



# ОТЕН2016



7<sup>th</sup> International Scientific Conference  
on Defensive Technologies



Mileva Marić (1875 - 1948)

# PROCEEDINGS

ISBN 978-86-81123-82-9

Belgrade, 6-7 October 2016  
MILITARY TECHNICAL INSTITUTE  
Belgrade, Serbia

**Publisher**

**The Military Technical Institute**  
Ratka Resanovića 1, 11030 Belgrade

**Publisher's Representative**

Col Assistant Prof. **Zoran Rajić**, PhD (Eng)

**Editor**

Miodrag Lisov

**Technical Editing**

Dragan Knežević  
Liljana Kojičin

Printing

300 copies

- Каталогизација у публикацији  
Народна библиотека Србије, Београд

623.4/.7(082)(0.034.2)  
66.017/.018:623(082)(0.034.2)

INTERNATIONAL Scientific Conference on  
Defensive Technologies (7th ; 2016 ; Beograd)  
Proceedings [Elektronski izvor] / 7th  
International Scientific Conference on  
Defensive Technologies, ОТЕН 2016, Belgrade,  
06-07 October 2016 ; organized by Military  
Technical Institute, Belgrade ; [editor Miodrag  
Lisov]. - Belgrade : The Military  
Technical Institute, 2016 (Beograd : The  
Military Technical Institute). - 1  
elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa  
naslovne strane dokumenta. - Tiraž 300. -  
Bibliografija uz svaki rad.

ISBN 978-86-81123-82-9

1. The Military Technical Institute  
(Belgrade)

a) Војна техника - Зборници b) Технички  
материјали - Зборници

COBISS.SR-ID

# CONTENTS

## OCCASIONAL LECTURE

- 3 **MILEVA MARIĆ EINSTEIN –HER LIFE, WORK AND FATE**, Velimir Abramović

## PLENARY LECTURES

- 7 **IMPLEMENTATION OF INTEGRATED LOGISTIC SUPPORT TECHNOLOGIES: FROM LOGISTIC SUPPORT ANALYSIS UP TO PERFORMANCE BASED LOGISTICS**, Evgeny V. Sudov
- 9 **HISTORICAL DEVELOPMENT OF MODERN SMALL ARMS TECHNOLOGY: OAK RIDGE NATIONAL LABORATORY PERSPECTIVE**, Slobodan Rajić

## 1. SECTION : AERODYNAMICS AND FLIGHT DYNAMICS

- 13 **EFFECT OF BASE BLEED ON THE DRAG REDUCTION**, Habib Belaidouni, Saša Živković, Mirko Kozić, Marija Samardžić, Boutemdjet Abdelwahid
- 19 **DIVERGENCE ANALYSIS OF THIN COMPOSITE PLATES IN SUBSONIC AND TRANSONIC FLOWS**, Mirko Dinulović, Aleksandar Grbović, Danilo Petrašinović
- 24 **AEROACOUSTIC ANALYSIS OF A JET NOZZLE**, Toni Ivanov, Vasko Fotev, Nebojša Petrović, Zorana Trivković, Dragan Komarov
- 29 **NUMERICAL AND EXPERIMENTAL INVESTIGATION OF AERODYNAMIC CHARACTERISTICS OF SPIN STABILIZED PROJECTILE**, Damir D. Jerković, Aleksandar V. Kari, Nebojša Hristov, Slobodan S. Ilić, Slobodan Savić
- 35 **A HIGH SPEED TRAIN MODEL TESTING IN T-32 WIND TUNNEL BY INFRARED THERMOGRAPHY AND STANDARD METHODS**, Slavica Ristić, Suzana Linić, Goran Ocokoljić, Boško Rašuo, Vojkan Lučanin
- 41 **AERODYNAMICS OF THE HIGH SPEED TRAIN BIO-INSPIRED BY A KINGFISHER**, Suzana Linić, Boško Rašuo, Mirko Kozić, Vojkan Lučanin, Aleksandar Bengin
- 47 **OBSERVATIONS ON SOME TRANSONIC WIND TUNNEL TEST RESULTS OF A STANDARD MODEL WITH A T-TAIL**, Dijana Damljanović, Đorđe Vuković, Aleksandar Vitić, Jovan Isaković, Goran Ocokoljić
- 52 **NUMERICAL AND EXPERIMENTAL ASSESSMENT OF TRANSONIC TURBULENT FLOW AROUND ONERA M4 MODEL**, Jelena Svorcan, Dijana Damljanović, Dragan Komarov, Slobodan Stupar, Nebojša Petrović
- 58 **COMPUTATIONAL ANALYSIS OF HELICOPTER MAIN ROTOR BLADES IN GROUND EFFECT**, Zorana Trivković, Jelena Svorcan, Marija Baltić, Dragan Komarov, Vasko Fotev
- 64 **SIMULATION OF ROLL AUTOPILOT OF A MISSILE WITH INTERCEPTORS**, Milan Ignjatović, Miloš Pavić, Slobodan Mandić, Bojan Pavković, Nataša Vlahović
- 68 **DESIGN OF THE MAIN PIVOT ON THE FORCED OSCILLATION APPARATUS FOR THE WIND TUNNEL MEASUREMENTS**, Marija Samardžić, Dragan Marinkovski, Dušan Ćurčić, Zoran Rajić, Abdelwahid Boutemedjet

- 73 **PRELIMINARY AERODYNAMIC COMPUTATION OF LONG ENDURANCE UAV WING**, Abdelwahid Boutemedjet, Marija Samardžić, Zoran Rajić

## 2. SECTION : AIRCRAFT

- 79 **DEVELOPMENTS IN HEAD-UP DISPLAY TECHNOLOGY FOR BASIC AND ADVANCED MILITARY TRAINING AIRCRAFT**, Robert Wilsey Fraes
- 85 **FLIGHT PERFORMANCE DETERMINATION OF THE PISTON ENGINE AIRCRAFT SOVA, COMPUTER PROGRAM „SOVAPERF“**, Nemanja Velimirović, Kosta Velimirović
- 90 **POSSIBLE APPROACHES TO EVALUATION OF TRAINING AIRCRAFTS USED IN FLIGHT SCREENING**, Slaviša Vlačić, Franc Hudomal, Aleksandar Knežević
- 95 **INTEGRATION OF TACTICAL - MEDIUM RANGE UAV AND CATAPULT LAUNCH SYSTEM**, Zoran Novaković, Zoran Vasić, Ivana Ilić, Nikola Medar, Dragan Stevanović
- 102 **CONTRIBUTION TO THE MAINTENANCE OF Mi-8 HELICOPTER IN THE SERBIAN AIR FORCE**, Zoran Ilić, Boško Rašuo, Miroslav Jovanović, Ljubiša Tomić, Stevan Jovičić, Radomir Janjić, Nenko Brkljač
- 108 **ON THE EFFECTIVE SHEAR MODULUS OF COMPOSITE HONEYCOMB SANDWICH PANELS**, Lamine Rebhi, Mirko Dinulović, Predrag Andrić, Marjan Dodić, Branimir Krstić
- 114 **EFFICIENT COMPUTATION METHOD FOR FATIGUE LIFE ESTIMATION OF AIRCRAFT STRUCTURAL COMPONENTS**, Stevan Maksimović, Mirjana Đurić, Zoran Vasić, Ognjen Ognjanović
- 119 **ANALYSIS OF AIRCRAFT STRUCTURES CROSS SECTION**, Bogdan S. Bogdanović, Dario A. Sinobad, Tonko A. Mihovilović
- 125 **STRESS CALCULATION OF NOSE GEAR SUPPORT WITH ASPECT OF WELDING OF AEROSPACE STEEL 15CRM0V6**, Aleksandar Petrović, Bogdan S. Bogdanović, Aleksandar Stanačev
- 131 **INFLUENCE OF PILOT'S AVERAGE BODY MASS INCREASING ON BALANCE OF LIGHT PISTON TRAINING AIRCRAFT**, Zorica Sarić, Zoran Vasić, Vojislav Dević, Boris Glavač
- 139 **PROTOTYPE SOVA DEVELOPMENT: AIRCRAFT LIFE CYCLE EXTENSION**, Vanja Stefanović, Marija Blažić, Marina Ostojić, Tonko Mihovilović, Dragan Ilić
- 145 **SOME ASPECTS OF THE DIFFERENT TYPES WIRELESS SENSORS IMPLEMENTATION WITHIN AIRBORNE FLIGHT TEST CONFIGURATION**, Zoran Filipović, Vladimir Kvrđić, Dragoljub Vujić
- 152 **UAS - FROM MINI TO TACTICAL**, Adi Cohen

## 3. SECTION : WEAPON SYSTEMS AND COMBAT VEHICLES

- 157 **A PRELIMINARY DESIGN MODEL FOR EXPLOSIVELY FORMED PROJECTILES**, Mohammed Amine Boulahlib, Miloš Marković, Slobodan Jaramaz, Momčilo Milinović, Mourad Bendjaballah

- 163 **TENDENCIES OF DEVELOPMENT OF AMPHIBIOUS ASSETS IN ARMED FORCES OF NATO COUNTRIES**, Nenad Kovačević, Nenad Dimitrijević
- 168 **ON ALGORITHM OF SYNCHRONIZED SWARMING AGAINST AN ACTIVE THREAT SIMULATOR**, Radomir Janković, Momčilo Milinović
- 173 **DETERMINING PROJECTILE CONSUMPTION DURING INDIRECT MORTAR FIRE**, Aca Randjelović, Vlado Djurković, Petar Repić
- 177 **PROPELLER AND SHIP MAIN ENGINE SELECTION IN CORRELATION WITH OVERALL EFFICIENCY PROPULSION COEFFICIENT IMPROVEMENT**, Jovo Dautović, Vojkan Madić, Sonja Đurković
- 182 **OPTIMIZATION OF PLANETARY GEARS AND EFFECTS OF THE THIN-RIMMED GEAR ON FILLET STRESS**, Miloš Sedak, Tatjana M. Lazović Kapor, Božidar Rosić
- 188 **PROJECTION OF QUALITY A COMPLEX TECHNICAL SYSTEM**, Ljubiša Tančić, Petar Jovanović, Samed Karović
- 194 **STRESS ANALYSIS OF INTEGRATED 12.7 MM MACHINE GUN MOUNT**, Aleksandar Kari, Dušan Jovanović, Damir Jerković, Nebojša Hristov
- 199 **STRATEGY IMPLEMENTATION OF DUAL-SEMI-ACTIVE RADAR HOMING GUIDANCE WITH COUPLING OF TANDEM GUIDED AND LEADING MISSILE OF AIR DEFENCE MISSILE SYSTEM ON REAL MANEUVERING TARGET**, Marković Stojan, Milinović Momčilo, Nenad Sakan
- 205 **EXPERIMENTAL INVESTIGATION OF OILS IN FOUR-STROKE ENGINES**, Sreten Perić, Bogdan Nedić
- 211 **OPTIMIZATION OF THE BOX SECTION OF THE SINGLE-GIRDER BRIDGE CRANE BY GRG ALGORITHM ACCORDING TO DOMESTIC STANDARDS AND EUROCODES**, Goran Pavlović, Vladimir Kvirgić, Stefan Mitrović, Mile Savković, Nebojša Zdravković
- 218 **MATHEMATICAL MODELING DYNAMIC PERFORMANCE OF ARTILLERY FIRE SUPPORT IN THE OFFENSIVE OPERATION**, Damir Projović, Zoran Karavidić, Miroslav Ostojić
- 223 **MODELING AND MULTIBODY SIMULATION OF LAND ROVER DEFENDER 110 RIDE AND HANDLING DYNAMICS**, Nabil Khetrou, Dragan Trifković, Slavko Muždeka
- 231 **PERSPECTIVES OF USE OF SWITCHED RELUCTANCE MOTORS IN COMBAT VEHICLES**, Radoslav Rusinov

#### 4. SECTION : AMMUNITION AND ENERGETIC MATERIALS

- 237 **PHYSICO-CHEMICAL PROPERTIES AND THERMAL STABILITY OF MICROCRYSTALLINE NITROCELLULOSE ISOLATED FROM WOOD FIBER**, Mohammed Amin Dali
- 243 **A METHOD OF GUNPOWDER GRAIN SHAPE OPTIMIZATION**, Stefan Jovanović
- 249 **COMPOSITE SOLID PROPELLANTS WITH OCTOGENE**, Vesna Rodić, Marica Bogosavljević, Aleksandar Milojković, Saša Brzić
- 255 **SOLVING TECHNICAL PROBLEMS WHILE WORKING WITH ORDNANCE USING INNOVATION PRINCIPLES**, Obrad Čabarkapa, Dušan Rajić, Marija Marković

- 260 **APPLYING OF NANOTECHNOLOGY IN PRODUCTION OF RIFLE AMMUNITION**, Mihailo Erčević, Veljko Petrović, Branka Luković
- 266 **DETERMINATION OF COMPATIBILITY OF DOUBLE BASE PROPELLANT WITH POLYMER MATERIALS USING DIFFERENT TEST METHODS**, Mirjana Dimić, Bojana Fidanovski, Ljiljana Jelisavac, Slaviša Stojiljković, Nataša Karišik
- 272 **CHARACTERIZATION OF BEHIND ARMOR DEBRIS AFTER PERFORATION OF STEEL PLATE BY ARMOR PIERCING PROJECTILE**, Predrag Elek, Slobodan Jaramaz, Dejan Micković, Miroslav Đorđević, Nenad Miloradović
- 278 **VISUALIZING THE THERMAL EFFECT OF THERMOBARIC EXPLOSIVES**, Uroš Anđelić, Danica Simić, Dragan Knežević, Marko Dević
- 283 **RELIABILITY OF SOLID ROCKET PROPELLANT GRAIN UNDER SIMULTANEOUS ACTION OF MULTIPLE TYPES OF LOADS**, Nikola Gligorijević, Saša Živković, Vesna Rodić, Saša Antonović, Aleksandar Milojković, Bojan Pavković, Zoran Novaković
- 290 **AN EXAMPLE OF PROPELLANT GRAIN STRUCTURAL ANALYSIS UNDER THE THERMAL AND ACCELERATION LOADS**, Saša Antonović, Nikola Gligorijević, Aleksandar Milojković, Sredoje Subotić, Saša Živković, Bojan Pavković
- 297 **TRANSFER OF GRANULATED PBX PRODUCTION TO THE INDUSTRIAL SCALE**, Slavica Terzić, Stanoje Biočanin, Aleksandar Đorđević, Živka Krstić, Biljana Kostadinović, Zoran Borković
- 304 **EXPLOSIVE REACTIVE ARMOR ACTION AGAINST SHAPED CHARGE JET**, Dejan Micković, Slobodan Jaramaz, Predrag Elek, Nenad Miloradović, Dragana Jaramaz, Dušan Micković
- 310 **AMMUNITION SURPLUS - THREAT TO POSSESSORS DISPOSAL METHODS: REVIEW OF DEMILITARIZATION TECHNOLOGIES**, Blaž Mihelič
- 324 **SHOCKWAVE OVERPRESSURE OF PROPELLANT GASES AROUND THE MORTAR**, Miodrag Lisov, Slobodan Jaramaz, Mirko Kozić, Novica Ristović

## 5. SECTION : INTEGRATED SENSOR SYSTEMS AND ROBOTIC SYSTEMS

- 331 **ACOUSTIC SOURCE LOCALIZATION USING A DISCRETE PROBABILITY DENSITY METHOD FOR POSITION DETERMINATION**, Ivan Pokrajac, Nadica Kozić, Predrag Okiljević, Miodrag Vračar, Brusin Radiana
- 336 **STATISTICAL APPROACH IN DETECTION OF AN ACOUSTIC BLAST WAVE**, Miodrag Vračar, Ivan Pokrajac
- 340 **ADAPTIVE TIME VARYING AUTOPILOT DESIGN**, Nataša Vlahović, Stevica Graovac, Miloš Pavić, Milan Ignjatović
- 345 **MATHEMATICAL MODEL FOR PARAMETER ANALYSIS OF PASSIVELY Q-SWITCHED Nd:YAG LASERS**, Mirjana Nikolić, Željko Vukobrat
- 350 **HFSW RADAR DESIGN: TACTICAL, TECHNOLOGICAL AND ENVIRONMENTAL CHALLENGES**, Dejan Nikolić, Bojan Džolić, Nikola Tosić, Nikola Lekić, Vladimir D. Orlić, Branislav M. Todorović
- 356 **EFFECTIVENESS OF ACTIVE VIBRATION CONTROL OF A FLEXIBLE BEAM USING A DIFFERENT POSITION OF STRAIN GAGE SENSORS**, Miroslav Jovanović, Aleksandar Simonović, Nebojša Lukić, Nemanja Zorić, Slobodan Stupar, Slobodan Ilić
- 362 **INFLUENCE OF GEOMETRICAL PARAMETERS ON PERFORMANCE OF**

- MEMS THERMOPILE BASED FLOW SENSOR**, Danijela Randjelović, Olga Jakšić, Milče M. Smiljanić, Predrag Poljak, Žarko Lazić
- 367 **MONITORING PHYSIOLOGICAL STATUS OF THE SOLDIER DURING COMBAT MISSION VIA INTEGRATED MEDICAL SENSOR (HEART RATE, OXYGEN SATURATION) SYSTEM**, Oliver Mladenovski, Jugoslav Ackoski, Milan Gocić
- 371 **ALUMINIUM TILES DEFECTS DETECTION BY EMPLOYING PULSED THERMOGRAPHY METHOD WITH DIFFERENT THERMAL CAMERAS**, Ljubiša Tomić, Vesna Damnjanović, Goran Dikić, Boban Bondžulić, Bojan Milanović, Rade Pavlović
- 377 **CHANNEL SELECTOR FOR OPTIMIZATION OF TEST AND CALIBRATION PROCEDURES OF ICTM PRESSURE SENSORS**, Predrag Poljak, Miloš Vorkapić, Danijela Randjelović
- 381 **SECURITY SYSTEM IN MILITARY BASES WITH MATLAB ALGORITHM**, Tamara Gjonedva, Sofija Velinovska, Jugoslav Achkoski, Boban Temelkovski
- 385 **IMAGING DETECTOR TECHNOLOGY: A SHORT INSIGHT IN HISTORY AND FUTURE POSSIBILITIES**, Branko Livada, Dragana Perić
- 391 **IMAGE QUALITY PARAMETERS: A SHORT REVIEW AND APPLICABILITY ANALYSIS**, Jelena Kocić, Ilija Popadić, Branko Livada
- 398 **MULTI-SENSOR SYSTEM OPERATOR'S CONSOLE: TOWARDS STRUCTURAL AND FUNCTIONAL OPTIMIZATION**, Dragana Perić, Saša Vujić, Branko Livada
- 404 **STATIONARY ON-ROAD OBSTACLES AVOIDANCE BASED ON COMPUTER VISION PRINCIPLES**, Mourad Bendjaballah, Stevica Graovac, Mohammed Amine Boulahlib, Miloš Marković
- 411 **GPS AIDED INS WITH GYRO COMPASSING FUNCTION**, Ivana Trajkovski, Nada Asanović, Vladimir Vukmirica, Milan Milošević
- 417 **MODERNIZATION OF THE RADAR P12**, Verica Marinković – Nedelicki, Branislav Pavić, Boris Mišković, Mladen Mileusnić, Predrag Petrović, Aleksandar Lebl, Dragan Borjan, Dejan Ivković, Dragan Nikolić
- 422 **DISTRIBUTED TARGET TRACKING IN CAMERA NETWORKS USING AN ADAPTIVE STRATEGY**, Nemanja Ilić, Khaled Obaid Al Ali, Miloš S. Stanković, Srdjan S. Stanković
- 428 **AUTONOMOUS MOBILE ROBOT PATH PLANNING IN COMPLEX AND DYNAMIC ENVIRONMENTS**, Novak Zagradjanin, Stevica Graovac
- 434 **SENSORLESS BRUSHED DC MOTOR SPEED CONTROL USING NATURAL TRACKING CONTROL ALGORITHM**, Miloš Pavić, Milan Ignjatović, Nataša Vlahović, Mirko Mišljen

## 6. SECTION : TELECOMMUNICATION AND INFORMATION SYSTEMS

- 441 **EVALUATION OF SELF-ORGANIZING UAV NETWORKS IN NS-3**, Nataša Maksić, Milan Bjelica
- 446 **CONCEPTUALIZING SIMULATION FOR LAWSON'S MODEL OF COMMAND AND CONTROL PROCESSES**, Nebojša Nikolić
- 451 **GENERATING EFFECTIVE JAMMING AGAINST GLOBAL NAVIGATION SYSTEMS**, Sergei Kostromitsky, Aliaksandr Dyatko, Petr Shumski, Yury Rybak

- 457 **EFFICIENT POWER FLOW ALGORITHM, MODIFIED ALGORITHM NAHMAN AND PERIĆ**, Branko Stojanović, Milan Moskovljević, Tomislav Rajić
- 462 **SOLID STATE L-BAND HIGH POWER AMPLIFIER USING GAN HEMT TECHNOLOGY**, Zvonko Radosavljević, Dejan Ivković, Dragan Nikolić
- 466 **PERFORMANCE EVALUATION OF NONLINEAR OPTIMIZATION METHODS FOR TOA LOCALIZATION TECHNIQUES**, Maja Rosić, Mirjana Simić, Predrag Pejović
- 472 **GPU-BASED PREPROCESSING FOR SPECTRUM SEGMENTATION IN DIRECTION FINDING**, Marko Mišić, Ivan Pokrajac, Nadica Kozić, Predrag Okiljević
- 478 **TECHNIQUES FOR INTELLIGENCE DATA GATHERING IN MOBILE COMMUNICATIONS**, Saša Stojković, Ivan Tot, Fejsov Nikola
- 481 **AN IMPLEMENTATION OF MANET NETWORKS ON COMMAND POST DURING MILITARY OPERATIONS**, Vladimir Ristić, Boban Z. Pavlović, Saša Devetak
- 486 **PRACTICAL IMPLEMENTATION OF DIGITAL DOWN CONVERSION FOR WIDEBAND DIRECTION FINDER ON FPGA**, Vuk Obradović, Predrag Okiljević, Nadica Kozić, Dejan Ivković
- 494 **STATISTICS OF RATIO OF TWO WEIBULL RANDOM VARIABLES WITH DIFFERENT PARAMETERS**, Ivica Marjanović, Dejan Rančić, Danijela Aleksić, Dejan Milić, Mihajlo Stefanović
- 500 **SOFTWARE AND INFORMATIONAL SYSTEMS IN THE PRODUCTION OF DTM25 OF THE MILITARY GEOGRAPHICAL INSTITUTE**, Aleksandar Pavlović, Viktor Marković, Ana Vučićević, Saša Bakrač

## 7. SECTION : MATERIALS, TECHNOLOGIES AND CBRN PROTECTION

- 507 **THERMAL STABILITY AND MAGNETIC PROPERTIES OF E- $Fe_2O_3$  POLYMORPH**, Violeta N. Nikolić, Marin Tadić, Vojislav Spasojević
- 513 **TECHNOLOGY FOR COMBATING BIOTERRORISM**, Elizabeta Ristanović
- 517 **ESTIMATION OF SAFT AND PC-SAFT EOS PARAMETERS FOR N-HEPTANE UNDER HIGH PRESSURE CONDITIONS**, Jovana Ilić, Mirko Stijepović, Aleksandar Grujić, Jasna Stajić – Trošić, Gorica Ivaniš, Mirjana Kijavčanin
- 522 **THE APPLICATION OF IR THERMOGRAPHY FOR THE CRACKS DETECTION IN THE COMPOSITE STRUCTURES USED IN AVIATION**, Stevan Jovičić, Ivana Kostić, Zoran Ilić, Ljubiša Tomić, Aleksandar Kovačević
- 525 **THERMAL AND CAMOUFLAGE PROPERTIES OF *ROSALIA ALPINA* LONGHORN BEETLE WITH STRUCTURAL COLORATION**, Ivana Kostić, Danica Pavlović, Vladimir Lazović, Darko Vasiljević, Dejan Stojanović, Dragan Knežević, Ljubiša Tomić, Goran Dikić, Dejan Pantelić
- 530 **ISOGEOMETRIC ANALYSIS OF FREE VIBRATION OF ELLIPTICAL LAMINATED COMPOSITE PLATES USING THIRD ORDER SHEAR DEFORMATION THEORY**, Ognjen Peković, Slobodan Stupar, Aleksandar Simonović, Toni Ivanov
- 536 **ON THE CORRELATION OF MICROHARDNESS WITH THE FILM ADHESION FOR „SOFT FILM ON HARD SUBSTRATE“ COMPOSITE SYSTEM**, Jelena Lamovec, Vesna Jović, Ivana Mladenović, Bogdan Popović, Miloš Vorkapić, Vesna Radojević
- 541 **A COMPARISON OF DIFFERENT CONVEX CORNER COMPENSATION**



- STRUCTURES APPLICABLE IN ANISOTROPIC WET CHEMICAL ETCHING OF {100} ORIENTED SILICON**, Vesna Jović, Jelena Lamovec, Milče Smiljanić, Žarko Lazić, Bogdan Popović, Predrag Poljak
- 547 **RADIOCESIUM-137 IN THE ENVIRONMENT AND THE EFFECT OF RADIATION-HYGIENE CERTIFICATION ON FOOD**, Nataša Pajić, Tatjana Marković
- 550 **SEPARATION OF THE CARBON-DIOXIDE FROM THE GAS MIXTURE**, Dragutin Nedeljković, Lana Putić, Aleksandar Stajčić, Aleksandar Grujić, Jasna Stajić-Trošić
- 556 **ELECTRODEPOSITION OF METAL COATINGS FROM EUTECTIC TYPE IONIC LIQUID**, Mihael Bučko, Jelena B. Bajat
- 561 **IMPACT OF THE ALTERED TEXTURE OF THE ACTIVE FILLING OF THE FILTER ON THE SORPTIVE CHARACTERISTICS WITH THE SPECIAL REFERENCE TO THE EFFICIENCY OF FILTERING**, Marina Ilić, Željko Senić, Vladimir Petrović, Biljana Mihajlović, Vukica Grković
- 567 **INFLUENCE OF DAMAGED INJECTORS USED IN COMMON RAIL SYSTEMS ON ECOLOGICAL AND ENERGY EFFICIENCY**, Dejan Janković, Mileta Ristivojević, Dimitrije Kostić
- 572 **DEFECT DURING PRODUCTION OF STEEL CARTRIDGE CASE**, Nada Ilić, Ljubica Radović
- 577 **FAILURE ANALYSIS OF THE STATOR BLADE**, Jelena Marinković, Dušan Vračarić, Ljubica Radović, Ivo Blačić
- 581 **READOUT BEAM COUPLING STRATEGIES FOR PLASMONIC CHEMICAL OR BIOLOGICAL SENSORS**, Zoran Jakšić, Milče M. Smiljanić, Žarko Lazić, Dana Vasiljević Radović, Marko Obradov, Dragan Tanasković, Olga Jakšić
- 587 **COMPLETE KINETIC PROFILING OF THE THREE NANOMOLAR ACETYLCHOLINESTERASE INHIBITORS**, Maja Vitorović-Todorović, Mirjana Jakišić, Sonja Bauk, Branko Drakulić
- 594 **DEPENDANCE OF CBRN INSULATING MATERIALS PROTECTION TIME UPON BUTYL-RUBBER AND FLAME RETARDANT CONTENT**, Vukica Grković, Vladimir Petrović, Željko Senić, Maja Vitorović-Todorović
- 598 **FILTERING HALF MASKS USAGE FOR PROTECTION AGAINST AEROSOL CONTAMINATION OF BIOLOGICAL AGENTS**, Negovan Ivanković, Dušan Rajić, Radovan Karkalić, Dejan Indjić, Dušan Janković, Željko Senić, Marina Ilić
- 603 **LASERS POSSIBILITIES IN BRASS SURFACE CLEANING**, Bojana Radojković, Slavica Ristić, Suzana Polić, Bore Jegdić, Aleksandar Krmpot, Branislav Salatić, Filip Vučetić
- 609 **EFFECT OF IF-WS<sub>2</sub> NANOPARTICLES ADDITION ON PHYSICAL-MECHANICAL AND RHEOLOGICAL PROPERTIES AND ON CHEMICAL RESISTANCE OF POLYURETHANE PAINT**, Dragana S. Lazić, Danica M. Simić, Aleksandra D. Samolov
- 614 **THERMAL ANALYSIS OF NANOCRYSTALLINE NIFE<sub>2</sub>O<sub>4</sub> PHASE FORMATION IN SOLID STATE REACTION**, Vladan Čosović, Aleksandar Čosović, Tomaš Žak, Nadežda Talijan, Duško Minić, Dragana Živković
- 618 **PRELIMINARY ANALYSIS OF THE POSSIBILITY OF PREPARING PVB/IF-WS<sub>2</sub> COMPOSITES. EFFECT OF NANOPARTICLES ADDITION ON THERMAL AND RHEOLOGICAL BEHAVIOR OF PVB**, Danica M. Simić, Dušica B. Stojanović, Mirjana Dimić, Ljubica Totovski, Saša Brzić, Petar S. Uskoković, Radoslav R. Aleksić

- 624 **HIGH PERFORMANCE LIQUID CHROMATOGRAPHY DETERMINATION OF 2,4,6-TRINITROTOLUENE IN WATER SOLUTION**, Jovica Nešić, Ljiljana Jelisavac, Aleksandar Marinković, Slaviša Stojiljković
- 630 **MEASURING CLEANING CLASS OF OIL AFTER TRIBOLOGICAL TESTING**, Radomir Janjić, Slobodan Mitrović, Dragan Džunić, Ivan Mačužić, Blaža Stojanović, Milan Bukvić, Zoran Ilić
- 636 **RECYCLING LITHIUM - ION BATTERY**, Milan Bukvić, Radomir Janjić, Blaža Stojanović
- 642 **NUMERICAL CALCULATION OF J-INTEGRAL USING FINITE ELEMENTS METHOD**, Bahrudin Hrnjica, Fadil Islamović, Dženana Gačo, Esad Bajramović
- 646 **INFLUENCE OF DIFFERENT TYPES OF POLYMER IMPREGNATION ON SPECTRAL REFLECTION OF TEXTILE MATERIALS**, Aleksandra Samolov, Milan Kulić
- 649 **QUALITY OF RECOVERED EXPLOSIVES OBTAINED FROM DELABORATED MUNITIONS**, Maja Matović, Ljiljana Bundalo
- 654 **THE STRENGTH INVESTIGATION OF SPECIFIC POLYMERIC COMPOSITE ELEMENT/METALLIC ELEMENT JOINT REALIZED BY PINS**, Slobodan Čitaković, Jovan Radulović
- 659 **QUALITATIVE AND QUANTITATIVE ASSESSMENT OF BOND STRENGTH OF SOLID ROCKET PROPELLANT AND THERMOPLASTIC MATERIAL FOR CARTRIDGE LOADED GRAIN**, Jovan Radulović
- 665 **SYNTHESIS OF RE/PD HETEROGENEOUS CATALYSTS SUPPORTED ON HMS USING SOL-GEL METHOD FOLLOWED BY SUPERCRITICAL DRYING WITH EXCESS SOLVENT**, Dragana Prokić Vidojević, Sandra B. Glišić, Aleksandar M. Orlović
- 671 **UNDERSTANDING PLASMA SPRAYING PROCESS AND APPLICATION IN DEFENSE INDUSTRY**, Bogdan Nedić, Marko Janković
- 678 **THERMAL STABILITY AND MICROSTRUCTURAL CHANGES INDUCED BY ANNEALING IN NANOCRYSTALLINE  $Fe_{72}Cu_1V_4Si_{15}B_8$  ALLOY**, Radoslav Surla, Milica Vasić, Nebojša Mitrović, Ljubica Radović, Ljubica Totovski, Dragica Minić
- 682 **LOW LEVEL TRITIUM DETERMINATION IN ENVIRONMENTAL SAMPLES USING 1220 QUANTULUS**, Nevena Zdjelarević, Marija Lekić, Nataša Lazarević
- 685 **OPTIMIZATION AND VIRTUAL QUALITY CONTROL OF A CASTING**, Srećko Manasijević, Radomir Radiša, Janez Pristravec, Velimir Komadinić, Zoran Radosavljević

**8. SECTION : QUALITY, STANDARDIZATION, METROLOGY,  
MAINTENANCE AND EXPLOITATION**

- 695 **RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT: PROBLEMS AND EXPERIENCE**, Slavko Pokorni
- 701 **APPLICATION OF INNOVATION STANDARDS IN THE FIELD OF WEAPONRY AND MILITARY EQUIPMENT**, Dušan Rajić, Obrad Čabarkapa
- 705 **SURFACE TEXTURE FILTRATION –INTERNATIONAL STANDARDS AND FILTRATIONS TECHNIQUE OVERVIEW**, Srdjan Živković, Branka Luković, Veljko Petrović

- 710 **SYSTEM FOR REMOTE MONITORING AND CONTROL OF HF-OTH RADAR**, Bojan Džolić, Dejan Nikolić, Nikola Tosić, Nikola Lekić, Vladimir D. Orlić, Branislav M. Todorović
- 715 **MODEL OF IMPROVING MAINTENANCE OF TELECOMMUNICATION DEVICES**, Vojkan Radonjić, Milenko Ćirić, Branko Resimić, Ivan Milojević
- 721 **USAGE AN INFRARED THERMOGRAPHY FOR THE PROCESS CONDITION-BASED MAINTENANCE OF SHIPS SYSTEMS**, Veselin Mrdak
- 727 **VOLUMETRIC CALIBRATION FOR IMPROVING ACCURACY OF AFP/ATL MACHINES**, Samoil Samak, Igor Dimovski, Vladimir Dukovski, Mirjana Trompeska
- 733 **DIAGNOSTIC APPROACH TO THE MAINTENANACE OF MARINE SYSTEMS**, Dušan Cincar
- 739 **MAINTENANCE OF HYBRID VEHICLES**, Blaža Stojanović, Milan Bukvić, Radomir Janjić
- 745 **A NEW APPROACH TO CREATING AND MANAGING TECHNICAL PUBLICATIONS FOR AIRCRAFT LASTA USING S1000D STANDARD**, Branko Dragić, Vojislav Dević, Miodrag Ivanišević
- 750 **NEW ISSUE OF STANDARD AS/EN 9100:2016, EXPECTATION AND BENEFITS FOR CUSTOMERS**, Biljana Marković

## SURFACE TEXTURE FILTRATION –INTERNATIONAL STANDARDS AND FILTRATIONS TECHNIQUE OVERVIEW

**SRDJAN ŽIVKOVIĆ**

Military Technical Institute Belgrade, Experimental Aerodynamics Division, Prototype Production Department,  
[srdjan.vti@gmail.com](mailto:srdjan.vti@gmail.com)

**BRANKA LUKOVIĆ**

[branka.lukovic@mod.gov.rs](mailto:branka.lukovic@mod.gov.rs)

**VELJKO PETROVIĆ**

Ministry of Defense, Material Resources Sector, Department for Defense Technologies, [veljko.petrovic@mod.gov.rs](mailto:veljko.petrovic@mod.gov.rs)

**Abstract:** Filtration is required at several reasons in the process of surface texture analysis. The main reason for using a filter is to separate long-scale components from short-scale components. Filtration techniques are used in surface metrology to separate the roughness component from the waviness component and the form component to calculate parameters according to international standards. Paper described problems roughness and waviness of profiles and surface area with a comprehensive reference to the relevant international standards.

**Keywords:** Filtration, Surface texture, Roughness, Waviness.

### 1. INTRODUCTION

An important application of metrology in industry arises while inspecting geometrical attributes of manufactured objects to verify whether they satisfy tolerances specified during the product development phase.

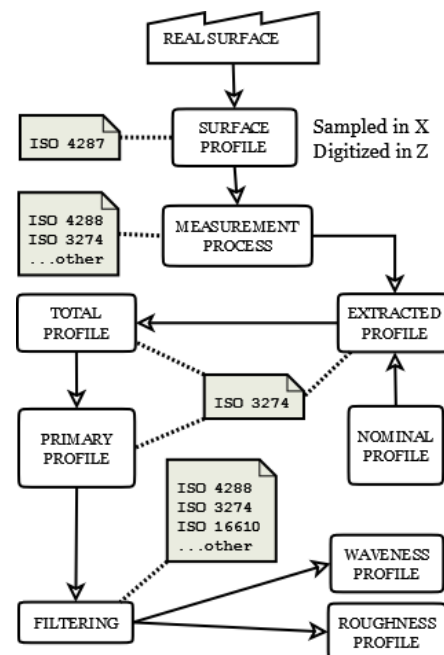
Intuitively, a real surface is the set of infinite number of points that separate a work-piece from its surrounding. Given any physical work-piece, it is, of course, impossible to come up with a computable mathematical representation of this set; we need some additional information about the resolution at which the real surface is perceived. Theoretically, a mathematical model that approximates the real surface can be obtained within any measure of closeness by choosing the nesting parameter very close to zero [4].

A real surface corresponding to a specified nesting parameter is then partitioned into real integral features. These features still contain infinite number of points. During actual inspection, however, we sample only a finite number of points on these features. These are called extracted integral features. It turns out that sampling alone is insufficient to extract a feature; it should be accompanied by some smoothing to remove noise and unwanted details from the measured data. Therefore, techniques for extracting information on real integral features involve both sampling and some filtration [5].

Filtration is required at several reasons in the process of surface texture analysis. The main reason for using a filter is to separate long-scale components from short-scale components. We want to separate waviness from roughness. Filtration techniques are used in surface

metrology to separate the roughness component from the waviness component and the form component to calculate parameters according to international standards. Characterization surface parameters can be derived with an aim to control the manufacturing process.

ISO 3274 defines a measurement scheme shown on picture 1. The profile measured by profile-meters is called the extracted profile. It is sampled and digitized, and represents an abstraction of the real surface [2].



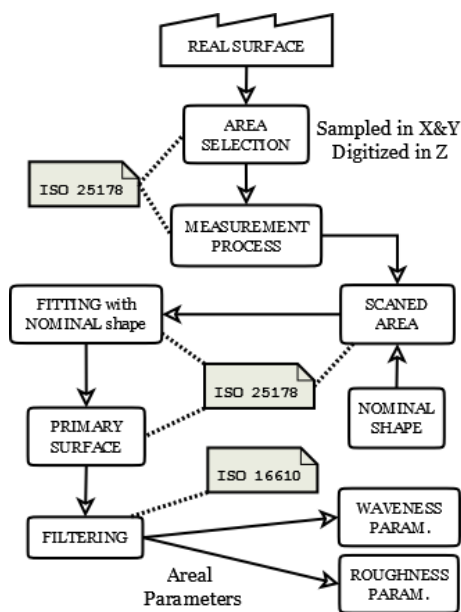
**Picture 1.** Procedure for obtaining Primary profile, Roughness and Waviness (ISO 3274)

Before the measurement process is started, the section of the surface that will be measured should be determined. The reference system is placed so that the  $x$ -axis runs perpendicular to the process traces. Several filtering effects are introduced by the probe and the bandwidth of the instrument). The real surface is modelled by a mechanical surface (boundary) when measured with a stylus, or by an electromagnetic surface which represents the surface envelope sensed by an optical probe [ISO 14406].

For profiles, we have **Pa** (Mean line/curve for Primary profile), **Ra** (Roughness parameters) and **Wa** (Waviness parameters).

In contrast with naming rules used with profile parameters, prefixes of the areal parameters do not reflect the nature of the surface, distinguishing between roughness and waviness. In the ISO 25178 standard, all areal parameters start with the upper case letter S or the upper case letter V.

For surfaces, we only have **Sa**, which can therefore be a parameter of roughness, or waviness, or calculated on the primary surface, depending upon the pre-filtering that is carried out before the parameter is calculated. This decision is based upon the multiplicity of processing and filtering methods that are available to metrology engineer for extracting information from a surface [1]. Processing methods do not necessarily separate the surface texture into two components that are roughness and waviness but in certain cases alter the surface in a subtler manner [5].



**Picture 2.** Procedure for obtaining Primary surface, areal waviness and roughness (ISO 25178)

Procedures, shown on pictures 1&2 are quite similar [2]. The vocabulary introduced in ISO 25178. The S-filter removes short-scale components. The L-filter removes long-scale components. The F-operator is the form removal operation. Scale-limited surfaces – SF surface or SL surface – are obtained after the respective filters or form removal operations have been applied. Areal parameters are then calculated on one of these surfaces,

but contrary to profile parameters, they do not reflect the previous filter operation in their name [5].

## 2. SURFACE TEXTURE INTERNATIONAL STANDARDS

Engineers working in the field of surface texture should know following GPS (Geometrical Product Specification) ISO standards; Profile Surface Texture Standards:

- ISO 1302 (GPS) - Indication of surface texture in technical product documentation
- ISO 3274 (GPS) - Surface texture: Profile method - Nominal characteristics of contact (stylus) instruments
- ISO 4287 (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters
- ISO 4288 (GPS) - Surface texture: Profile method - Rules and procedures for the assessment of surface texture
- ISO 5436-1 (GPS) - Surface texture: Profile method - Measurement standards - Part 1: Material measures
- ISO 5436-2 (GPS) - Surface texture: Profile method - Measurement standards - Part 2: Software measurement standards
- ISO 12085 (GPS) - Surface texture: Profile method - Motif parameters
- ISO 12179 (GPS) - Surface texture: Profile method - Calibration of contact (stylus) instruments
- ISO 13565-1 (GPS) - Surface texture: Profile method - Surfaces having stratified functional properties - Part 1: Filtering and general measurement conditions
- ISO 13565-2 (GPS) - Surface texture: Profile method - Surfaces having stratified functional properties - Part 2: Height characterization using the linear material ratio curve
- ISO 13565-2 (GPS) - Surface texture: Profile method - Surfaces having stratified functional properties - Part 3: Height characterization using the material probability curve
- ISO 16610-1 (GPS) - Filtration - Part 1: Overview and basic concepts.

Areal surface texture standards ISO 25178 consist of the following parts:

- Part 1: surface texture indications; specifies the rules for indication of areal surface texture in technical product documentation (e.g. drawings, specifications, contracts, reports) by means of graphical symbols.
- Part 2: terms, definitions and surface texture parameters
- Part 3: specification operators
- Part 6: classification of methods for measuring surface texture
- Part 70: material measures for the calibration of

instruments

- Part 71: soft gauges - SDF file format
- Part 72: soft gauges - X3P file format
- Part 600: nominal characteristics of surface texture measuring instruments
- Part 601: nominal characteristics of contact (stylus) instruments
- Part 602: nominal characteristics of non-contact (confocal chromatic probe) instruments
- Part 603: nominal characteristics of non-contact (wave front interferometric microscope) instruments
- Part 604: nominal characteristics of non-contact (coherence scanning interferometry) instruments
- Part 605: nominal characteristics of non-contact (point autofocus profiling) instruments
- Part 606: nominal characteristics of non-contact (focus variation) instruments
- Part 607: nominal characteristics of non-contact (confocal) instruments
- Part 700: calibration of surface texture measuring instruments
- Part 701: calibration and measurement standards for contact (stylus) instruments

Other useful international standards for surface texture:

- ISO 1 (GPS) - Standard reference temperature for geometrical product specification and verification
- ISO 1101 (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out
- ISO 8785 (GPS) - Surface imperfections - Terms, definitions and parameters
- ISO 14406 (GPS) - Extraction
- ISO 14253 (GPS) - Inspection by measurement of workpieces and measuring equipment - Part 1: Decision rules for proving conformance or non-conformance with specifications
- ISO 14638 (GPS) - Masterplan
- ISO/IEC Guide 98-1:2009 Uncertainty of measurement - Part 1: Introduction of the expression of uncertainty in measurement
- ISO/IEC Guide 98-3:2008 Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (= GUM)
- ISO/IEC Guide 99:2007 International vocabulary of metrology - Basic and general concepts and associated terms (= VIM)

### 3. FILTRATION TECHNIQUE

Filtration is one of the core elements of analysis tools in geometrical metrology. It is the means by which the information of interest is extracted from the measured data for further analysis. Noises are removed by filters before fitting routines are applied to generate the geometry of the measurand [2].

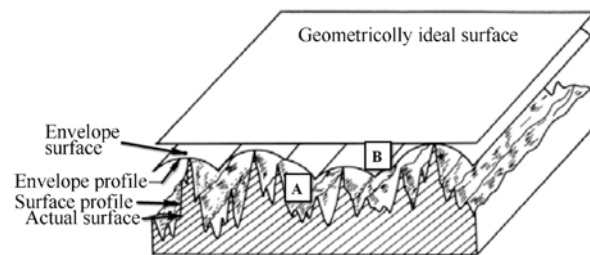
The first filters were implemented as physical high-pass filters using resistors and capacitors soldered behind a selector. The initial aim was to avoid large signal variations in order to draw the profile correctly on a thermal band of paper, or to display a roughness average indication on a dial indicator. These RC filters were used for almost 30 years on all types of stylus profile-meters.

These filters could date back to two traditional filtration systems emerged in 1950s [4], the mean-line based system (M-system, picture 3.) and the envelope based system (E-system, picture 4.).



**Picture 3.** The mean-line system

The M-system generates a reference line passing through the measured profile from which the roughness is assessed. Reference line, shown on picture 3. represent reference line [4]. This line is called the mean line due to the fact that the profile portions above and below the reference line are equal in the sum of their areas.



**Picture 4.** The envelope system; A-Roughness; B-Waviness [4]

The E-system was acting totally differently; the E-system appeared as a large disk rolling across over the profile from above, and the covering envelope formed by the rolling disk [4]. As shown in picture 4, the E-system gains its basis from the simulation of the contact phenomenon of two mating surfaces, whereby peak features of the surface play a dominant role in the interaction operation.

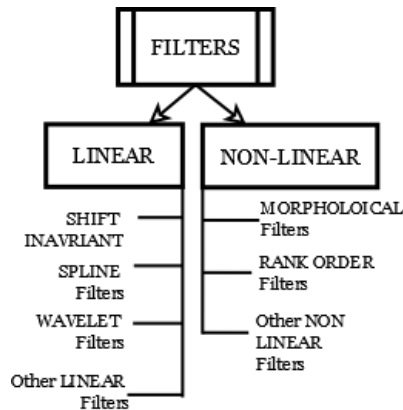
The fact is that the M-system and the E-system are complement to each other, rather than compete against each other and none of them can fulfill all the practical demands by themselves alone.

The M-system was greatly enriched by incorporating advanced mathematical theories. The Gaussian regression filter overcame the problem of end distortion and poor performance of the Gaussian filter in the presence of significant form component.

The E-system also experienced significant improvements. Introducing mathematical morphology, morphological filters emerged as the superset of the early envelope filter, but offering more tools and capabilities.

Filters can be classified in a certain hierarchy, picture 5. Most of the filters used today in dimensional metrology belong to the class of linear filters [3]. Especially the following filters are used:

- Electrical RC filters, implemented by hardware
- Phase correct 2RC filters, implemented by software
- Gaussian filter, implemented by software
- Spline filter, implemented by software
- Robust Spline filter, implemented by software



Picture 5. Filters Classification

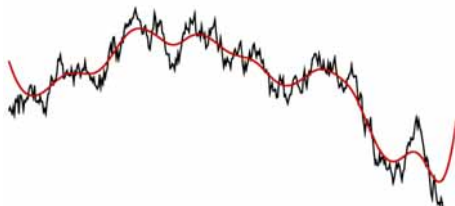
#### 4. FILTRATION ACCORDING ISO 16610

The following profile filters are published in the ISO 16610 series [1]:

- Gaussian filters (ISO 16610-21)
- Spline filters (ISO 16610-22)
- Spline wavelets (ISO 16610-29)
- Robust Gaussian regression filters (ISO 16610-31)
- Robust Spline filters (ISO 16610-32)
- Morphological filter (ISO 16610-41)

##### 4.1. Gaussian filter

The Gaussian filter, picture 6, belongs to the class of linear shift invariant filters. The implementation is possible by software only, because the filter is non-causal. It is a phase correct filter with a symmetrical weighting function [1]. The Gaussian filter has replaced the phase correct 2RC filter.



Picture 6. The Gaussian filter (ISO 16610-21) [6]

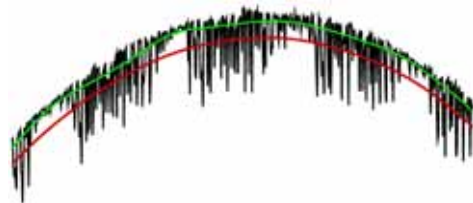
The Gaussian filter has the following disadvantages [4]:

- The filter is a continuous filter, i.e. the implementation is arbitrary (no unique algorithm).

- The filter has end-effects, i.e. data at both ends of the filtered signal must be discarded.
- The filter has problems with signals, which have a large curvature.
- An adjustment of the signal before filtering is necessary.
- Finite periodic signals cannot be filtered, because of the end-effects.
- The filter is not robust, i.e. sensitive to outliers.

##### 4.2. Spline filter

The spline filter has been developed to overcome the disadvantages of the linear shift invariant filters like the Gaussian filter, picture 7. Spline filters are still linear phase correct filters, but are not shift invariant filters. They are implemented by software only, using a very fast matrix algorithm. There exists a robust version of the spline filter, which is insensitive to outliers [5].

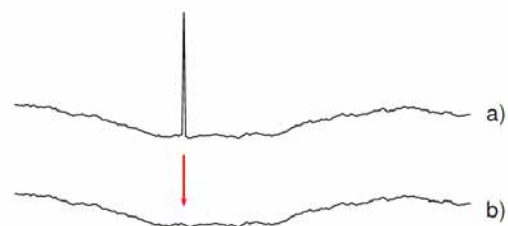


Picture 7. Spline filter (green) vs. Gaussian filter (red) [6]

##### 4.3. Wavelet filters

Wavelet filters are linear filters and can be used to remove noise or outliers [1], picture 8.

Contrary to the Fourier transformation, the wavelet decomposition allows not only to determine the wavelength content of a measured profile, but also to localize where a particular wavelength occurs.



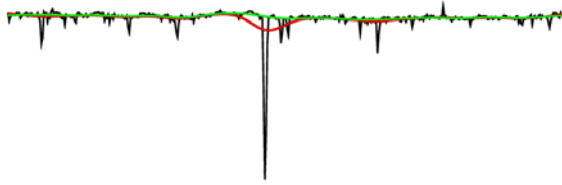
Picture 8. (a) original profile with outlier; (b) outlier removed by a wavelet filter [6]

The smooth part of a wavelength decomposition of a profile corresponds to a low pass filter, while the detail part corresponds to a high pass filter. The wavelength decomposition, like the Fourier transformation, can be reversed and allows thus the construction of wavelet filters [5].

##### 4.4. Robust Spline filter

The robust Spline filter is applied as a profile filter in roughness or form measurements, picture 9. The filtered signal shows no unwanted deviation caused by deep holes

or scratches in the surface (green line on picture 9.), as the Gaussian filter does (red line on picture 9.). The robust Spline filter is also insensitive to outliers.

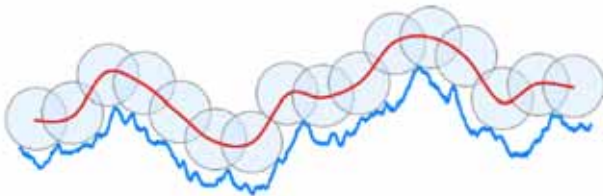


**Picture 9.** The robust Spline filter (ISO 16610-32) [6]

#### 4.5. Morphological filters

Morphological filters can be interpreted as a simulation of the track of a reference point of a rigid solid body, as for example the center of a ball, which is moving along the surface of a workpiece being continuously in contact with the surface to be filtered [4].

One of the main application of morphological operations is the morphological reconstruction of a tactile measured profile. Morphological filters are non-linear filters.



**Picture 10.** Morphological closing filter (upper red curve) obtained by rolling a disk over the profile [5]

Two morphological operation called *dilatation & erosion* are used to define a mechanical surface. If the disk is rolled over the surface, it is called *dilatation*. The path of its center is recorded (red line, picture 10). Note how this fills "valleys" while preserving the "peaks" [4]. If the disk is rolled below the surface, it is called *erosion* (gray dotted line, picture 11). The path of disk envelope is recorded. Note how this knocks out the "peaks" and preserves the "valleys".



**Picture 11.** Morphological opening filter (upper red curve) obtained by rolling a disk over the profile [5]

Dilation and erosion are not filters; they are just morphological operations [5]. When dilation is followed by erosion, it is called a morphological closing filter. If the sequence is reversed, i.e. erosion followed by dilation, it is called a morphological opening filter.

When applied in alternating sequence, these two filters can be used to selectively eliminate features of any given "size" from the input data [3]. Closing and opening filters can also be cascaded to create alternating symmetrical filters.

## 5. CONCLUSION

This paper provides a brief overview of the standards and technique that are relevant to the texture of the surface. Paper described problems roughness and wavering of profiles and surface area with a comprehensive reference to the relevant international standards. Paper offers to metrology engineers a guideline to choose the appropriate filter for various applications.

## References

- [1] SRPS EN ISO 16610-1:2015; Institute for Standardization of Serbia.
- [2] Tomov,M., Kuzinovski,M., Cichosz,P.: *A New Parameter of Statistic Equality of Sampling Lengths in Surface Roughness Measurement*, Strojniški vestnik - Journal of Mechanical Engineering 59(2013)5, 339-348; DOI:10.5545/sv-jme.2012.606
- [3] Srinivasan,V., Scott,P.J., Krystek,M.: *ISO standards for geometrical filters*; Proceeding XVI IMEKO World Congress; Vienna, AUSTRIA, 2000, September 25-28
- [4] Shan Lou Wen-Han Zeng, Xiang-Qian Jiang, Paul J. Scott: *Robust Filtration Techniques in Geometrical Metrology and Their Comparison*; International Journal of Automation and Computing 10(1), February 2013, 1-8; DOI: 10.1007/s11633-013-0690-4
- [5] Blateyron,F.: *Good practices for the use of areal filters*; Conference proceedings, 3<sup>rd</sup> Seminar on Surface Metrology of the Americas, Albuquerque New Mexico, May 2014; DOI: 10.13140/2.1.1007.9361
- [6] Michael,K.: *Filtration of data according to the new ISO 16610 series*, CENAM 5<sup>th</sup> Simposio de Metrología Querétaro, Mexico, 2008, online: [http://www.cenam.mx/ammc/eventos/evento2008/cmu-mmc\\_2008\\_krystek.pdf](http://www.cenam.mx/ammc/eventos/evento2008/cmu-mmc_2008_krystek.pdf), accessed 30.05.2016.