and must be monitored zealously. From the perspective of the employee, individual rights, such as privacy, freedom of speech, and freedom from unreasonable search and seizure, continue to be stalwart legal guarantees that employers are not legally or ethically entitled to abridge in the workplace. These issues have been the source of great debate and the catalyst for legal reform. The fine line between ethical and legal has been complicated by emerging technologies. This manuscript will identify and discuss a number of specific legal and ethical issues raised by the dynamic electronic workplace and conclude with suggestions that employers should follow to respect the delicate balance between employees- legal rights to privacy and the employer's right to protect its knowledge systems and infrastructure.

Keywords: Information, ethics, legal, privacy

STUDIES ON THE FEASIBILITY OF COW DUNG AS A NON-CONVENTIONAL ENERGY SOURCE

Raj Kumar Rajak, Bharat Mishra

Associate professor, at the Mahatma Gandhi Chitrakoot Gramodaya Vishwavidhyalaya , India

Abstract:

Bio-batteries represent an entirely new long-term, reasonable, reachable and ecofriendly approach to produce sustainable energy. In the present experimental work, we have studied the effect of generation of power by bio-battery using different electrode pairs. The tests show that it is possible to generate electricity using cow dung as an electrolyte. C-Mg electrode pair shows maximum voltage and SCC (Short Circuit Current) while C-Zn electrode pair shows less OCV (Open Circuit Voltage) and SCC. We have chosen C-Zn electrodes because Mg electrodes are not economical. By the studies of different electrodes and cow dung, it is found that C-Zn electrode battery is more suitable. This result shows that the bio-batteries have the potency to full fill the need of electricity demand for lower energy equipment.

Keywords: Bio-batteries, electricity, cow dung, electrodes, non-conventional.

REFINING WASTE SPENT HYDROPROCESSING CATALYST AND THEIR METAL RECOVERY

Meena Marafi, Mohan S. Rana

Petroleum Research Center, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109-Safat, Kuwai

Abstract:

Catalysts play an important role in producing valuable fuel products in petroleum refining; but, due to feedstock's impurities catalyst gets deactivated with carbon and metal deposition. The disposal of spent catalyst falls under the category of hazardous industrial waste that requires strict agreement with environmental regulations. The spent hydroprocessing catalyst contains Mo, V and Ni at high concentrations that have been found to be economically significant for recovery. Metal recovery process includes deoiling, decoking, grinding, dissolving and treatment with complexing leaching agent such as ethylene diamine tetra acetic acid (EDTA). The process conditions have been optimized as a function of time, temperature and EDTA concentration in presence of ultrasonic agitation. The results indicated that optimum condition established through this approach could recover 97%, 94% and 95% of the extracted Mo, V and Ni, respectively, while 95% EDTA was recovered after acid treatment.

Keywords: Spent catalyst, deactivation, hydrotreating, spent catalyst.

OIL RECOVERY STUDY BY LOW TEMPERATURE CARBON DIOXIDE INJECTION IN HIGH-PRESSURE HIGH-TEMPERATURE MICROMODELS

Zakaria Hamdi, Mariyamni Awang

Heriot-Watt University, Malaysia (corresponding author,

Professor with Elsa Energy, Malaysi

Abstract:

For the past decades, CO_2 flooding has been used as a successful method for enhanced oil recovery (EOR). However, high mobility ratio and fingering effect are considered as important drawbacka of this process. Low temperature injection of CO_2 into high temperature reservoirs may improve the oil recovery, but simulating multiphase flow in the non-isothermal medium is difficult, and commercial simulators are very unstable in these conditions. Furthermore, to best of authors' knowledge, no experimental work was done to verify the results of the simulations and to understand the pore-scale process. In this paper, we present results of investigations on injection of low temperature CO_2 into a high-pressure high-temperature micromodel with injection temperature range from 34 to 75 °F. Effect of temperature and saturation changes of different fluids are measured in each case. The results prove the proposed method. The injection of CO_2 at low temperatures increased the oil recovery in high temperature reservoirs significantly. Also, CO_2 rich phases available in the high temperature system can affect the oil recovery through the better sweep of the oil which is initially caused by penetration of LCO_2 inside the system. Furthermore, no unfavorable effect was detected using this method. Low temperature CO_2 is proposed to be used as early as secondary recovery.

Keywords: Enhanced oil recovery, CO2 flooding, micromodel studies, miscible flooding.

ALÜMİNYUM ESASLI YATAK MALZEMELERİNİN ABRAZİV AŞINMASINA ALAŞIM ELEMENTLERİNİN ETKİLERİNİN İNCELENMESİ

Erol FEYZULLAHOĞLU

Kocaeli Üniversitesi, Mühendislik Fakültesi, ORCID ID: 0000-0003-0739-9643

ÖZET

Alüminyum alaşımları, diğer yatak malzemelerine göre düşük maliyet, korozif etkilere karşı dayanım, yüksek ısıl iletkenliği, yüksek basınç ve yorulma dayanımı, hafiflik, gömülebilirlik ve işlenebilirlik gibi birçok iyi özelliklere sahiptir. Klasik yatak malzemelerinde meydana gelen en büyük sorun aşınma direncinin düşük olmasıdır. Bu nedenle, alüminyum esaslı alaşımlar otomotiv endüstrisinde yatak malzemesi olarak kullanılmak üzere özel olarak geliştirilmiştir. Krank mili yataklarında beyaz metal ve bakır alaşımları yerine Al esaslı yatak malzemeleri tercih edilmektedir. Bu deneysel çalışmada, metal kalıba döküm yöntemi ile üretilen yeni Al esaslı yatak alaşımları geliştirilmiş ve bu alaşımların abrasiv aşınma özellikleri deneysel olarak incelenmiştir. Al8.5Si3.5Cu, Al15Sn5Cu3Si, Al15Pb3.7Cu1.5Si1.1Fe ve ticari saf Al olmak üzere dört farklı alüminyum alaşımı abraziv aşınma test cihazında aşınma testine tabi tutulmuştur. Numunelerin aşınma oranı değerleri hesaplanmıştır. Numunelerin kimyasal bileşimleri, sertlikleri ve yoğunlukları ölçülmüştür. Alaşım elementlerinin alüminyum esaslı yatak malzemelerinin abraziv aşınma özellikleri üzerindeki etkileri araştırılmıştır.

Anahtar Kelimeler: Alüminyum Alaşımları, Al-Si Alaşımı, Al-Pb Alaşımı, Al-Sn Alaşımı, Abrasiv Aşınma.

1. GİRİŞ

Kaymalı yataklarda çoğunlukla bakır, alüminyum, çinko, kurşun ve kalay bazlı alaşımlar kullanılmaktadır. Son zamanlarda, alüminyum alaşımları aynı yük aralıklarında kalay ve bronz içeren alaşımlara göre daha fazla kullanılmaktadır. Alüminyum esaslı kaymalı yataklar, beyaz metal (kalay alaşımlı) yataklardan daha fazla yorulma mukavemetine sahip olup daha yüksek sıcaklıklardaki çalışmalarda kullanılabilmektedir. Alüminyum alaşımları düşük maliyet, korozif etkilere karşı dayanıklılık, yüksek ısı iletkenliği, yüksek basınç ve yorulma mukavemeti, hafiflik, gömülebilirlik ve işlenebilirlik diğer yatak malzemelerine göre birçok iyi özelliklere sahiptirler. Yüksek performanslı ve düşük yakıt tüketimli içten yanmalı motorlar zor koşullarda çalışacak kaymalı yataklara ihtiyaç duymaktadırlar. Bu nedenle, motorlarda kullanılan kaymalı yataklarda yüksek yük ve sıcaklık koşullarında mil ve yatak zarfı arasında çok ince bir yağ oluşması beklenir. Kaymalı yatak malzemelerinde meydana gelen en büyük problem yatak malzemelerin aşınma direncinin düşük olmasıdır. Bu nedenle alüminyum esaslı alaşımlar, yüksek performanslı motorlarda kullanılmak üzere geliştirilmiştir. Son zamanlarda otomotiv endüstrisinde krank mili yataklarında Al bazlı yatak malzemeleri beyaz metal ve bakır alaşımları yerine tercih edilmiştir.

Aşınma, endüstride kullanılan ve birbirlerine göre izafi hareketli makine elemanlarında büyük bir problem olarak karşımıza çıkmakta olup makina sistemlerinin çalışma verimini büyük ölçüde düşürmektedir. Aşınma; malzeme yüzeylerinden, mekanik nedenlerle küçük parçacıkların ayrılması sonucu, malzeme yüzeylerinde arzu edilmeyen şekilde meydana gelen değişiklik olarak tanımlanmaktadır. Aşınmanın azaltılması ve kontrol altına alınması oldukça önemlidir. Aşınma türlerinden en önemlisi olan abraziv aşınma, birbirine göre izafi hareket halindeki iki cisim arasına çevre etkisiyle yabancı sert partiküllerin girmesi ve bu parçacıkların yumuşak yüzeye gömülerek sert yüzeyden zımparalama yapar gibi malzeme kaldırmasıyla meydana gelmektedir [1]. Mil ve yatak zarfı gibi temas eden yüzeyler arasında bulunan sert partiküller gömüldükleri yüzeyde tahribata yol açarlar. Abraziv aşınma, kaymalı yataklarda büyük oranda hasar oluşum nedeni olarak ortaya çıkmaktadır. Kaymalı yatakların abraziv aşınmaya maruz kalması ekonomik yönden de büyük sıkıntılar doğurmaktadır.

Literatürde Al esaslı yatak malzemelerinin aşınma davranışları üzerinde yapılmış olan birtakım çalışmalar bulunmaktadır. Desaki ve diğ. Al-Sn-Si alaşımı kullanarak yüksek aşınma direncine sahip Al bazlı kaymalı yatak malzemesi geliştirmişlerdir. Bu çalışmada silisyumun (Si) Al alaşımına eklenmesinin malzemenin aşınma direncini ve sert Si partiküllerin de malzemenin sertliğini artırdığı belirlenmiştir [2]. Zhu ve diğ. yaptıkları çalışmada Al-Pb alaşımlarında, mekanik alaşımlamanın mikro yapıyı ve aşınmayı iyileştirmenin en etkili yolu olduğunu tesbit etmişlerdir. Daha fazla kurşun (Pb) içeriğinin Al alaşımlarında aşınma oranını azalttığı belirlenmiştir [3]. Zhu ve diğ. başka bir çalışmada mekanik alaşımlama yöntemi ile üretilen Al-Pb-Cu alaşımının kuru sürtünme koşullarında aşınma özelliklerini incelemişlerdir. Bakır (Cu) ilavesinin Al-Pb alaşımının aşınma özellikleri üzerindeki etkili olduğu ve yüksek yüklerde Cu ilavesinin aşınmayı arttırdığı ifade edilmiştir [4]. Rodriguez ve diğ. SiC partiküllerle güçlendirilmiş alüminyum-lityum alaşımlarının kuru sürtünme koşullarında altındaki aşınma davranışlarını incelemişlerdir. Burada temas yüzeydeki nominal basıncın aşınma miktarının artmasında önemli bir rol oynadığı belirlenmiştir [5]. Aung ve diğ. magnezyum ve alüminyum içeren AZ91D alaşımının kuru sürtünme koşulları altındaki aşınma davranışını incelemişlerdir. Düşük kayma hızlarında abraziv aşınmanın meydana geldiğini belirlemişlerdir. En yüksek aşınma oranı değeri abrasiv aşınma durumunda ortaya çıkmıştır [6].

Bu deneysel çalışmada, metal kalıba döküm yöntemi ile üretilen Al esaslı yeni yatak alaşımları geliştirilmiştir. Geliştirilen dört farklı malzeme dikkate alınarak alaşım elementlerinin alüminyum esaslı yatak malzemelerinin abraziv aşınma özellikleri üzerindeki etkileri araştırılmıştır.

2. DENEYSEL ÇALIŞMALAR

2.1. Abraziv Aşınma Deney Cihazı ve Deney Prosedürü

Test edilen numunelerin aşınma dayanımı, ASTM D5963 standartlarına göre abraziv aşınma test cihazı (EKT-2013-ABRASION TESTER) kullanılarak incelenmiştir (Görsel 1).

Görsel 1. Aşınma Test Cihazı

Aşınma testi esnasında test numunesi hem kendi etrafında dönmekte, hemde dönen tambur boyunca yanal hareket etmektedir. Bu durum, test numunesinin aşındırıcı tambura düzgün temasını sağlamaktadır. Aşınma test cihazında, numune 15 N luk bir kuvvetle aşındırıcı alüminyum zımpara kağıdı ile kaplanmış (#60 grid) dönen tambura doğru temas eder. Test esnasında numune tambur üzerinde 40 m ilerleme hareketi yapmaktadır. Deneyler, 22±2 °C sıcaklık ve %45±10 nem koşullarında yapılmıştır. Test numunelerinin aşınmadan önceki ağırlıkları dijital elektronik tartıyla ölçülmüştür. Abraziv aşınma yapıldıktan sonra test numunelerine tekrar ağırlık ölçümü yapılarak ağırlık kayıpları belirlenmiştir.

Abraziv aşınma testlerinin ardından, deney numunelerindeki aşınma izleri Nikon SMZ 745T streo mikroskobu ile incelenmiştir.

2.2. Deneysel Çalışmada Kullanılan Malzemeler

Bu çalışmada dört farklı Al yatak alaşımı geliştirilmiş ve abraziv aşınma testlerine tabi tutulmuştur [7]. Deney numunelerinin üretim prosedürü aşağıda ifade edildiği gibidir:

1) Al8.5Si3.5Cu numunesi; indüksiyon ocağında yaklaşık 800 C°' de bekletilen malzemenin, silindirik metal kalıba dökülmesi ve ardından su verilerek hızlı soğutulması ile katılaştırılması sonrası elde edilmiştir.
2) Saf Alüminyum (%97 saflıkta).
3) Al15Pb3.7Cu1.5Si1.1Fe numunesi; indüksiyon ocağında ergitilen Al3.7Cu1.5Si1.1Fe alaşımının metal kalıba dökülmesi ve kalıbın içindeki sıvı alaşımın içine kurşun ilave edilerek alaşımlandırılmış ve sonrasında su verilerek katılaştırılmasıyla elde edilmiştir.
4) Al15Sn5Cu3Si numunesi; indüksiyon ocağının 700 C° ye kadar ısıtılmasından sonra başlangıçta 1600 gr. ticari alüminyum-silisyum, daha sonra 300 gr kalay ilave edilerek ergitme işlemi başlatılmıştır. Kalayın eriyik hale geçmesinden sonra sıcaklık 1000 C°' nin üzerine yükseltilerek 100 gr bakır ilave edilmiştir. Bakırın da eriyiğe karışması ile (ilavesinden 5 dk sonra) ergimiş metal kokil kalıba dökülerek havada soğumaya bırakılarak katılaştırılmıştır.

Bu deneysel çalışmada kullanılan malzemelerin kimyasal içerikleri Çizelge 1' de sunulmuştur.

Çizelge 1. Numunelerin Kimyasal Bileşimi (%)

Alaşım	Al	Si	Cu	Sn	Pb	Fe	Mg	Mn	Zn	Ni	Ti
Al8.5Si3.5Cu	86.2	8.5	3.51	0.02	0.04	0.88	0.13	0.11	0.49	0.04	0.02
Al	97.3	0.62	0.26	0.02	0.01	0.9	0.4	0.07	0.22	0.18	0.02
Al15Pb3.7Cu1.5Si1.1Fe	76.5	1.5	3.7	0.13	15.1	1.17	0.78	0.16	0.41	0.17	0.9
Al15Sn5Cu3Si	73.6	3.1	5.1	15.2	0.37	0.95	0.27	0.13	1.2	0.04	0.02

Deneysel çalışmada kullanılan numunelerin yoğunlukları AND GR-200 analitik hassas terazi ve yoğunluk ölçme kiti ile ölçülmüştür. Deney numunelerine ait yoğunluklar Çizelge 2' de verilmiştir.

Çizelge 2. Numunelerin Yoğunlukları

Alaşım	Yoğunluk (gr/cm^3)
Al8.5Si3.5Cu	2.7566
Al	2.6963
Al15Pb3.7Cu1.5Si1.1Fe	2.7173
Al15Sn5Cu3Si	3.0710

Deneysel çalışmada kullanılan numunelerin sertlikleri Wolpert sertlik ölçüm cihazı kullanılarak belirlenmiştir. Sertlik cihazında HB sertlik değerleri 2.5 mm çapındaki bilyaya 612 N yük uygulanarak ölçülmüştür. Deney numunelerine ait sertlik değerleri Çizelge 3' de verilmiştir. Çizelgeden de görüldüğü gibi daha fazla Si içeren Al8.5Si3.5Cu alaşımı en sert ve ticari saf Al en yumuşak numunedir. Si, Cu, Fe gibi alaşım elementleri numunelerin sertlik değerleri üzerinde etkilidir. Özellikle Si içeriğinin artması alüminyum alaşımlarının sertliğini büyük ölçüde artırmaktadır. Ayrıca alaşımların sertlik değerlerinin artması açısından Cu ilavesi büyük önem taşımaktadır [5, 7].

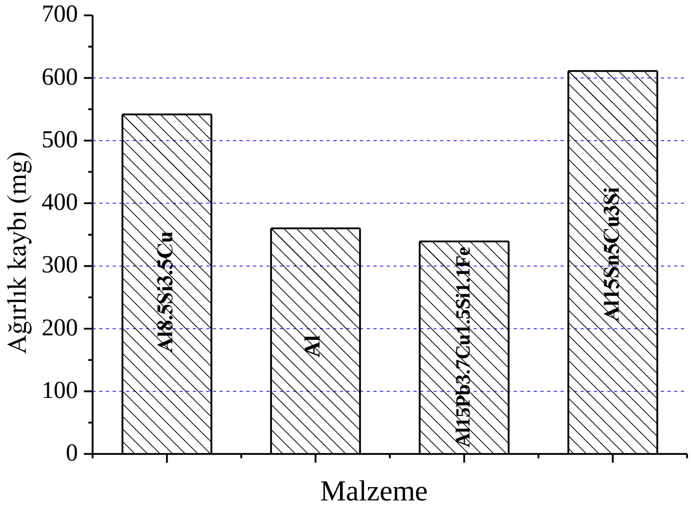
Çizelge 3. Numunelerin Sertlikleri

Alaşım	Sertlik (HB)
Al8.5Si3.5Cu	94
Al	55
Al15Pb3.7Cu1.5Si1.1Fe	79
Al15Sn5Cu3Si	65

3. SONUÇLAR VE DEĞERLENDİRME

3.1. Numunelerin Abraziv Aşınma Deney Sonuçları

Her numunenin aşınma deneyi öncesinde ve sonrasında ağırlıkları ölçülerek abraziv aşınma deneyi sonrasında ağırlık kayıpları belirlenmiştir. Numunelerin ağırlık kayıpları Görsel 2' de sunulmuştur. Görselden de görüleceği üzere en büyük ağırlık kaybı diğer numunelere göre nisbeten daha yumuşak bir malzeme olan Al15Sn5Cu3Si alaşımında görülmektedir. Diğer numunelere göre nisbeten daha sert bir malzeme olan Al15Pb3.7Cu1.5Si1.1Fe en az aşınmış alaşımdır. Feyzullahoğlu ve Şakiroğlu tarafından kuru sürtünme koşullarında yapılan adhesiv aşınma deneylerinde de en çok ağırlık kaybı Al-Sn alaşımında görülmüştür [7].



Görsel 2. Numunelerin Ağırlık Kayıpları

Abraziv aşınma deneyi sonrasında ağırlık kayıpları hesaplanan numunelerin ağıdaki bağıntıya göre aşınma oranları hesaplanmıştır:

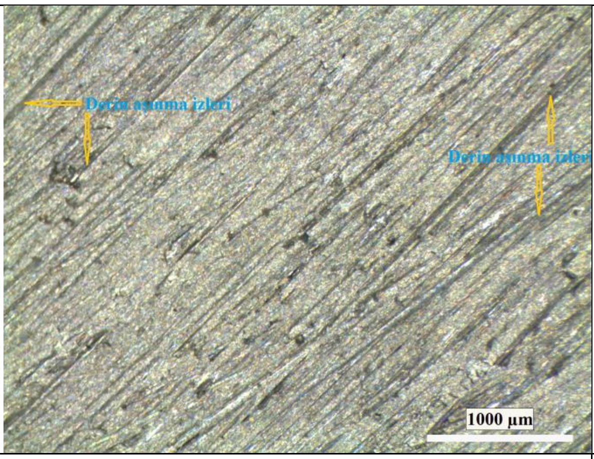
$$W = \frac{\Delta M}{\rho * L * F_N} \quad (1)$$

Burada W aşınma oranı ($\frac{m^3}{N.m}$), ΔM ağırlık kaybı (gr), ρ yoğunluk ($\frac{gr}{m^3}$), L kayma mesafesi (40 m) ve F_N ise uygulanan normal kuvvet (15 N) dur. Numunelerin aşınma oranları Görsel 3' de sunulmuştur. Buradan da görüleceği üzere kuru sürtünme ve abraziv aşınma koşullarında yapılan deneylerde en düşük aşınma oranı Al15Pb3.7Cu1.5Si1.1Fe alaşımında belirlenmiştir. Zhu ve diğ. yaptıkları çalışmada benzer sonuçları elde etmiş ve alüminyum alaşımı içindeki Pb içeriğinin artmasının aşınma oranını azaltığını ifade etmişlerdir [3]. Deney numuneleri içinde en çok aşınan Al15Sn5Cu3Si alaşımının mikroyapısında yumuşak faz olarak bulunan bulunan Sn fazı sünek ve düşük mukavemetlidir; buna bağlı olarak alüminyum alaşımının mukavemet özelliklerini de düşürmektedirler. Yumuşak faz, sert matrise göre daha önce deformasyona uğramaktadır. Bu yüzden matris içindeki gerilme konsantrasyonu azalarak, matrisi daha fazla deformasyona uğratır. Sonuçta alüminyum alaşımının sünekliği artarak aşınma direnci azalır ve daha fazla aşınır [8]. Numuneler içinde aşınma dayanımı en az olan numuneler ise Al8.5Si3.5Cu ve Al15Sn5Cu3Si alaşımıdır. Feyzullahoğlu ve Şakiroğlu tarafından kuru sürtünme koşullarında yapılan adhesiv aşınma deneylerinde de en yüksek aşınma oranı Al-Sn alaşımında görülmüştür [7]. Bu çalışmada sertliği en düşük ticari saf Al' ın kuru sürtünme koşullarında Al8.5Si3.5Cu ve Al15Sn5Cu3Si alaşımlarından daha az aşınması, alaşımların aşınma davranışlarının her zaman sertlik gibi mekanik özelliklere bağlı olmadığını ve kimyasal karakterizasyonun da malzemenin aşınmasında etkili olduğunu göstermektedir.

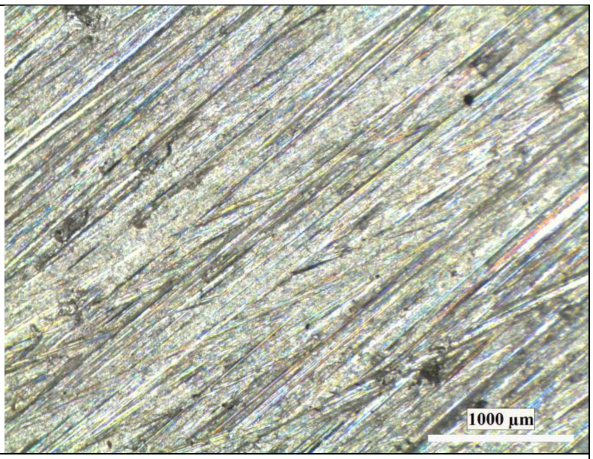
Görsel 3. Numunelerin Aşınma Oranları

3.2. Numunelerin Aşınma Yüzeylerinin İncelenmesi

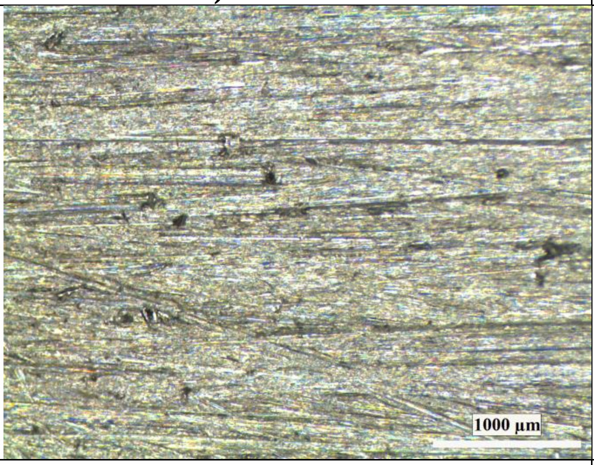
Deney numunelerinin abraziv aşınma sonrası streomikroskop ile elde edilen aşınma yüzeyi görüntüleri incelendiğinde, Al15Sn5Cu3Si ve Al8.5Si3.5Cu alaşımlarının aşınma yüzeyinin diğerlerinden tamamen farklı olduğu görülmektedir. En çok aşınmasın oluştuğu bu nunumelerde daha geniş ve daha derin aşınma izlerin olduğu belirlenmiştir (Görsel 4). Diğer nununelerde ise daha ince, yüzeysel ve hafif çizik şeklinde aşınma izleri gözlemlenmiştir.



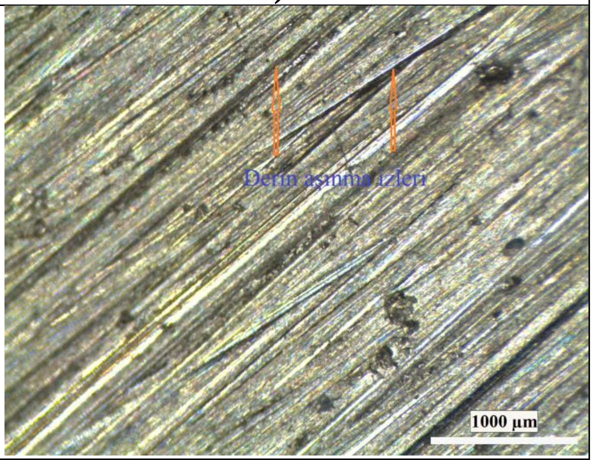
a) Al8.5Si3.5Cu



b) Al



c) Al15Pb3.7Cu1.5Si1.1Fe



d) Al15Sn5Cu3Si

Görsel 4. Streo Mikroskop İle Numunelerin Aşınma Yüzeylerinin Fotoğrafları (30X)

4. GENEL DEĞERLENDİRME

Bu çalışmadan elde edilen sonuçlar şu şekildedir:

- Deney numuneleri içerisinde Al8.5Si3.5Cu alaşımı en sert ve ticari saf Al en yumuşak numune olarak saptanmıştır.
- Aşınma deneyleri sonrasında en büyük ağırlık kaybı Al15Sn5Cu3Si alaşımında ortaya çıkmıştır.
- Deneysel çalışmada en düşük aşınma oranı Al15Pb3.7Cu1.5Si1.1Fe alaşımında elde edilmiştir.
- Geliştirilen dört farklı yatak malzemesi dikkate alındığında, Al-Pb esaslı yatak malzemelerinin abraziv aşınma dayanımının diğer numunelere göre daha yüksek olduğu tespit edilmiştir.

Kaymalı yatak malzemesi olarak Pb (kurşun) içeren malzemelerin aşınma dayanımının yüksek olmasına rağmen kurşunun zehirleyici ve canlılara zararlı etkilerinin de yatak malzemesi seçiminde dikkate alınmasında yarar vardır.

KAYNAKÇA

[1] Akkurt, M., *Makina Elemanları, Cilt 2*, Birsen Yayınevi, İstanbul, 1992.

[2] Desaki, T., Goto, Y., Kamiya, S. Development of the Aluminium Alloy Bearing with Higher Wear Resistance, JSAE Review, 21, 2000.

[3] Zhu, M., Gao, Y., Chung, C.Y., Che, Z.X., Luo, K.C., Li, B.L. Improvement of the Behaviour of Al-Pb Alloys by Mechanical Alloying, Wear, 242, 2000.

[4] Zhu, M., Zeng, M.Q., Gao, Y., Ouyang, L.Z., Li, B.L. Microstructure and Wear Properties of Al-Pb-Cu Alloys Prepared by Mechanical Alloying, Wear, 253, 2002.

[5] Rodriguez, J., Poza, P., Garrido, M.A., Rico, A. Dry Sliding Wear Behaviour of Aluminium-lithium Alloys Reinforced with SiC Particles, Wear, 262, 2007.

[6] Aung, N.N., Zhou, W., Lim, L.E.N. Wear Behaviour of AZ91D Alloy at Low Sliding Speeds, Wear, 265, 2008.

[7] Feyzullahoglu, E., Sakiroglu, N. The Tribological Behaviours of Aluminium-based Materials under Dry Sliding, Industrial Lubrication and Tribology, 63, 5, 2011.

[8] Pathak, J. P., Mohan, S. Tribological Behaviour of Conventional Al–Sn and Equivalent Al–Pb Alloys under Lubrication, The Bulletin of Materials Science, 26, 3, 2003.