UNIVERZITET CRNE GORE
Mašinski fakultet Podgorica
Broj: 2377
Podgorica, 07. 10. 2019. godine

UNIVERZITET CRNE GORE

- Centru za doktorske studije –

OVDJE

U prilogu dostavljamo Predlog odluke Vijeća Mašinskog fakulteta, sa sjednice održane dana 07. 10. 2019. godine, o predlogu formiranja Komisije za odbranu polaznih istraživanja i ocjenu podobnosti doktorske teme i kandidata, Mr Vidosave Vilotijević.

DEKAN
Prof. dr Igor Vušanović

UNIVERZITET CRNE GORE
Mašinski fakultet Podgorica
Broj: 2378
Podgorica, 07. 10. 2019. godine

Na osnovu člana 64 Statuta Univerziteta Crne Gore, u vezi sa članom 34, stav 1 Pravila doktorskih studija, Vijeće Mašinskog fakuteta u Podgorici, na sjednici održanoj dana 07. 10. 2019. godine, utvrdilo je predlog

ODLUKE

Član 1

Komisiju za odbranu polaznih istraživanja i ocjenu podobnosti teme pod nazivom: „Numeričko simuliranje i analiza podataka aerodinamičke buke generisane radom vjetroturbina“, kandidata, Mr Vidosave Vilotijević čine:

1. Prof. dr Uroš Karadžić, predsjednik

2. Prof. dr Igor Vušanović, mentor – član i

3. Doc. dr Milan Šekularac, član.

Član 2

Odluka stupa na snagu kada je verifikuje Senat Univerziteta Crne Gore.

DEKAN
Prof. dr Igor Vušanović

UNIVERZITET CRNE GORE
Mašinski fakultet
Komisija za doktorske studije
Podgorica, 01. 10. 2019.

- VIJEĆE MAŠINSKOG FAKULTETA –

Poštovani,

U skladu sa Pravilima doktorskih studija i Vodičem za doktorske studije, u prilogu dostavljamo prijavu koleginice **Vidosave Vilotijević** na predviđenom **obrascu PD**, kao i prateću dokumentaciju.

Komisija za doktorske studije na Mašinskom fakultetu je na sjednici održanoj dana 01. 10. 2019. godine, razmatrala formalne uslove dostavljene prijave, sa stanovišta neophodnih podataka i ispunjavanju uslova za prijavu teze, i poštujući princip kompetentnosti, imajući u vidu dostavljenu prijavu i prateći materijal, inicira sledeći sastav komisije za odbranu polaznih istraživanja i ocjenu podobnosti teme i kandidata:

1. Prof. dr Uroš Karadžić, predsjednik,

2. Prof. dr Igor Vušanović, mentor – član i

3. Doc. dr Milan Šekularac, član.

Predlažemo Vijeću Mašinskog fakulteta da na bazi ovog inicijalnog predloga, **utvrdi predlog sastava komisije i isti dostavi Odboru za doktorske studije na dalje postupanje**.

Srdačno,

Crna Gora
UNIVERZITET CRNE GORE
MAŠINSKI FAKULTET

Primljeno: 1. 10. 2019			
Org. jed.	Broj	Prilog	Vrijednost
	2252		

PREDSJEDNIK KOMISIJE ZA DOKTORSKE STUDIJE

Prof. dr Aleksandar Vujović

PRIJAVA TEME DOKTORSKE DISERTACIJE

OPŠTI PODACI O DOKTORANTU	
Titula, ime i prezime	Mr Vidosava Vilotijević, spec.sci. mašinstva
Fakultet	Mašinski fakultet
Studijski program	Mašinstvo
Broj indeksa	1/2018
Ime i prezime roditelja	Milorad Vilotijević
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BIOGRAFIJA I BIBLIOGRAFIJA	
Obrazovanje	• Magistar mašinstva, Mašinski fakultet u Podgorici, Univerzitet Crne Gore, 24.10.2018., ocjena A • Spec.sci mašinstva, Mašinski fakultet u Podgorici, Univerzitet Crne Gore, 23.09.2016., ocjena B • BsC mašinstva, Mašinski fakultet u Podgorici, Univerzitet Crne Gore, 02.07.2015., Mašinski fakultet u Podgorici, Univerzitet Crne Gore, ocjena C
Radno iskustvo	Saradnik u nastavi,2017 – Mašinski fakultet, Univerzitet Crne Gore
Popis radova	*Magistarski rad:* „Odabir instalisanog protoka kod malih hidroelektrana“, 24.10.2019., Univerzitet Crne Gore, Mašinski fakultet *Specijalistički rad:* „Varijante hidroenergetskog iskorištenja rijeke Komarnice“, 23.09.2019., Univerzitet Crne Gore, Mašinski fakultet. *Radovi objavljeni na međunarodnim konferencijama:* [1] **Vilotijević V.**, Karadžić U., Božić. I., Ilić. J. (2019). Design discharge determination for SHPPs with capacity below 1 MW. *14th International Conference on Accomplishments in Mechanical and Industrial Engineering*, Banja Luka, Republic of Srpska, BiH, 24-25 May [2] **Vilotijević V.**, Karadžić U., Vušanović I. (2018). Determination of the degree of installed flow in small hydropower plants. *International Conference Energy and Ecology Industry*. Belgrade, Serbia, 10-13 October. [3] Vuković D., **Vilotijević V.**, Karadžić U. (2017). Hydraulic transients calculations on Komarnica HPP. *13th International Conference on Accomplishments in Mechanical and Industrial Engineering*, Banja Luka, Republic of Srpska, BiH, 26-27 May

NASLOV PREDLOŽENE TEME	
Na maternjem jeziku	Numeričko simuliranje i analiza podataka aerodinamičke buke generisane radom vjetroturbina
Na engleskom jeziku	Numerical simulations and field data analyses of aerodinamical noise generation by wind turbine

Obrazloženje teme

Energija vjetra i njeno iskorišćenje kao obnovljivog vida energije je trenutno jedna od najvažnijih tema globalno u svijetu. Udio energije vjetra u proizvodnji eleketrične energije u velikom broju evropskih i van evropskih zemalja je u snažnom porastu, i predviđa se i dalji rast u skladu sa Pariškim sporazumom iz 2015. godine čiji je cilj smanjenje emisija gasova staklene bašte na predindustrijski nivo iz 1850. Prema podacima iz Njemačke kao najrazvijenije evropske ekonomije, i njene agencije za energetiku, energija vjetra u ukupnoj proizvodnji električne energije već danas učestvuje sa više od 30% od ukupno proizvedene energije, a taj procenat će nezaustavljivo rasti u sljedećem periodu.

Rad vjetrogeneratora prate i određeni negativni efekati, od kojih je svakako najzanačajniji generisanje niskofrekventne buke koja je posljedica složenog turbulentnog strujanja oko lopatica kola turbine, koja u dužini može biti i veća od 50m. Niskofrekventna buka može da ima značajan uticaj po ekosistem u kojem se nalazi vjetroturbina, pa je poznavanje ovog fenomena neophodno za bolje sagledavanje uticaja ovih uređaja na životnu sredinu.

Pregled dosadašnjih istraživanja

Ozbiljnija istraživanja na polju vjetroturbina počela su 70 – ih godina prošlog vijeka. Primarni fokus u posljednje četiri decenije bio je na razvoju što većih turbomašina sa što većim lopaticama kao i veća proizvodnja energije. Razlozi za to su smanjivanje ukupnih troškova proizvodnje energije i omogućavanje proizvodnje većeg procenta svjetskih energetskih potreba iz obnovljivih izvora, a da pritom nema stotina hiljada ili čak miliona manjih turbina.
Relativna novost u iskorišćavanju energije vjetra i proizvodnja električne energije kao i ogromna količina prethodnog truda i znanja uloženog u druga vazduhoplovna polja tokom proteklog vijeka učinili su vrlo prirodnim sagledati šta je urađeno na tim poljima i primijeniti to na izazove sa kojima se suočava veliki razvoj horizontalnih vjetroturbina.
Buka koja nastaje iz vjetroturbina uglavnom se može podijeliti na dvije vrste - mehanička i aerodinamička. Mehanička buka nastaje iz različitih komponenti mašina u vjetroturbinama i ima ton zvuka. Aerodinamička buka nastaje usled protoka vazduha oko lopatica koji je na različite načine u interakciji sa površinom lopatica. Izvor aerodinamičke buke je turbulencija izazvana opstrujavanjem vazduha oko vrha lopatice i njenih prednjih i zadnjih ivica.
Mehaničku buku u vjetroturbinama stvaraju razne pokretne komponente kao što su mjenjač, generator, ventilatori za hlađenje i drugi pomoćni uređaji. Mehanički šum je uglavnom tonalnog karaktera, što znači da buka koja nastaje iz mehaničkih izvora dostiže određene frekvencija i oštrija je za ljudska čula od šuma koji dolazi od širokopojasnih frekvencija.
1952. godine **Lighthill** je predstavio svoj prvi rad o aerodinamički generisanoj buci Kraljevskom društvu Londona. Iz rada koji je predstavljen, Lightill je definisao akustičku analogiju, koja se danas naziva Lighthillova akustička analogija. Važan zaključak je da Lighthill-ova teorija omogućavala izračunavanje zvučnog polja u području fluktuirajućeg (turbulentnog) toka rješavanjem analognog problema prinudnih oscilacija, pod uslovom da je protok vazduha poznat. Lighthill-ova analogija defnisala je zapreminski integral Lighthill-ovog tenzora koji je pokazao da Rejnoldsovi naponi dominiraju u zvučnom polju. Lighthillov tenzor, T_{ij} se primjenjuje u jednačinama kontinuiteta i jednačini promjene količine kretanja za opisivanje strujanja u graničnom sloju.

Powell (1963,1964) je imao drugačiji pristup i dokazao je da formiranje i kretanje vrtloga stvaraju dominantne izvore buke. Izvođenje u Powell-ovoj analizi rezultira nehomogenom jednačinom talasa za promjenljivu gustinu izazvanu kretanjem tečnosti.
I **Powell-ove i Lighthill-ove** teorije (1986) izvedene su iz istih jednačina, jednačine kontinuiteta i jednačina promjene količine kretanja, i pokazalo se da su ekvivalentne.
Williams – Hawinks (2006) jednačina (FW-H) jednačina daje odlične rezultate kod izračunavanja buke koju stvaraju lopatice turbina, pod uslovom da se znaju tačne informacije o graničnom sloju. Ova jednačina postala je osnova za neke numeričke kodove predviđanja buke koji ili izračunavaju granični sloj ili koriste empirijske podatke za unošenje podataka o graničnom sloju u FW-H jednačinu. Mehanička buka može se, međutim, u velikoj mjeri smanjiti pravilnim oblikom kućišta i korišćenjem materijala koji apsorbuju zvuk i suzbijaju vibracije (**Wagner S** 2012). Ovo smanjenje rezultiralo je time da aerodinamički šum postaje dominantan izvor buke u vjetroturbinama. Buka ulazne turbulencije (IT) nastaje usljed interakcije površine lopatice, posebno vodeće ivice, sa atmosferskom turbulencijom. Ova interakcija turbulentnih vrtloga sa lopaticom stvara širokopojasni šum koji se nalazi u niskofrekventnom spektru (do 1000Hz) i veoma zavisi od intenziteta atmosferske turbulencije i dužine turbulencije. Doprinos IT buke ukupnoj buci vjetroturbina još uvijek nije u potpunosti istražen, posebno zbog njegove zavisnosti od atmosferske stabilnosti i strukture turbulencije. Prema mjerenjima akustičkog polja **Oerlemansa** i drugih (2016) udio buke preko vodeće ivice najznačajnije je u blizini vrha gdje je brzina strujanja velika. Tupa zadnja ivica uzrokuje vrtloge tipa Von Karman što rezultira emisijom tonalne buke. Ovaj izvor buke zavisi od oblika noseće ivice, Rejnoldsovog broja i odnosa (δ^*/t^*) (gde je δ^* debljina graničnog sloja, a t^* debljina sloja noseće ivice).

1. Smanjenje buke od ulazne turbulencije

Buka ulazne turbulencije koja zavisi od atmosferske turbulencije ne omogućava veliku fleksibilnost za ublažavanje buke iz ovog izvora. Međutim, dokazano je da promjene oblika nosećih ivica značajno utiču na stvaranje buke (**Oerlemans S.** 2011). Na osnovu ovoga predloženo je mnogo različitih oblika nosećih profila za ublažavanje IT buke. Biomimetičko istraživanje za smanjenje šuma modifikacijom nosećih ivica bilo je zanimljivo mnogim istraživačima. U eksperimentalnom radu **Hansena** i njegove grupe (2010) koji je bio baziran na konceptima kaverni kod repova kitova, koji na repovima i perajima koriste sinusoidalne prednje ivice za smanjenje komponenata tonalne buke. Utvrđeno je da su izrasline sa velikom amplitudom i malom talasnom dužinom efikasne u smanjenju tonalne buke. Na mehanizam utiču parni vrtlozi proizvedeni iz korita kaverni koje pojačavaju razmjenu zamaha u pograničnom sloju i na taj način mijenjaju njegove karakteristike stabilnosti i učestalost fluktuacija brzine u blizini krajnje ivice. Takođe, kako lokacija razdvajanja varira zbog vodeće sinusoidne ivice, linija razdvajanja se poremeti što dovodi do promjene stabilnosti sloja smicanja i učestalosti promjene brzine. Nedavna eksperimentalna istraživanja buke sprovedena od strane **Chaitanye** (2018) na različitim profilima prednjeg ruba istakli su značajnu ulogu vodećih proreza kao superiornu kod profila sa jednom mono-talasnom dužinom za smanjenje buke niske frekvencije. Novi profili imaju dva dominantna nivoa buke i visoko koherentan kompaktni izvor buke po izreckanoj talasnoj dužini, a koja podliježu destruktivnim smetnjama za ublažavanje buke sa vodeće ivice. Čak 15dB smanjenje buke postignuto je s prednjim rubovima, za razliku od samo 7dB za konvencionalne jednostruke talasne dužine.

2. Smanjenje aerodinamičke buke od ivica sa kraja lopatice

Budući da je tzv. *Turbulent Boundary Layer - Trailing Edge noise* (TBL-TE) dominantan izvor buke za većinu vjetroturbina, razvijene su brojne tehnike ublažavanja i njene kontrole. Baronova tehnika smanjenja TE-a (2011) pruža pregled nekoliko metoda osmišljenih za ublažavanje TE buke. Buka od zadnjih ivica je direktno proporcionalan trećem stepenu $\cos^3\gamma$ prema analitičkom izvođenju, koristeći polu-beskonačnu aproksimaciju ravne ploče (**Williams J and Hall L.** 1970). Ova zavisnost od $\cos^3\gamma$ pokazuje da se buka raspršuje najefikasnije kada je put turbulentnih vrtloga normalan na zadnju ivicu. Zadnje ivice pružaju način da se smanji ugao između vrtložne putanje i ivice ispod 90°, čime se smanjuje rasipanje zvuka. Međutim, budući da ove funkcije ne mogu uvijek biti usklađene sa pravcem strujanja zbog promjenljive brzine strujanja, one dovode do povećanja nivoa zvuka na većim frekvencijama (**Oerlemans S.** 2011). Za prevazilaženje problema usklađivanja protoka sa neravnotežnim ivicama, predstavljen je koncept repnih četkica. U eksperimentalnom radu **Herr-a** (2007) i **Finez – a** (2010) potvrđena je prednost primjene repnih četkica za redukciju aerodinamičke buke. Porozne repne ivice rade slično repnim četkicama za smanjenje naglih promjena u akustičnoj impedansi koje se odigravaju na oštroj ivici blizu struje pored profila lopatice. Studija **Geyer – a** i koautora (2009) kao i **Kinzie – a** i njegove grupe (2013) takođe je pokazala potencijal ovih tehnologija za smanjenje aerodinamičke buke, i sveukupno je pokazana neophodnost sprovođenja tzv. potpunog eksperimenata na turbinama.

3. Smanjenje šuma koje je posledica aerodinamičke buke sa vrha lopatica

Buka na vrhu lopatica turbine je dominantan izvor buke vjetroturbina na visokim frekvencijama. **Madsen i Fuglsang** (1996) su najprije identifikovali jačinu vrtloga na vrhu i proširenje i separaciju regiona od buke sa vrha lopatice i predložili su nerazdvajajući vrlog na vrhu kao moguće rješenje problema. **Fleig i dr.** (2004) izvršili su numeričku analizu oblika vrha koristeći akustičku analogiju i došli do smanjenje buke od 5 dB za frekvencije veće od 4kH. U kasnijem eksperimentalnom radu, **Kinzie i dr.** (2013) istraživali su efikasnost ovih oblika vrhova u ublažavanju buke sa vrha preko tupih, vitkih tipova. Odabrani oblici vrhova dizajnirani su tako da minimizuju dužinu vrtloga i interakciju vrtloga i bočne ivice. Skorašnja numerička istraživanja od strane **Maizi-ja** i koautora (2018) čiji je cilj bio smanjenje buke od vrha lopatice, pokazala su da korišćenjem referentnog vrha i tzv. ajkulinog vrha može da se ostvari smanjenje buke od 7% ali istovremeno i smanjenje snage turbine za 3%. Ove kompjuterske analize aeroakustike (CAA) koristile su tzv. tehniku *Detached Eddy Simulations* (DES) za rješavanje strujnog polja i tzv. Fowcs-Williams- Hawkings jednačine i zahtijevaju značajne kompjuterske resurse. U radu **Deshmukh-a** i koautora (2018) implementirana je tzv. proširena anularna domen metodologija, koja u analizu uključuje region oko vrha lopatice, da bi se uradila parametarska analiza mješovitih krilaca za poboljšanje aerodinamičkih i aeroakustičkih performansi.

Ova metodologija pruža način da se značajno smanje računski troškovi (do 75%) i rezultira smanjenjem buke od oko 25% na srednjim i visokim frekvencijama, zajedno sa poboljšanim izlaznim momentom. Takve jeftine CAA metodologije mogu otvoriti domen opsežnoj optimizaciji dizajna oblika vrhova za smanjenje buke i poboljšanje snage.

Pregled različitih aerodinamičkih mehanizama izvora buke i tehnika za smanjenje buke u vjetroturbinama pružio je uvid u osnovnu prirodu aeroakustike vjetroturbina. Zaostali šum i buka usljed turbulencije su dominantni u oblasti niske frekvencije. Oblik vrha kontroliše snagu i dužinu razdvajanja vrtloga vrha što utiče na buku vrha. Iz prethodnih istraživanja je poznato da većina buke koja se generiše sa zadnjim rubom dolazi od izlaznog dijela lopatica turbine gdje je brzina strujanja veća. Buka sa tupih dijelova ruba, i ona koja je generisana graničnim slojem je manje značajna i lako se reguliše. Danas je u opticaju više tehnika kojima se opisuje mitigacija

(prostiranje) buke. Metode zarubljivanja zadnjeg ruba lopatice za smanjenje buke već se koriste na nekim turbinama, ali neke efektnije metode su neophodne u budućem periodu. Ivice u obliku četkica i tzv. porozni zadnji rubovi lopatica su potencijalne tehnologije koje mogu obezbijediti dodatno smanjenje buke koja se generiše radom turbine. Dosta radova je do sada urađeno na polju prepoznavanja buke koja je posledica dolaznog strujanja i turbulencije. Korišćenje rješenje iz prirode sa živih organizama je jedan od načina koji su dosta pomogli u rješavanju problema smanjenja generisanja buke koja je posledica strujanja i turbulencije koja je njime izazvana. Pokazalo se da izreckanost vodećih ivica omogućava značajno smanjenje buke. Smanjenje šuma sa vrha može se postići optimizacijom oblika vrha za smanjenu snagu vrtloga i manju interakciju vrtloga sa ivicama vrhova. Računarska aero-akustika može pomoci u bržoj optimizaciji oblika lopatice za smanjenje buke uvođenjem manje računski skupih numeričkih tehnika. Većina ovih tehnologija zahteva dalju eksperimentalnu validaciju i opsežne terenske testove.

Cilj istraživanja

Cilj ove doktorske disertacije je istraživanje fenomena generisanja niskofrekventne buke koja nastaje usljed strujanja vazduha, tokom rada vjetrogeneratora. Generalno istraživanje se može podijeliti u dva pravca.

Kao prvo potrebno je fundamentalno poznavanje fenomena generisanja turbulencije usljed strujanja vazduha oko profila lopatica vjetroturbina, koji direktno zavise od različitih režima rada turbine sa manjim ili većim brzinama vjetra. Generisana turbulencija je osnova za formiranje niskofrekventne buke koja ima uticaj na životnu sredinu. U tom smislu kao jedan od ciljeva rada je definisanje i razvijenje matematičkog modela i kompjuterskog programa, sa kojim će se analizirati različiti profili vjetrogereneratora, kako sa pitanja uticaja niskofrekventne buke na životnu sredinu tako i sa pitanja efikasnosti rada vjetroturbine.

Kao drugo, potrebno je tokom rada istražiti i kako različiti profili lopatica utiču na efikasnost rada vjetrogeneratora, odnosno na stepen konverzije kinetičke energije vjetra u mehaničku energiju vratila turbine koja se koristi za proizvodnju električne energije.

S obzirom na to da će u ovom radu kandidatu biti dostupni eksperimentalni podaci sa realnih vjetroturbina u Crnoj Gori i iz Sjedinjenih Američkih Država (SAD), razvijeni modeli će biti testirani za realne uslove koji vladaju na ovim objektima, kako bi se u istraživanjima dao doprinos zajednicama u kojima će se istraživanja obavljati.

Materijali, metode i plan istraživanja

Osnovni numerički alat koji će biti korišćen u istraživanju biće softwerski paket ANSYS Fluent, koji je nabavljen u Laboratoriji za energetiku Mašinskog fakulteta. U mnogim naučnim poljima Fluent se već koristi kao tzv. benchmark standard, što znači da se rezultati koji se sa njime dobijaju mogu koristi kao osnova za upoređivanje za modele koji će se razvijati, ili koji će biti testirani. Laboratorijski dio istraživanja biće organizovan u: (i) Laboratoriji SAFL Univerziteta u Minnesoti, USA gdje su predviđena mjerenja na pravoj vjetroturbini snage 2.5 MW, (ii) Laboratoriji za energetiku Mašinskog fakulteta gdje će se na postojećem tunelu za ispitivanje vjetrogeneratora izvršiti simulacije na modelu vjetrogeneratora takođe u cilju verifikacije i validacije rezultata numeričkog modela.

Pravi put za razmijevanje ovog fenomena je:

1. detaljno fundamentalno modeliranje vjetroturbina primjenom parcijalnih diferecijalnih jednačina koje opisuju strujanje vazduha kod vjetroturbina,
2. eksperimentalna mjerenja turbulencije u laboratorijskim i realnim uslovima rada turbine radi verfikacije i validacije rezultata dobijenih numeričkim simulacijama, modeliranje fenomena generisanja niskofrekventne buke, na osnovu razvijenog turbulentnog polja i verifikacija i validacija modela za predviđanje buke za potrebe daljeg korišćenja u praksi u cilju sagledavanja uticaja ovih uređaja na životnu sredinu.

U radu će biti korištene analitičke, numeričke i eksperimentalne metode.

Očekivani naučni doprinos

Očeivani naučni doprinosi:

1. Razvijen matematički i numerički model za proračun aerodinamičke buke za vjetrogeneratore,
2. Testiranje dobijenog modela sa realnim mjerenjima na vjetrogeneratorima za komercijalnu upotrebu,
3. Testiranje dobijenog modela u laboratorijskim uslovima na umanjenom modelu,
4. Publikovanje najmanje 3 rada u časopisima sa SCI liste tokom i nakon izrade rada.
5. Dugoročno razvijanje procedura i pravila za ispitivanje uticaja vjetrogeneratora na životnu sredinu.

Popis literature

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SAGLASNOST PREDLOŽENOG/IH MENTORA I DOKTORANTA SA PRIJAVOM		
Odgovorno potvrđujem da sam saglasan sa temom koja se prijavljuje.		
Mentor	Igor Vušanović	
Ko-mentor	Miki Hondžo	
Doktorant	Vidosava Vilotijević	

IZJAVA

Odgovorno izjavljujem da doktorsku disertaciju sa istom temom nisam prijavio/la ni na jednom drugom Univerzitetu.

U Podgorici,

27.09.2019.

Vidosava Vilotijević

MP

OSOBNE INFORMACIJE Vidosava Vilotijević

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Pol Ženski| Datum rođenja 12/11/1993 | Državljanstvo Cme Gore

RADNO ISKUSTVO

2017-2018 **Saradnik u nastavi**
Univerzitet Cme Gore, Mašinski fakultet Podgorica (http://www.ucg.ac.me/mf)

OBRAZOVANJE I OSPOSOBLJAVANJE

Zamijenite razinom NKO-a ako je primjenjivo

2012-2015 **BsC mašinstva**
2015-2016 **Spec.sci mašinstva**
2016-2018 **Magistar mašinstva**

LIČNE VJEŠTINE

Matemji jezik Srpski jezik

Ostali jezici	RAZUMIJEVANJE		GOVOR		PISANJE
	Slušanje	Čitanje	Govorna interakcija	Govorna produkcija	
Engleski jezik	B2	B2	B2	B2	B2
Ruski jezik	B2	B2	B2	B2	B2

Računarske vještine
- Microsoft Office™
- Matlab
- Fortran
- Autocad
- ANSYS- Fluent

Vozačka dozvola
- B kategorija

DODATNE INFORMACIJE

Konferencije

- **Vilotijević** V., Karadžić U., Božić. I., Ilić. J. (2019). Design discharge determination for SHPPs with capacity below 1 MW. 14th International Conference on Accomplishments in Mechanical and Industrial Engineering, Banja Luka, Republic of Srpska, BiH, 24-25 May.
- Vuković D., **Vilotijević** V., Karadžić U. (2017). Hydraulic transients calculations on Komamica HPP. 3th International Conference on Accomplishments in Mechanical and Industrial Engineering, Banja Luka, Republic of Srpska, BiH, 26-27 May.
- Vilotijević V., Karadžić U., Vušanović I. (2018). Determination of the degree installed flow in small hydropower plants. International Conference "Energy and Ecology Industry EEI2018", Beograd, Serbia, 10-13 Septembar.

UNIVERZITET CRNE GORE
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MAŠINSTVO
Broj dosijea: **1/2018**

Na osnovu člana 165 stava 1 Zakona o opštem upravnom postupku ("Službeni list RCG", broj 60/03.), člana 115 stava 2 Zakona o visokom obrazovanju ("Službeni list CG", broj 44/14.) i službene evidencije, a po zahtjevu studenta Vilotijević Milorad Vidosava, izdaje se

UVJERENJE O POLOŽENIM ISPITIMA

Student **Vilotijević Milorad Vidosava**, rođena **12-11-1993** godine u mjestu **Šavnik**, opština **Šavnik**, Republika **Crna Gora**, upisana je studijske **2018/2019** godine, u **I** godinu studija, kao student koji se **samofinansira** na **doktorske akademske studije**, studijski program **MAŠINSTVO**, koji realizuje **MAŠINSKI FAKULTET** - Podgorica Univerziteta Crne Gore u trajanju od **3** (**tri**) godine sa obimom **180** ECTS kredita.

Student je položio ispite iz sljedećih predmeta:

Redni broj	Semestar	Naziv predmeta	Ocjena	Uspjeh	Broj ECTS kredita
1.	1	AKVIZICIJA I OBRADA EKSPERIMENTALNIH PODATAKA	"A"	(odličan)	8.00
2.	1	CVFEM NUMERIČKE METODE ZA FLUIDE I ČVRSTA TIJELA	"A"	(odličan)	8.00
3.	1	METODE NAUČNO-ISTRAŽIVAČKOG RADA	"A"	(odličan)	6.00
4.	2	ENERGETSKA I EKSERGETSKA ANALIZA	"A"	(odličan)	8.00
5.	2	ODABRANA POGLAVLJA IZ TURBINA	"A"	(odličan)	8.00

Zaključno sa rednim brojem **5**.

Ostvareni uspjeh u toku dosadašnjih studija je:
- srednja ocjena položenih ispita **"A" (10.00)**
- ukupan broj osvojenih ECTS kredita **38.00** ili **63.33%**
- indeks uspjeha **6.33**.

Uvjerenje se izdaje na osnovu službene evidencije, a u svrhu ostvarivanja prava na: (dječji dodatak, porodičnu penziju, invalidski dodatak, zdravstvenu legitimaciju, povlašćenu vožnju za gradski saobraćaj, studentski dom, studentski kredit, stipendiju, regulisanje vojne obaveze i slično).

Broj: 2173
Podgorica, 27.09.2019 godine

M. P.

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MAŠINSKI FAKULTET
KOMISIJA ZA DOKTORSKE STUDIJE

OVDJE

PREDMET: Predlog komisije za odbranu mpolaznih istraživanja za izradu doktorske disertacije

Odlukom Senata Univerziteta Crne Gore br. 03-942/3 od 21.03.2019. godine imenovan sam za mentora na izradi doktorske disertacije kandidatu mr Vidosavi Vilotijević.

Pošto su se stekli uslovi za odbranu polaznih istraživanja, i na osnovu razgovora sa kandidatom **mr Vidosavom Vilotijević**, predlažem **Komisiju za odbranu polaznih istraživanja** za izradu doktorske disertacije

„Numeričko modeliranje i analiza podataka aerodinamičke buke generisane vjetroturbinama"

u sledećem sastavu:

1. **Prof. dr Uroš Karadžić, predsjednik,**
2. **Prof. dr Igor Vušanović, mentor,**
3. **Doc. dr Milan Šekularac, član.**

U Podgorici, 27.09.2019

MENTOR
Prof. dr Igor Vušanović

Na osnovu člana 32 stav 1 tačka 14 Statuta Univerziteta Crne Gore, u vezi sa članom 29 Pravila doktorskih studija, Senat Univerziteta Crne Gore, u postupku razmatranja prijedloga Vijeća Mašinskog fakulteta i na prijedlog Centra za doktorske studije, na sjednici održanoj 21.03.2019. godine, donio je sljedeću

ODLUKU

I

Dr Igor Vušanović, redovni profesor Mašinskog fakulteta Univerziteta Crne Gore **imenuje se za mentora** pri izradi doktorske disertacije **kandidatkinje mr Vidosave Vilotijević.**

II

Dr Miki Hondže, UMN Minesota, USA imenuje se **za komentora** pri izradi doktorske disertacije **kandidatkinje mr Vidosave Vilotijević.**

II

Odluka stupa na snagu danom donošenja.

Broj: 03-9423
Podgorica, 21.03.2019. godine

UNIVERZITET CRNE GORE 1974

PREDSJEDNIK SENATA

Prof. dr Danilo Nikolić, rektor

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Na osnovu člana 72 stav 2 Zakona o visokom obrazovanju (Službeni list Crne Gore br. 44/14) i člana 18 stav 1 tačka 3 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 29. januara 2015. godine, donio je

O D L U K U
O IZBORU U ZVANJE

Dr UROŠ KARADŽIĆ bira se u akademsko zvanje **vanredni profesor Univerziteta Crne Gore** za predmete: Pumpe, ventilatori i turbokompresori, Turbine, Projektovanje energetskih postrojenja i Hidroelektrane, na Mašinskom fakultetu., na period od 5 godina.

REKTOR

Prof. Radmila Vojvodić

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Датум, 27.06.20 13 г.

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Date, _____

Na osnovu člana 75 stav 2 Zakona o visokom obrazovanju (Sl.list RCG, br. 60/03 i Sl.list CG, br. 45/10 i 47/11) i člana 18 stav 1 tačka 3 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 27.06.2013. godine, donio je

O D L U K U
O IZBORU U ZVANJE

Dr IGOR VUŠANOVIĆ bira se u akademsko zvanje **redovni profesor** Univerziteta Crne Gore za predmete: Termodinamika, Energetika u saobraćaju, Kompjuterske metode u energetici i Mjerenje i simulacija energetskih procesa, na Mašinskom fakultetu.

REKTOR

Prof.dr Predrag Miranović

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Datum / Date 25. 12. 2018

Na osnovu člana 72 stav 2 Zakona o visokom obrazovanju („Službeni list Crne Gore" br. 44/14, 47/15,40/16,42/17,71/17 i 55/18) i člana 32 stav 1 tačka 9 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 25.12. 2018.godine, donio je

O D L U K U
O IZBORU U ZVANJE

Dr MILAN ŠEKULARAC bira se u akademsko zvanje **docent Univerziteta Crne Gore za oblast Termotehnika na Mašinskom fakultetu Univerziteta Crne Gore**, na period od pet godina.

UNIVERZITET CRNE GORE 1974 UCG

SENAT UNIVERZITETA CRNE GORE
PREDSJEDNIK

Prof.dr Danilo Nikolić, rektor

Crna Gora
UNIVERZITET CRNE GORE
MAŠINSKI FAKULTET

Primljeno: 09. 01. 2019			
Org. jed.	Broj	Prilog	Vrijednost
	02		

CURRICULUM VITAE

1.	**Family Name**	**Karadžić**
	First Name	**Uroš**
	Maiden Name (if any)	

2.	**Date of Birth:**	**08.05.1974.**
3.	**Marital Status:**	**Married, two children**
4.	**Sex:**	**Male**

5.	**Address:**	**Studentska street, Lamela 2, V-40, 81000 Podgorica, Montenegro**
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6.	**Education (College and/or University or equivalent)**			
	Name	*Years Attended*	*Degree Obtained*	*Major Subject of Study*
	University of Montenegro, Faculty of Mechanical Engineering	**2005 – 2008**	**PhD ME**	**Research on Fluid Transients Phenomena on Perućica HPP, Montenegro**
	University of Montenegro, Faculty of Mechanical Engineering	**2000 – 2004**	**MSc ME**	**Fluid Transients, Water Hammer, Unsteady Friction**
	University of Montenegro, Faculty of Mechanical Engineering	**1992 - 1999**	**BSc ME**	**Air Conditioning**

7.	**Additional Education Information**	
	Scholarships or Academic Distinctions:	1. Scholarship from The Ministry of the Republic of Slovenia for Education, Science and Sport for two months (January 2005 – February 2005)
	Publications:	***1. Books*** 1. Vukoslavčević P., **Karadžić U.** (2010). Fundamentals of Fluid Mechanics. *Textbook, University of Montenegro, Faculty of Mechanical Engineering,* Podgorica, Montenegro. (in Serbian) ***2. Disertations*** 1. **Karadžić U.** (2008). Modelling of complex boundary conditions for transients in hydraulic systems. *PhD thesis, Faculty of Mechanical Engineering, University of Montenegro,* Podgorica, Montenegro. (in Serbian) 2. **Karadžić, U.** (2004). Analysis fluid transients phenomena in hydraulic systems. *Master thesis, Faculty of Mechanical Engineering, University of Montenegro,* Podgorica, Montenegro. (in Serbian) ***3. Monographs*** *3.1. Part of scientific monograph* 1. **Karadžić, U.** (2005). Fluid transients and unsteady friction in hydraulic pipeline systems. *Monograph 35 years of mechanical engineering studies in Montenegro, University of Montenegro, Faculty of Mechanical Engineering,* Podgorica, Montenegro. (in Serbian) ***4. Journal papers*** *4.1. Journal with impact factor* 1. **Karadžić U.**, Bergant A., Starinac D., Božović B. (2019). Water hammer investigation of the shut-down of a high-head hydropower plant at very high Reynolds number flows. *Strojniški Vestnik-Journal of Mechanical Engineering*, 65(7-8), 430-440.

DOI:10.5545/sv-jme.2019.6092

2. **Karadžić U.**, Janković M., Strunjaš F., Bergant A. (2018). Water hammer and column separation induced by simultaneous and delayed closure of two valves. *Strojniški Vestnik-Journal of Mechanical Engineering*, 64(9), 525-535. DOI:10.5545/sv-jme.2017.4993

3. Bergant A., Tijsseling A. Kim Y., **Karadžić U.**, Zhou L., Lambert M.F., Simpson A.R. (2018). Unsteady pressures influenced by trapped air pockets in water-filled pipelines. *Strojniški Vestnik-Journal of Mechanical Engineering*, 64(9), 501-512. DOI:10.5545/sv-jme.2018.5238

4. Vujadinović R., Tombarević E., **Karadžić U.** (2017). Valorization of potentials of wind energy in Montenegro. *Thermal Science*, 21(5), 1893-1903. doi:10.2298/TSCI161201016V

5. **Karadžić U.**, Bulatović V., Bergant A. (2014). Valve induced water hammer and column separation in pipeline apparatus. *Strojniški Vestnik-Journal of Mechanical Engineering*, 60(11), 742-754.

6. **Karadžić U.**, Kovijanić V., Vujadinović R. (2014). Possibility for hydro energetic utilization of relatively researched water streams. *Water Resources*, 41(6), 774-781.

7. **Karadžić U.**, Bergant A., Vukoslavčević P. (2009). A novel Pelton turbine model for water hammer analysis. *Strojniški Vestnik-Journal of Mechanical Engineering*, 55(6), 369-380.

8. Bergant, A., **Karadžić, U.**, Vitkovsky, J., Vušanović, I., and Simpson, A.R. (2005). A Discrete Gas-Cavity Model that Considers the Frictional Effects of Unsteady Pipe Flow. *Strojniški Vestnik-Journal of Mechanical Engineering,* 51(11), 692-710.

4.2. Journal without impact factor

1. **Karadžić U.**, Bergant A.(2018). Experimental investigations of pipeline filling and emptying in a small scale apparatus. *JET Journal of Energy Technology,* Vol.11, Issue 2, pp 11-22, ISSN 1855-5748.
2. Bergant A., Mazij J., **Karadžić U.** (2018). Design of water hammer control strategies in hydropower

plants. *Applied engineering letters*, Vol.3, No.1, pp 27-33, e-ISSN 2466-4847, https://doi.org/10.18485/aletters.2018.3.1.5

3. Kuljić S., **Karadžić U.** (2017). Hydraulic analysis of water supply system in town Nevesinje. *Machine design,* Vol.9, No.4, pp 155-160, ISSN 1821-1259, DOI: 10.24867/MD.9.2017.4.155-160.
4. Bergant A., **Karadžić U.**, Tijsseling A. (2017). Developments in multiple-valve pipeline column separation control. *IOP Conf. Series:* Journal of Physics: Conf. Series, 813, doi:10.1088/1742-6596/813/1/012015.
5. Bergant A., **Karadžić U.**, Tijsseling A. (2016). Dynamic water behavior due to one trapped air pocket in a laboratory pipeline apparatus. *IOP Conf. Series: Earth and Environmental Science*, Vol.49, doi:10.1088/1755-1315/49/5/052007.
6. Vujadinović R., **Karadžić U.** (2016). Techno-economic analysis of the project Možura wind park with installed capacity of 46 MW, *Energetika-Ekonomija-Ekologija,* ISSN 0354-8651, god. XVIII, (in Montenegrin)
7. Vujadinović R., **Karadžić U.** (2015). Education of local governments as a way towards sustainable development of the countries of the Western Balkans – case study of Montenegro. *EJSDR European Journal of Sustainable Development Research,* Vol.1, Issue 1, pp 63-71.
8. Bergant A., **Karadžić U.** (2015). Numerical and experimental investigations of transient cavitating pipe flow. *JET Journal of Energy Technology,* Vol.8, Issue 2, pp 31-42.
9. **Karadžić U.**, Vujadinović R. (2013). Hydro potential of Montenegro – status, perspective of utilization and legislative framework. *Energetika-Ekonomija-Ekologija,* ISSN 0354-8651, god. XV, (in Serbian)
10. **Karadžić U.**, Bergant A., Vukoslavčević P., Sijamhodžić E., Fabijan D. (2011). Water hammer caused by shut-off valves in hydropower plants. *JET Journal of Energy Technology,* Vol.4, Issue 2, pp 47-54.
11. Vujadinović R., Bošković Lj., **Karadžić U.** (2011). Renewable energy sources as alternative to diesel generators in telecommunications companies. *Energetika-Ekonomija-Ekologija,* ISSN 0354-8651, god. XIII, br.2, pp 178-184. (in Serbian)
12. **Karadžić U.**, Bergant A., Vukoslavčević P. (2010). Water hammer caused by closure of

turbine safety spherical valves. *IOP Conf. Series: Earth and Environmental Science*, Vol.12, pp 1-8.

5. Publications on conferences, symposiums and seminars

5.1. International conferences

1. Brđanin R., Ilić J. **Karadžić U.**, Bergant A. (2019). Experimental water hammer setup at University of Montenegro – description and possibilities. *DEMI 2019 - 14th International Conference on Accomplishments in Mechanical and Industrial Engineering,* Banja Luka, Republic of Srpska, BiH, 24-25 May, pp 195-200.

2. Vilotijević V., **Karadžić U.**, Božić I., Ilić J. (2019). Design discharge determination for SHPPs with capacity below 1 MW. *DEMI 2019 - 14th International Conference on Accomplishments in Mechanical and Industrial Engineering,* Banja Luka, Republic of Srpska, BiH, 24-25 May, pp 297-302.

3. Ilić J., Božić I., **Karadžić U.**, Brđanin R. (2019). Comparative analysis of the hydro power plant transient processes for various surge tank types and improved guide vanes closing law. *DEMI 2019 - 14th International Conference on Accomplishments in Mechanical and Industrial Engineering,* Banja Luka, Republic of Srpska, BiH, 24-25 May, pp 215-222.

4. **Karadžić U.**, Iliev V., Bergant A. (2018). Fluid structure interaction effects in small-scale pipeline apparatus. *International Conference Energy and Ecology Industry*. Belgrade, Serbia, 10-13 October.

5. Vilotijević V., **Karadžić U.**, Vušanović I. (2018). Determination of the degree of installed flow in small hydropower plants. *International Conference Energy and Ecology Industry*. Belgrade, Serbia, 10-13 October.

6. **Karadžić U.**, Janković M., Strunjaš F. (2017). Influence of the initial conditions on water hammer in reservoir-pipeline-valve system. *DEMI 2017 - 13th International Conference on Accomplishments in*

Mechanical and Industrial Engineering, Banja Luka, Republic of Srpska, BiH, 26-27 May.

7. Vuković D., Vilotijević V., **Karadžić U.** (2017). Hydraulic transients calculations on Komarnica HPP. *DEMI 2017 - 13th International Conference on Accomplishments in Mechanical and Industrial Engineering,* Banja Luka, Republic of Srpska, BiH, 26-27 May.

8. Bergant A., **Karadžić U.** (2015). Developments in valve-induced water hammer experimentation in a small-scale pipeline apparatus. *12th International Conference on Pressure Surges, BHR Group,* Dublin, Ireland, 18-20 November.

9. **Karadžić U.**, Bergant A., Mavrič R., Strunjaš F., Buckstein S. (2015). Developments in pipeline filling and emptying experimentation in a laboratory pipeline apparatus. *6th IAHR International Meeting of the Workgroup on Cavitation and Dynamic Problems in Hydraulic Machinery and Systems,* Ljubljana, Slovenia, September 09-11.

10. Bulatović V., **Karadžić U.**, Bergant A. (2013). Investigation of water hammer and column separation in unsteady friction dominated pipeline apparatus. *5th IAHR International Workshop on Cavitation and Dynamic Problems in Hydraulic Machinery, EPFL,* Lausanne, Switzerland, September 08-11.

11. Bergant A., Mazij, J., **Karadžić U.**, Gale, J. (2013). Assessment and mitigation of water hammer effects in hydropower plants on environment. *ENRE* 3rd *International Conference Energy Technology*, Velenje, Slovenia, 20-21 June.

12. Prvulović S., **Karadžić U.** (2012). Application of analytical hierarchy process in the selection of optimal technological solutions. II *International Conference Industrial Engineering and Environmental Protection IIZS*, University of Novi Sad, Technical faculty of Mihajlo Pupin, Zrenjanin, Serbia, 31st October.

13. Vujadinović R., **Karadžić U.** (2012). Use of aluminium in the production of cars. II *International Conference Industrial Engineering and Environmental Protection IIZS*, University of Novi Sad, Technical faculty of Mihajlo Pupin, Zrenjanin, Serbia, 31st

October.

14. Bergant A., Anderson A., Nicolet C, **Karadžić U.** Mazij J. (2012). Issues related to fluid transients in refurbished and upgraded hydropower schemes. *11th International Conference on Pressure Surges, BHR Group,* Lisbon, Portugal, 24-26 October.

15. **Karadžić U.** Bergant A. (2012). Pipeline apparatus for investigation of water hammer and column separation phenomena at the University of Montenegro. 2nd *IAHR Europe Congress*, TUM, Munich, Germany, 27-29 June.

16. Kovijanić V., **Karadžić U.** Vujadinović R. (2012). Assessment of possibility for hydro energetic utilization of small water streams. *Hidroenergia 2012*, Wroclaw, Poland, 23-26 May.

17. **Karadžić U.**, Bergant A., Vukoslavčević P. (2011). Influence of unsteady friction on hydraulic transients in a high-head hydropower plant. *4th IAHR International Meeting of the Work Group on Cavitation and Dynamic Problems in Hydraulic Machinery and Systems, Faculty of Mechanical Engineering, University of Belgrade,* Belgrade, Serbia, October 26-28, pp 313-320.

18. **Karadžić U.**, Bergant A., Vukoslavčević P. (2009). Water hammer effects during Pelton turbine load rejection. *3rd IAHR International Meeting of the Work Group on Cavitation and Dynamic Problems in Hydraulic Machinery and Systems, Brno University of Technology, Brno, Czech Republic October* 14-16, pp 443-452.

19. **Karadžić U.**, Bergant A., Vukoslavčević P. (2008). Parameters affecting water hammer in a high-head hydropower plant with Pelton turbines. *10th International Conference on Pressure Surges, BHR Group,* Edinburgh UK, 14-16 May, pp 351-364.

5.2. National and local conferences

1. Brđanin R., **Karadžić U.**, Ilić J. Božić I. (2019). Comparison of dynamic pressure transducers on experimental water hammer setup. 7th *Regional Conference Industrial Energy and Environmental*

Protection in South-Eastern Europe, IEEP 2019. Zlatibor, Serbia, 19-22 June.

2. **Karadžić U.** (2019). Hydraulic transient calculation in case of Vrelo SHPP. *VI Symposium CG KO CIGRE,* Bečići, Montenegro, 14-17 May. (in Montenegrin)

3. Radonjić N., Perišić V., **Karadžić U.**, Vujadinović R. (2017). The analysis of investments in renewable energy. *V Symposium CG KO CIGRE,* Bečići, Montenegro, 09-12 May. (in Montenegrin)

4. Janković M., Strunjaš F., Bergant A., **Karadžić U.** (2017). Hydraulic transients due to gradual valve closure. *V Symposium CG KO CIGRE,* Bečići, Montenegro, 09-12 May. (in Montenegrin)

5. Rakočević S., Mićanović M., Bošković Lj., **Karadžić U.**, Vujadinović R. (2017). Criteria for the selection of the installed flow of small hydropower plants. *V Symposium CG KO CIGRE,* Bečići, Montenegro, 09-12 May. (in Montenegrin)

6. Ćipranić I., Sekulić G., Bošković Lj., **Karadžić U.** (2016). Design principles of small hydropower plants and their integration into the environment. 6th International conference GNP, Žabljak, Montenegro, 07-11 March. (in Montenegrin)

7. Mazij, J., Bergant, A., **Karadžić, U.** (2015). Critical parameters of hydraulic transient regimes in hydropower plants with complex water conveyance systems. *IV Symposium CG KO CIGRE,* Herceg Novi, Montenegro, 11-14 May.

8. Bošković, Lj., **Karadžić, U.**, Drašković, I., Mičeta, G., Stanojević, M., Vujadinović, R. (2015). Experience in the process of development of idea, design and realization of SHPP Vrelo. *IV Symposium CG KO CIGRE,* Herceg Novi, Montenegro, 11-14 May, (in Serbian).

9. Bulatović, V., **Karadžić, U.** (2013). Experimental apparatus for investigation of hydraulic transients. *8th International meeting „Renewable Energy Sources and Energy Efficiency"*, The Montenegrin Academy of Sciences and Arts, Podgorica, Montenegro, 7 Oktober, (in Serbian).

10. Giljen Z., **Karadžić, U.** (2013). Analysis of

hydraulic transients on „Piva“ HPP for the case of emergency shut-down of the Francis turbine unit. *III Symposium CG KO CIGRE,* Budva, Montenegro, 13-16 May, (in Serbian).

11. **Karadžić U.**, Bošković Lj., Vujadinović R. (2011). Hydroenergetic utilization of small water streams. *7th International meeting „Renewable Energy Sources and Energy Efficiency“*,The Montenegrin Academy of Sciences and Arts, Budva, Montenegro, 10 - 11 Oktober, (in Serbian).

12. **Karadžić U.**, Bergant A., Vukoslavčević P. (2011). Numerical modeling of extreme hydraulic transients on „Perućica“ HPP. *II Symposium CG KO CIGRE,Budva,* Montenegro, 16-19 May, (in Serbian).

13. Giljen Z., **Karadžić, U.** (2011). Analysis of hydraulic transients on „Piva“ HPP. *II Symposium CG KO CIGRE,* Budva, Montenegro, 16-19 May, (in Serbian).

14. Vujadinović R., Bošković Lj., **Karadžić U.** (2011). Application of renewable energy sources in the telecomunication sector. *II International Symposium „Engineering, Ecology And Materials in Process Industry*, Jahorina, Bosnia and Hercegovina, 09-11 March (in Serbian).

15. **Karadžić U.**, Bergant A., Vukoslavčević P. (2009). Hydraulic transients on „Perućica“ HPP with their influence on EES. *I Symposium CG KO CIGRE, Budva,* Crna Gora, 12-16 October, (in Serbian).

16. Jokić S., Nikolić Z., **Karadžić U.** (2009). Start-up and stop of renewed turbine units during the first phase of „Perućica“ HPP modernisation. *I Symposium CG KO CIGRE,Budva,* Crna Gora, 12-16 October, (in Serbian).

17. **Karadžić U.**, Bergant A., Vukoslavčević P. (2009). Hydraulic transients in penstocks after load rejection of Pelton turbine unit. *14th Symposium on Thermal Science and Engineering of Serbia*, Sokobanja, Serbia, 13-16 October (in Serbian).

18. **Karadžić U.**, Vukoslavčević, P (2009). Water turbines for small hydro power plants. *Renewable Energy and Future of its Application, The Montenegrin Academy of Sciences and Arts,* Budva,

Montenegro, 07-09 October, (in Serbian).

19. Vukoslavčević P., **Karadžić U.** (2007). Heat energy transfer in supercritical conditions. *Renewable Energy and Future of its Application, The Montenegrin Academy of Sciences and Arts*, Budva, Montenegro, (in Serbian).

20. **Karadžić U.**, Bergant A., Vukoslavčević P. (2007). Influence of unsteady friction on hydraulic transients in case of industrial hydropower system. *13th Symposium on Thermal Science and Engineering of Serbia*, Sokobanja, Serbia, 16-19 October, (in Serbian).

21. **Karadžić U.**, Bergant A., Vušanović I. (2006). Validation of convolution unsteady friction model for transients in hydraulic pipeline systems, *30. HIPNEF with international contribution,* Vrnjačka Banja, Serbia, 24-26 May, (in Serbian).

22. **Karadžić, U.**, Bergant, A., Vušanović, I. (2005). Influence of unsteady friction on transients in hydraulic pipeline systems. *12th Symposium on Thermal Science and Engineering of Serbia*, Sokobanja, Serbia. 22-25 October, (in Serbian).

6. Invited and plenary lectures

6.1. With international contribution

1. Bergant, A., **Karadžić, U.**, Vitkovsky, J., Vušanović, I., and Simpson, A.R. (2008). Discrete Gas Cavity Model with Convolution Based Unsteady Friction Model. *Meeting of the Advisory Group on Unsteady Friction*, Edinburgh, United Kingdom, 16 May 2008.

6.2. Invited lectures

1. **Karadžić, U.** (2016). Hydraulic transients investigations at University of Montenegro, *Hohai University, College of Mechanics and Materials,* Nanjing, China, 08.12.2016.

2. **Karadžić, U.** (2013). Developments in water hammer and column separation experimentation in a newly built apparatus at the University of Montenegro. *Litostroj Power doo, Ljubljana,* Slovenia, 15.12.2013.

	3. **Karadžić, U.** (2010). Hydraulic transients investigations on Perućica HPP. *Litostroj Power doo, Ljubljana,* Slovenia, 15.12.2010.
Mentoring:	***1. PhD Thesis***
	2. Master Thesis
	1. Vilotijević, V. (2018). Determination of the installed flow in small hydro power plants. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 2. Janković, M. (2016). The influence of closing and opening of the valve at the end of pipeline on hydraulic transients. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 3. Strunjaš, F. (2016). Hydraulic transients as result of simultaneous closure of the valves at the beginning and the end of pipeline. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 4. Bulatović, V. (2014). Experimental and numerical investigations of water hammer effects. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 5. Kuljić, S. (2012). Numerical calculation of water supply system Nevesinje. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 6. Giljen, Z. (2011). Hydraulic transients modelling on Piva HPP. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 7. Jokić, S. (2011). Development of the experimental installation for water hammer investigation. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 8. Nikolić, Z. (2011). Verification of water hammer numerical model by comparison with results of measurement obtained on the experimental facility. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian)

8.	Knowledge of Languages								
		Read		*Write*		*Speak*		*Understand*	
		Easily	*Not Easily*	*Easily*	*Not Easily*	*Easily*	*Not Easily*	*Easily*	*Not easily*
	English	x		x		x		x	
	Others:Russian	x			x		x	x	

9.	Computer Literacy	
	Basic:	**Microsoft Office, Internet and Email, Corel Draw, Auto Cad**
	Programming:	**Fortran, Visual Basic**
	Hydraulic:	**Wanda 3.0 (Deltares), AFT Fathom 6.0 (Applied Flow Technology), AFT Impulse 4.0 (Applied Flow Technology)**

10.	Work Experience
	January 2015 by now **Associate Professor at Faculty of Mechanical Engineering on the following subjects: Pumps and Fans, Hydraulic turbines, Design of Power Plants, Hydropower Plants** **October 2009 – January 2015** **Assistant Professor at Faculty of Mechanical Engineering on the following subjects: Pumps and Fans, Hydraulic turbines, Design of Power Plants, Hydropower Plants** **May 2000 – October 2009** **Assistant at Faculty of Mechanical Engineering on the following subjects: Fluid Mechanics, Heat and Mass Transfer, Hydraulic turbines, Pumps and Fans**

11.	References

	1. Dr Anton Bergant, Litostroj Power d.o.o., Ljubljana, Slovenia, anton.bergant@litostrojpower.eu 2. Dr Petar Vukoslavčević, Professor, Faculty of Mechanical Engineering, University of Montenegro, Podgorica, Montenegro, petarvuk@ucg.ac.me 3. Dr Igor Vušanović, Professor, Faculty of Mechanical Engineering, University of Montenegro, Podgorica, Montenegro, igorvus@ucg.ac.me 4.

12.	International projects

2006 – 2008
"Measurements of the flow fields characteristics in high pressure conditions". Scientific and technological cooperation between Governments of Republic Slovenia and Montenegro. (member of working team)

2009-2010
Conecting Energy NCPs: A proactive network of National Contact Points in the Seventh Framework Programme under the Energy Theme, C-ENERGY financed by European Commission contract number 226548-2. (Energy NCP in Montengro)

2010 – 2011
"Measurements of turbulent flow characteristics in pipes and channels". Scientific and technological cooperation between Governments of Republic Slovenia and Montenegro. (member of working team)

2011-2012
Development of a small hydropower registry for Northern Montenegro, financed by EBRD. (member of working team)

2012-2013
Technical Monitoring and Evaluation Consultant for the Clinic Center in Podgorica", MNE-EE-P107992-CQ-S-09-C.1., financed by World Bank. (member of working team)

2012-2013
"Investigations of water hammer effects in a test facility". Scientific and technological cooperation between Governments of Republic Slovenia and Montenegro. (leader of working team)

2012-2014
"Training courses for public services in sustainable infrastructure development in Western Balkans- SDTRAIN" 530530-TEMPUS-1-2012-1-SE-TEMPUS-JPHES. (member of working team at the University of Montenegro)

2013-2014
"Western Balkans regional energy efficiency programme (REEP), Policy dialogue – Supporting ESCO projects in the public sector, Legal assistance for an ESCO project enabling legal framework, financed by EBRD. (technical expert for Montenegro)

	2014-2015 "Investigations of hydraulic transients during filling and emptying of pipelines". Scientific and technological cooperation between Governments of Republic Slovenia and Montenegro. (leader of working team) 2015 "Western Balkans regional energy efficiency programme (REEP), Scoping study for Street Lighting Modernization Programme using ESCO approach in Montenegro, financed by EBRD. (technical expert for Montenegro) 2016 - 2017 „Investigation of the turbulent swirl flow influence on the energy parameters of the axial fans by using contemporary measurement techniques". Scientific and technological cooperation between Governments of Republic Serbia and Montenegro. (leader of working team) 2016 – 2018 Enhancement of Registry of Small Rivers for Small Hydropower Projects Potential of up to 10 MW in Montenegro, financed by EBRD. (Expert for hydraulic engineering and technical solutions for SHPPs) 2016 – 2019 REady for BUSiness, Integrating and validating practical entrepreneurship skills in engineering and ICT studies – REBUS, 573664-EPP-1-2016-BA-EPPKA2-CBHE-JP, ERASMUS+. (meamber of working team) 2019 – 2020 "Research and development of improved measures for protection of hydropower plants during hydraulic transients in order to increase their reliability and energy efficiency". Scientific and technological cooperation between Governments of Republic Serbia and Montenegro. (leader of working team)

13.	National projects
	2006 – 2008 "Mjerenje karakteristika strujnih polja u uslovima visokog pritiska". Projekat finansiran od strane Ministarstva prosvjete i nauke Crne Gore. (member of working team) 2008 – 2011 "Mjerenje karakteristika turbulentnih strujnih polja u cijevima i kanalima". Projekat finansiran od strane Ministarstva prosvjete i nauke Crne Gore. (member of working team) 2012 – 2014 "Investigations of transients phenomena in hydraulic and aeromechanical systems". Ministry of Science Montenegro. (member of working team)

14.	Professional engagement

1. „Hydraulic transients in Perucica HPP: Water hammer analysis in system under pressure before commisioning tests – load rejection of turbine unit A1", Perućica HPP EPCG, Litostroj EI Slovenija, May 2006, (member of working team).
2. Energy NCP (National Contact Point) in Montenegro in Seventh Framework Programe EU (FP7) from May 2007 till June 2012
3. „Investigations of the stress state in characteristics intersection of penstock C3 in Perućica HPP", September 2007 and January 2008 (member of working team)
4. „Analysis and determination of final as-built condition of the installation of air conditioning and heating on Agency for Telecomunications, Podgorica", March 2009, (member of working team)
5. "Preliminary assessment of possibility for hydro energetic utilization of Bjeluha and Moraca river ", March 2010, (member of working team)
6. „Idea solutions for small hydropower plants (SHPP) on Komaraca river", April 2010, (member of working team)
7. „Hydropotential analysis of Komaraca river", April 2010, (member of working team)
8. "Preliminary assessment of possibility for hydro energetic utilization of Meho water stream ", May 2010, (member of working team)
9. "Preliminary assessment of possibility for hydro energetic utilization of Skrbusa river ", July 2010, (member of working team)
10. „Calculation of the stress state on A2 „Piva" HPP generator shaft in the zone of crack's appearance", September 2010, (responsible designer for calculation of axial hydraulic force)
11. "Preliminary assessment of hydro potential utilization of some rivers from Šavnik municipality", November 2010, (member of working team)
12. "Preliminary assessment of hydro potential utilization of some rivers from Plav municipality", November 2010, (member of working team)
13. "Preliminary assessment of hydro potential utilization of some rivers from Bijelo Polje municipality", November 2010, (member of working team)
14. "Preliminary assessment of hydro potential utilization of some rivers from Kolašin municipality", November 2010, (member of working team)
15. Environmental impact assessment for the SHPP "Grlja", ECG Ltd. 2011
16. „Technical solution for exhaust system from diesel engine", Telenor doo, Podgorica, February 2011, (member of working team)
17. „Program of continuous monitoring of penstock III on Perucica HPP", EPCG, March 2011, (member of working team)
18. "Preliminary assessment for possibility of hydro energetic utilization of river Vrelo", Synergy doo, Podgorica, March 2011, (member of working team)
19. „Idea solution with pre-feasibility study for small hydropower plant (SHPP) on river Vrelo", Synergy doo, Podgorica, April 2011, (leader of working team)
20. "Preliminary assessment for possibility of hydro energetic utilization of river Ljevak", BEI doo, Podgorica, August 2011, (member of working team)

21. Idea project for Jara SHPP, Kronor doo, Podgorica, June 2012, (leader of working team)
22. Environmental impact assessment of the SHPP "Jara", Kronor doo, 2012
23. Idea project for Vrelo SHPP, Synergy doo, Podgorica, October 2012, (leader of working team)
24. Environmental impact assessment of Babino polje SHPP, Kronor doo, 2013
25. Idea project for Rastak SHPP, Kol-energy doo, Kolasin, Montenegro February 2013, (member of working team)
26. Idea project for Babino Polje SHPP, Kronor doo, Podgorica, March 2013, (member of working team)
27. Idea project for Meteh SHPP, Kronor doo, Podgorica, March 2013, (member of working team)
28. Main design for Vrelo SHPP, Synergy doo, Podgorica, May 2013, (leader of working team)
29. "Preliminary assessment for possibility of hydro energetic utilization of river Sjevernica", BMR, Oxon, UK May 2013, (member of working team)
30. „Development of Conceptual design for reconstruction of water supply system and construction of SHPP on Krkori water source in municipality of Andrijevica (Montenegro)" , UNDP – Montenegro, May-June 2013, (member of working team)
31. „Idea solution for small hydropower plant (SHPP) on river Bistrica Majstorovina", Synergy doo, Podgorica, November 2013, (member of working team)
32. „Idea solution for small hydropower plant (SHPP) on river Djuricka with tributaries", Triangle inc, New York, November 2013, (member of working team)
33. „Idea solution for small hydropower plant (SHPP) on river Vrbnica", Hydropol, Prague, November 2013, (member of working team)
34. „Idea solution for small hydropower plant (SHPP) on river Kaludarska", Hydropol, Prague, November 2013, (member of working team)
35. Main design for Jara SHPP, Kronor doo, Podgorica, April 2014, (member of working team)
36. Idea solution for small hydropower plant (SHPP) on river Ljevak, Simes Engineering, Podgorica, April 2014, (member of working team)
37. Main design for Babino Polje SHPP, Kronor doo, Podgorica, May 2014, (member of working team)
38. Idea solution for small hydropower plant (SHPP) on river Leverska, BB Hydro, Podgorica, May 2014, (member of working team)
39. Idea solution for small hydropower plant (SHPP) on river Ljevak, Simes ingeniering Ltd. , 2014, (member of working team)
40. Idea solution for small hydropower plant (SHPP) on river Slatina, BB Hydro, 2014, (member of working team)
41. Idea solution for small hydropower plant (SHPP) on river Bistrica Lipovska, BB Hydro, 2014. (member of working team)

42. Idea solution for small hydropower plant (SHPP) on river Bistrica Lipovska, BB Hydro, 2014. (member of working team)
43. Idea solution for small hydropower plant (SHPP) on river Ratnja, Ljetopis automotive Ltd, 2014. (member of working team)
44. Idea solution for small hydropower plant (SHPP) on river Požnja, Ljetopis automotive Ltd, 2014. (member of working team)
45. Idea solution for small hydropower plant (SHPP) on river Trnovačka, Ljetopis automotive Ltd, 2014. (member of working team)
46. Idea solution for small hydropower plant (SHPP) on river Skrbuša, Soko group , 2014. (member of working team)
47. Idea solution for small hydropower plant (SHPP) on river Slatina, BB Hydro, 2014. (member of working team)
48. Idea project of the wind park "Možura", Možura wind park Ltd., 2014. (member of working team)
49. Main design of the SHPP „Raštak 1", KOL ENERGY Ltd., 2014. (member of working team)
50. Idea solution for small hydropower plant (SHPP) on river Radmanska, SHPP Montenegro 2, 2014. (member of working team)
51. Preliminary assessment for possibility of hydro energetic utilization of Umski water stream, Synergy, 2015. (member of working team)
52. Preliminary assessment for possibility of hydro energetic utilization of Rupočajski water stream, Municipility Kolašin, 2015. (member of working team)
53. Preliminary assessment of possibility for hydro energetic utilization for SHPP Šitarička , 2015. (member of working team)
54. Preliminary assessment of possibility for hydro energetic utilization for SHPP Rzačka, 2015. (member of working team)
55. Preliminary assessment of possibility for hydro energetic utilization of Vrelo Ljućansko, 2015. (member of working team)
56. Preliminary assessment of the possibility of using the hydropower potential of water courses for SHP "Štitska", 2015. (member of working team)
57. Main design of the SHPP „Bistrica Majstorovina", Hidro Bistrica, 2015. (member of working team)
58. Idea solution for small hydropower plant (SHPP) on river Šeremet, Nord Electro, 2015. (member of working team)
59. Idea solution for small hydropower plant (SHPP) on river Vrbnica, MHE Vrbnica d.o.o. , 2015. (member of working team)
60. Idea solution for small hydropower plant (SHPP) on river Vođenički potok, Nord Electro, 2015. (member of working team)
61. Preliminary assessment of the possibilities for using hydropower potential of the Crnja river, the municipality of Rožaje, 2015. (member of working team)
62. Idea solution for small hydropower plant (SHPP) on river Meteška, Normal Company, 2015. (member of working team)
63. Idea solution for small hydropower plant (SHPP) on river Bukeljka, Artek Ltd. , 2015. (member of working team)
64. Idea solution for small hydropower plant (SHPP) on river Lazanjska, Erlang Ltd. , 2015. (member of working team)
65. Preliminary assessment of the possibility of using the hydropower potential of river Bukovica, municipality Šavnik, 2016, (member of working team)

	66. Preliminary assessment of the possibility of using the hydropower potential of watercourses for SHPP Perućica, municipalities Andrijevica, 2016. (member of working team) 67. Idea solution for small hydropower plant (SHPP) on river Mišnjića potok, 2016. (member of working team) 68. Idea solution for small hydropower plant (SHPP) on river Bukovička Vrela, Water group Ltd., 2016. (member of working team) 69. Preliminary assessment of the possibility of using the hydropower potential of river Bjelojevićka, municipality Mojkovac, 2016, (member of working team) 70. Main design for Meteh SHPP, Kronor doo, Podgorica, 2016, (member of working team) 71. Main design of the wind park "Možura", Možura wind park Ltd., 2016. (member of working team) 72. Main design for small hydropower plant (SHPP) on river Ljevak, Simes engineering Ltd., 2016, (member of working team) 73. Main design of the SHPP „Bistrica Lipovska", BB Hidro, 2017, (member of working team) 74. Main design of the SHPP „Đurička 1&2 ", Plawa Hidro Power, 2017, (member of working team) 75. Revision of Idea Project of SHPP "Slap Zete" , Zeta Energy Ltd, 2017, (member of working team) 76. Revision of Idea Project of SHPP "Glava Zete" , Zeta Energy Ltd, 2017, (member of working team) 77. Main design of the SHPP „Bjelojevićka 1", C&S Energy, 2018, (member of working team) 78. Main design of the SHPP „Bjelojevićka 2", C&S Energy, 2018, (member of working team) 79. Main design of the SHPP "Slatina", BB Hidro, 2019, (member of working team) 80. Revision of Main design of SHPP "Slap Zete" , Zeta Energy Ltd, 2019, (member of working team) 81.
15.	Memberships
	Member of IAHR (International Association for Hydro-Environment Engineering and Research) since January 2009 Member of Engineering Chamber of Montenegro since December 2009 Member of CG KO CIGRE since January 2012

16.	Awards

	University of Montenegro recognition award for the achieved results and contribution to the development of scientific research and professional work at the Faculty of Mechanical Engineering in 2018 **Annual award from Engineering Chamber of Montenegro for achievements in professional activities in 2013**

Uroš Karadžić	**16.07.2019.**
Signature	Date

CURRICULUM VITAE

Igor Vušanović

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Web: http://www.hmt-hvac.ac.me, E-mail: igorvus@ac.me

Education

2002	Ph.D. Degree, Mechanical Engineering, University of Montenegro;
1996	M.S. Degree, Mechanical Engineering, University of Montenegro;
1992	B.S. Mechanical Engineering Degree, University of Belgrade;

Employment

2016 –
Dean of Mechanical Engineering, University of Montenegro
2012 -
Full Professor, University of Montenegro, Faculty of Mechanical Engineering;
2008 – 2012
Associate Professor, University of Montenegro, Faculty of Mechanical Engineering;
2003-2008
Assistant Professor, University of Montenegro, Faculty of Mechanical Engineering;
1996-2002
Assistant (Second Level), University of Montenegro, Faculty of Mechanical Engineering;
1992-1996
Assistant (First Level), University of Montenegro, Faculty of Mechanical Engineering

Honors

Purdue University, School of Materials Engineering, USA, Visiting Scholar, Fellowship of Ministry of Science of Montenegro, 1999

Ministry of Science and Education Scholarship, 1989/90, 1990/91, and 1991/92, (granted to students with high scholastic record)

Grants

University of Belgrade, Best student of generation 1992

Professional Societies

ASHRAE, Associate Member, USA

Research Interests

The main thrust of my research is the mathematical and numerical modeling of macrosegregation and microsegregation during the solidification of multicomponent alloys. Macrosegregation phenomenon has been successfully described with standard set of conservation equations (mass, momentum, energy and compositions). Additional pressure drop due to the solidification usually describes with Darcy-law for pseudo porous media. Microsegregation phenomenon has been successfully described with different sets of equations, depending on phase that precipitates during the solidification process. Generic ternary phase diagram is described with equations that represent liquid's and solid's surface and binary troughs as well. Partition coefficient equations have been used in order to describe solid's surface. Mass ratio between phases for secondary and ternary solidification has been calculated using the well-known tie triangle rule. A limitation on predicting final material properties as a function of processing is the fact that the phenomena, which govern the final structure and properties, occur over a wide range of length scales, from the microscopic (micron to millimeter) to the macroscopic (millimeters to meters). We are interested in developing predictive capabilities to model the final multiscale structure of metal alloys during and after solidification. From a microscopic point of view, a solidification problem is one of understanding the growth of several solid phases from a liquid, which most often occurs, by the growth of microscopic dendritic structures. The morphology, the crystal structure, and the freezing/melting behavior of those dendrites and the mass diffusion fields around them have significant influence on the properties of the final cast part. These phenomena interact with the heat and mass transfer and fluid flow occurring at macroscopic length scales. A careful integration of predictive models that describe the multiscale development of microstructure and properties is necessary to advance the fundamental science of materials processing.

Ph.D. Thesis: "Analysis of Phase Change Phenomena in Multicomponent Systems with Aspects of Technical Applying"

M.S. Thesis: "Analysis of ice making and melting processes by using modify "enthalpy method", in ice storage systems"

References

USA

1. Vaughan R. Voller, Professor, Department of Civil, Enviromental and Geo – Engineering University of Minnesota, Minnesota, USA

2. Matthew J. M. Krane, Associate Professor, Materials Engineering, Purdue University, West Lafayette, IN, USA
3. Velimir Radmilović, Professor, National Center for Electron Microscopy, Lawrenc Berk ley National Laboratory, Berkeley, CA, USA
4. Vaughan R. Voller, Professor, Department of Civil, Environmental, and Geo Engineering, University of Minnesota, Minneapolis, MN 55455, USA

SLOVENIA

1. Dr Božidar Šarler, Professor, University of Nova Gorica, Laboratory for Multiphase Processes, Slovenia (http://www.p-ng.si/en/research/multiphase-processes/)

SERBIA

1. Dr Dimitrije Voronjec, Professor, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Yugoslavia
2. Dr Milovan Studović, Professor, Faculty of Mechanical Engineering, University of Belgrade, Belgrade, Yugoslavia

MONTENEGRO

1. Dr Petar Vukoslavčević, Professor, Faculty of Mechanical Engineering, University of Montenegro, Podgorica, Yugoslavia
2. Dr Nenad Kažić, Professor, Faculty of Mechanical Engineering, University of Montenegro, Podgorica, Yugoslavia

Research Activity

Over the past fifth ten years, I have studied:

- Modeling of two-phase flow (water-steam) in evaporator channels with couple of different mathematical models
- Phase change phenomena in ice water system using modify "enthalpy" method for describing energy balance equation
- Phase change phenomena during the solidification of two and three component alloys with special attention on Al-Cu-Mg alloy

During the undergraduate study and for graduate work I have developed different mathematical models for predicting heat and mass transfer in evaporator channels. The most simply model treat two phase mixture as homogenous, but it can be successfully used for calculating the pressure drop and temperature profiles in 1-D channels trough the time. Most advanced model of characteristics has been developed also, and it can be successfully used for predicting fast heat and mass transfer processes in evaporator channels. Those phenomena occur in many technical systems (stream generators, heat exchangers, and steam boilers) during the accident, which happens under the undesirable conditions.

During the Master degree study I made efforts to developing mathematical and numerical models for describing phase change phenomena in ice water system. Transport phenomena

during the phase change in ice water system are important in many systems of latent energy storage, which is commonly used for energy saving in processes that demand low energy consumption. Mathematical model for describing phase changes phenomena in ice water that's developed treat problem as 2-D unsteady. An energy balance equation is written with enthalpy instead of temperature, and special algorithm is developed for calculating local temperature and fraction of solid and liquid, knowing mixture enthalpy. Isothermal character of phase change phenomena was a main difficulty in order to get temperature and mass fraction of solid phase field from mixture enthalpy, known from governing equations.

During my Ph.D. study, I worked on mathematical and numerical modeling of transport phenomena in ternary Al-Cu-Mg alloy as multi-component system. Macrosegregation i.e. redistribution of alloying elements which occurs in ingot scale is usually induced by a relative movement of both solid and liquid phase during the casting process, and can be successfully described with standard set of transport equations (mass, momentum, energy and concentration). As a constitutive correlation for macroscopic set of equations, generic ternary phase diagram of ternary Al-Cu-Mg alloy and appropriate microsegregation model has been implemented. This microscopic model was used to compute local temperatures, solid and liquid fractions and compositions of both alloying elements. The different sets of equations were used for primary and subsequent solidifications. The non-equilibrium in primary phase is enforced as well as diffusion that is modeled 1-D planar model. Compositional profiles of Cu and Mg in primary, secondary and ternary phase can be calculated with represented model, as well as ratio between phases and diffusion of Cu and Mg in primary phase.

After finishing of my Ph.D. dissertation the main research is focused on experimental validation of macro and micro modeling of ternary Al alloys. Experimental installation is composed from metal mold, electrical heaters and water-cooled heat exchanger for heat removal during the casting. Temperature measurements have been performed at the all six sides of mold, while the measurements inside the mold are taken too. Aluminum based *Al-4wt%Cu-1wt%Mg* alloy was cast couple of times and temperature and compositional measurements have been cut and compared with predicted values. Also, alloy *Al-32wt%Cu-2wt%Mg* is also cast with similar conditions as previous mentioned. The purpose of those experiments is to evaluate model that was developed during my PhD study. Some of these results have been published at EUROTHERM 69 Conference, held in Slovenia 2003.

During the period 2004 – 2008 I participated in two separate projects in the frame of scientific cooperation with Slovenian institutions (University of Nova Gorica), and we successfully worked on developing of microsegregation codes for ternary commercial alloys (Al-Cu-Mg, Al-Mg-Si, Al-Fe-Si) which are of interest of company IMPOL d.d (www.impol.si) from Slovenska Bistrica. The all developed codes were successfully implemented in well known macroscopic mixture models and codes for vertical (VDC) and horizontal (HDC) casting of ternary aluminum alloys.

Teaching Experience

At the Faculty of Mechanical Engineering and Faculty of Metallurgy and Technology at University of Montenegro I have taught as an Assistant the following graduate courses:

- Thermodynamics

- Refrigeration systems,
- Steam Boilers,
- Heating and Ventilation,
- Fluid Mechanics.

After finishing my Ph.D. work after I was promoted in Assistant Professor I started teach two new established courses:

- Numerical Heat Transfer and Fluid Flow;
- Measuring and Simulations of Energy Processes;

These courses were performed for a first time at the Faculty of Mechanical Engineering in school year 2003/2004.

After 2006 I started teach

- Air conditioning at the Faculty of Mechanical Engineering;
- Thermodynamics at Maritime faculty in Kotor.

Igor Vušanović - Publications

A. Paper published or submitted for publishing in international review journals

1. E. Tombarević, I. Vušanović, "Numerical Analysis of Unsteady Heat Transfer in U-tube Geothermal Heat Exchanger", *ANNALS of Faculty Engineering Hudenoara – International Journal of Engineering*, Vol. 16(2), (2018) pp. 141-144. (ISSN 1584-2665)
2. I. Vušanović, V. R. Voller, "Best practice for measuring grid convergence in numerical models of alloy solidification", *International Journal of Numerical Methods for Heat and Fluid Flow*, Vol. 26 No. 2, (2016) pp. 1-14
3. I. Vušanović, V. R. Voller, "Simple metrics for verification and validation of macrosegregation model predictions", *IOP Conference Series: Materials Science and Engineering* ***117*** (2016) 012062.
4. I. Vušanović, "Transient permeability in macrosegregation of static casting in binary alloys: Use of CDF statistical model for analysis ", *IOP Conference Series: Materials Science and Engineering* ***84*** (2015) 012008.
5. V. R. Voller, I. Vušanović "Frequency Analysis of Macrosegregation Measurements and Simulations", *International Journal of Heat and Mass Transfer* 79 (2014) 468–471.
6. I. Vušanović, V. R. Voller, "Understanding channel segregates in numerical models of alloy solidification: A case of converge first and ask questions later ", *Materials Science Forum*, Vols. 790-791, pp. 73-78, (2014), Trans Tech Publications, Switzerland (doi:10.4028/www.scientific.net/MSF.790-791.732013).
7. E. Tombarević, V.R. Voller, I. Vušanović, "Detailed CVFEM Algorithm for Three Dimensional Advection-diffusion Problems ", (2013), *Computer Modeling in Engineering and Science* CMES, Vol. 96, no.1, pp. 1 – 29.
8. B. Šarler, R. Vertnik, A.Z. Lorbiecka, I. Vušanović, B. Senčič. Application of continuous casting simulation at Štore Steel, II. *BHM Berg Huettenmaennische Monatshefte, (2013),* str. 1-9, doi: 10.1007/s0050101301477.
9. B. Šarler, R. Vertnik, A. Z. Lorbiecka, I. Vušanović, B. Senčič, "A multiscale slice model for continuous casting of steel", *IOP Conference Series: Materials Science and Engineering* ***33*** *(2012) 012021.*

10. J. D. Jovanović, E. M. Tombarević, I. C. Vušanović, "Control volume finite element method for modeling of spur gear frictional heat", (2013), *Technics Technologies Education Management – TTEM,* Vol. 8, No 2. 5/6.
11. I. Vušanović, M. J. M. Krane, "Macrosegregation in horizontal direct chill casting of ternary Al alloys: Investigation of solid motion", *IOP Conference Series: Materials Science and Engineering* ***27*** (2011) 012069.
12. I. Vušanović, R. Vertnik, B. Šarler, "A simple slice model for prediction of macrosegregation in continuously cast billets", *IOP Conference Series: Materials Science and Engineering* ***27*** (2011) 012056.
13. E. Tombarević, I. Vušanović, "Modeling of ice-water phase change in horizontal annulus using modified enthalpy method", (2011), *Advances in Applied Mathematics and Mechanics*, Vol. 3, No 3, pp. 354 – 369.
14. I. Vušanović, "Macrosegregation of ternary Al – 4.5Cu – 1.0Mg alloy in horizontal direct chill casting: implementation of non-equilibrium microsegregation model", (2009), *International Journal of Cast Metal Research*, Vol. 22, No 1 – 4, pp. 314 – 317.
15. M. J. M. Krane, I. Vušanović "Macrosegregation in horizontal direct chill casting of aluminum slabs", (2009), *Materials Science & Technology*, Vol. 25, No. 1, pp. 102 – 107.
16. I. Vušanović, B. Šarler, M.J.M. Krane, "Microsegregation during the solidification of an Al–Mg–Si alloy in the presence of back diffusion and macrosegregation", (2005), *Materials Science Engineering (A),* Vol. 413 – 414, pp. 217 – 222.
17. A. Bergant, U. Karadžić, J. Vitkovsky, I. Vušanović, A. R. Simpson, " A Discrete Gas-Cavity Model that Considers the Frictional Effects of Unsteady Pipe Flow", (2005), *Strojniški vestnik – Journal of Mechanical Engineering,* Vol. 51(11), pp. 692 – 710.
18. I. Vušanović, M. J. M. Krane, "Microsegregation during solidification of Al-Cu-Mg alloys with varying composition", (2002), *International Communications in Heat and Mass Transfer,* Vol. 29, N° 1, (2002), pp. 1037-1046.
19. I. Vušanović, D. Voronjec, M.J.M. Krane, "Microsegregation phenomena in Al-Cu-Mg alloy with considering of diffusion phenomena in primary phase" *Facta Universitatis,* Vol. 1, N° 8, (2001), pp. 965 - 980.
20. V. Asanovic, B. Perovic, Z. Markovic, I. Vušanović, A. Kostov, "The influence of heat treatment on shape memory effect, *Materials Science Forum,* Vol. 352. (2000) pp. 165-170.
21. V. Asanović, B. Perović, Z. Marković-Leka, A. Kostov, I. Vušanović, "Thermoelastic Martensitic Transformation and Shape Memory Effect in Cu-Zn-Al Alloys," *Acta periodica technologica*, Vol. 31, (2000), Issue B, pp. 515-523.

B. Papers published in national Yugoslav journals (in Serbian; abstract in English)

1. M. Šekularac, I. Vušanović, "Dinamika sistema toplotne pumpe sa klima – komorom u rashladnom režimu rada", *KGH,* No. 3/2008, pp. 27 – 44, (2008).
2. I. Vušanović, M.J.M. Krane, "Matematički model mikrosegregacije u u Al-Cu-Mg leguri sa promjenljivim koncentracijama tokom očvršćavanja", *Termotehnika,* No. 1–4 Vol. 27 (2001), pp. 25–36.
3. V. Asanovic, B. Perovic, Z. Markovic, I. Vušanović, A. Kostov, "The influence of heat treatment on shape memory effect, *Journal of Technique*, No. 3/1999, Belgrade, 1999.

4. I. Vušanović, "Numerical modeling of phase change phenomena in ice – water system by using modify entalphy method", *Thermal Science – Journal of Heat Transfer Engineers*, No. 1-4/1998, Belgrade, 1998.
5. I. Vušanović, "Mathematical modeling of phase change phenomena in two component system, based on enthalpy approach", *Journal - Process Technique*, No. 2-3/1998, Belgrade, 1998.
6. N. Kazic, I.Vušanović, "The Phenomena of ice making process in ice storage systems", *KGH*, No. 2/1995, Belgrade, 1995.

C. Papers published in the proceedings or international conferences (in English)

1. J. Coleman, I. Vušanović, and M. J. M. Krane, "Characterization of the 3D Flow Field and Macrosegregation in Horizontal Direct Chill Cast Slabs", *5th International Conference on Advances in Solidification Processes – ICASP5*, Salzburg, Austria, June 2019.
2. M. Đekić, E. Tombarević and I. Vušanović, "Long term performance of building with vertical ground coupled heat pump system, *In P. Gvero (Ed.) Book of Abstracts of the 14th International Conference on Accomplishments in Mechanical and Industrial Engineering DEMI, May 24 – 25th, 2019, Banja Luka, Bosnia and Herzegovina.*
3. I. Vušanović, VR Voller, "Numerical Modeling of Solid Movement in Phase Change Processes", *ICCES: International Conference on Computational & Experimental Engineering and Sciences, March 25 – 28th, 2019, Tokyo, Japan.*
4. E. Tombarević, I. Vušanović "Experimental validation of a quasy-3D CVFEM model of borehole heat exchangers", *Fourth International Conference on Computational Methods for Thermal Problems, THERMACOMP 2016, July 6-8, 2016, Georgia Tech, Atlanta, USA, N. Massarotti, P. Nithiarasu and Y. Joshi (Eds.)*
5. I. Vušanović, "Transient permeability in macrosegregation of static casting in binary alloys: Use of CDF statistical model for analysis ",*Modeling of Casting, Welding and Advanced Solidification Processes (MCWASP XV 2015)* Awaji Island, Japan, *June* 2015.
6. I. Vušanović, V. R. Voller, "Simple metrics for verification and validation of macrosegregation model predictions", *4th International Conference on Advances in Solidification Processes*, Beaumont Estates, Old Windsor, UK, 2014.
7. I. Vušanović, V. R. Voller, "Effect of domain size on grid convergence in numerical models of alloy solidification", *Third International Conference on Computational Methods for Thermal Problems, THERMACOMP 2014, June2-4, 2014, Lake Bled, Slovenia, (N. Massarotti, P.Nithiarasu and B. Šarler (Eds.)*
8. E. Tombarević, I. Vušanović, "Numerical Model of Heat flow in a Geothermal borehole heat exchanger ", *Third International Conference on Computational Methods for Thermal Problems, THERMACOMP 2014, June2-4, 2014, Lake Bled, Slovenia, (N. Massarotti, P.Nithiarasu and B. Šarler (Eds.)*
9. B. Šarler, A. Z. Lorbiecka, U. Hanoglu, R. Vertnik, I. Vušanović, "A meshless slice model for continuous casting and hot rolling of steel. " V: LIU, Gui-Rong (ur.), LIU, Z. S. (ur.). Proceedings of the 5th Asia Pacific Congress on Computational Mechanics (APCOM2013) and 4th International Symposium on Computational Mechanics (ISCM2013), 11th -14th December 2013, Singapore.
10. I. Vušanović, V. R. Voller, "Understanding channel segregates in numerical models of alloy solidification: A case of converge first and ask questions later ", *The 6th International*

Conference on Solidification and Gravity, Miskolc Lillafured, Hungary, *2 – 6th September 2013.*

11. B. Šarler, R. Vertnik, A. Z. Lorbiecka, U. Hanoglu, I. Vušanović, " An Extended Heat and Mass Transfer Slice Model for Continuous Casting of Steel", *ECCOMAS Special Interest Conference Numerical Heat Transfer* , Gliwice-Wrocław, Poland , *4-6 September 2012.* Eds.: A. Nowak, R.A. Białecki
12. E. Tombarević, I. Vušanović, "Control Volume Finite Element Method for two and three dimensional advection-diffusion problems", *ICCES Special Symposium on Meshless & Other Novel Computational Methods*, Budva, Montenegro, *September 2012.*
13. B. Šarler, R. Vertnik, A. Z. Lorbiecka, I. Vušanović, B. Senčič, "A multiscale slice model for continuous casting of steel", *Modeling of Casting, Welding and Advanced Solidification Processes (MCWASP XIII 2012),* Schladming, Austria, *June 2012*
14. I. Vušanović, R. Vertnik, B. Šarler, "A simple slice model for prediction of macrosegregation in continuously cast billets: influence of different solid diffusion models", *International symposium on liquid metal processing and casting, LMPC,* Nancy, France, *September, 2011*
15. I. Vušanović, R. Vertnik, B. Šarler, "A simple slice model for prediction of macrosegregation in continuously cast billets",*3rd International Conference on Advances in Solidification Processes,* Rolduc Abbey/Aachen, Germany, *June 2011*
16. I. Vušanović, M. J. M. Krane, "Macrosegregation in horizontal direct chill casting of ternary Al alloys: Investigation of solid motion", *3rd International Conference on Advances in Solidification Processes,* Rolduc Abbey/Aachen, Germany, *June 2011*
17. E. Tombarević, I. Vušanović, "3D Numerical model of the borehole heat exchanger", *Slovenian-Italian Conference on Materials and Technologies for Sustainable Growth,* University of Nova Gorica, Ajdovščina, Slovenia, *May 2011*
18. I. Vušanović, "Energy efficiency in building sector: solutions for heating and air conditioning in Montenegro", *Third International Conference GNP 2010,* Žabljak, Montenegro, 2010.
19. E. Tombarević, I. Vušanović, "Modelling of ice melting in horizontal annulus using enthalpy method", *First International Conference on Computational Methods for Thermal Problems*, ThermaComp 2009, Naples, Italy, 2009.
20. E. Tombarević, I. Vušanović, "Influence of inner pipe wall temperature on freezing of water in a horizontal cylindrical annulus", *EUROTHERM Nr. 84 Thermodynamics of phase change,* Namur, Belgium, 2009.
21. I. Vušanović, "Macrosegregation of ternary Al – 4.5wt%Cu – 1.0wt% Mg alloy in horizontal direct chill casting – implementation of non-equilibrium microsegregation model" *Proceedings of the Second International Conference on Advances in Solidification Processing*, Graz/Seggau, Austria, *June 2008.*
22. M. Šekularac, I. Vušanović, "Mathematical modeling of HVAC instalations", *Klima Forum 2007,* Godovič, Slovenia, *September 2007*
23. I. Vušanović, I. Vujošević, "Energy efficiency strategy in Montenegro – implementation and challenges", *Klima Forum 2007,* Godovič, Slovenia, *September 2007.*
24. I. Vušanović, B. Šarler, "Modeling of micro and macro segregation in DC casting of ternary Al based alloys", *EUROMAT 2007,* Nurnberg, Germany, *September 2007.*
25. I. Vušanović, M. J. M. Krane, "Macrosegregation in horizontal direct chill casting (HDC) of aluminium binary alloys billets- influence of casting parameters," *in Solidification Processing 07*, H. Jones et al. (eds.), pp 428-432 (2007).

26. I. Vušanović, M.J.M. Krane, "Macrosegregation In Horizontal Direct Chill Casting (HDC) Of Aluminum Alloy Billets – Influence Of Casting Parameters", *Proceedings of the 5th Decennial International Conference on Solidification Processing,* Sheffield, UK, *July 2007.*
27. U. Karadžić, A. Bergant, I. Vušanović, "Influence of unsteady friction on transients in hydraulic pipeline systems", 12th *Symposium on thermal science,* Sokobanja, Serbia, *October 2005.*
28. N. Kažić, I. Vušanović, "Exergy and HVAC", *Klima forum 2006*, Godovič, Slovenia, *September 2006.*
29. Šarler, B., Kovačević, I., Vertnik, R., Hartman, S., Vušanović, I., Založnik, M., Šafhalter, R., Slaček, E., Dragojevič, V., Jelen, M., Strnad, V., Robič, A. : Integrated numerical simulation approach in IMPOL aluminium industry casthouse, *International Conference on Aluminium in conjunction with the 6th World Trade Fair*, Essen, Germany, *September*, 2006.
30. I. Vušanović, B. Šarler, M.J.M. Krane, "Microsegregation during the solidification of an Al–Mg–Si alloy in the presence of back diffusion and macrosegregation", *International Conference on Advances in Solidification Processes*, Stockholm, Sweden, 2005.
31. I. Vušanović, M.J.M. Krane, "Mathematical model for microsegregation of Al rich Al-Cu-Mg alloys with considering of diffusion in primary phase", *II International Symposium LIGHT METALS AND COMPOSITE MATERIALS,* Belgrade, Serbia & Montenegro, 2004.
32. I. Vušanović, M.J.M. Krane, "Numerical and Experimental study of Macrosegregation During the Casting of Al-Cu-Mg Alloys", *EUROTHERM 69 Heat and Mass Transfer in Solid – Liquid Phase Change Processes,* Ljubljana, Slovenia, 2003.
33. V.D. Asanovic, I. Vušanović, Z.B. Markovic, A. Kostov, B. Bosnjak, B. Radulovic, "The influence of the heat treatment on martensitic transformation and properties of Cu-Zn-Al shape memory alloys", 3rd *Macedonian Conference of Metallurgy*, Ohrid, 2000.
34. V.D. Asanovic, Z.B. Markovic, I. Vušanović, B. T. Bosnjak, B. Radulovic, A. Kostov, "Isothermal decomposition of β_1 phase in Cu-Zn-Al shape memory alloy", 2nd *International Conference on "Chemical Sciences for Sustainable Development"*, Greece, 2000.
35. V.D. Asanovic, B. Perovic, Z. Markovic, A. Kostov, I. Vušanović, "Thermoelastic martensitic transformation and shape memory effect in Cu-Zn-Al alloys", *YUCFPCE (Yugoslav Congress of food, pharmaceutical and Chemical engineering)*, Novi Sad, 1999.
36. I. Vušanović, "Numerical modeling of phase change in ice-water system by using modify entalphy method", 10th *Symposium YU - TERM '97*, Zlatibor, 1997.
37. I. Vušanović, N. Kažić, "One numerical approach to the process in the ice storage device", 12th *International Congress of Chemical and Process Engineering - CHISA '96*, Prague, 1996.
38. I. Vušanović, V. Stevanovic, M. Studovic, "Transferring of waves in evaporator channel with disturbances of intake fluid flow", 24th *Congress KGH*, Belgrade, 1993.
39. I. Vušanović, V. Stevanovic, M. Studovic, "Mathematical model of forced and natural circulation – Modular approach", 23rd *Congress KGH*, Belgrade, 1992.

D. Papers published in the proceedings of domestic conferences (in Serbian)

1. Karadžić, U., Bergant, A., Vušanović, I. "Validacija konvolucijskog modela nestacionarnog trenja za prelazne procese u hidrauličkim cijevnim sistemima", *30. HIPNEF sa međunarodnim učešćem 24-26 maj,* Vrnjačka Banja, Srbija, 2006.

2. V.D. Asanovic, B. Perovic, Z. Markovic, I. Vušanović, "Aging effect on shape memory in Cu-25.38Zn-3.3Al", *XXXIX Meeting of Serbs Chemical Society*, Belgrade, 1999.
3. V. Asanovic, B. Perovic, Z. Markovic, I. Vušanović, A. Kostov, "The influence of heat treatment on shape memory effect", *YUCOMAT '99*, Herceg Novi, 1999.
4. I. Vušanović, N. Kazic, "Analysis of ice making process with various regimes of work of ice storage and their influence on efficiency of system", *Industrial Energetics '96*, Herceg Novi, 1996.
5. I. Vušanović, "Model simulation of thermohydraulic instabilities in two phase flow", *Symposium "Thermohydraulics '94"*, Belgrade, 1994.
6. N. Kazic, I. Vušanović, "Processes of making and melting of ice in ice storage systems", *Industrial Energy '94*, Belgrade, 1994.
7. I. Vušanović, N. Kazic, "Numerical Modeling of natural convection in Thermal Cavity", *Industrial Energy '94*, Belgrade, 1994.

E. International & National Scientific Projects on which I. Vušanović participated

1. I. Vušanović, V. R. Voller, M. Valant, E. Tombarević, "Numeričko i eksperimentalno istraživanje mogućnosti korišćenja geotermalne energije za potrebe rada geotermalnih toplotnih pumpi", Ministarstvo nauke Crne Gore, 2012 – 2015.
2. I. Vušanović, B. Šarler, " Modelling of industrial solidification processes under influence of electromagnetic fields", *Financed and supported by Ministry of Science of Montenegro and Ministry of Science, Education and sport of Slovenia, BI – SCG/2014 – 2015.*
3. V. Novaković, M. Vukčević, I. Vušanović, "HERD QIMSEE – Higher Education Research & Development – Quality Improvement in Science, Engineering and Education, Financed by Norwegian Ministry of foreign affairs with NTNU University, Trondheim, 2014 – 2016.
4. I. Vušanović, W. Chen, "Implementation of fast meshless simulations methods on solid mechanics and heat transfer problems in large scale structures", Financed and supported by Ministry of Science of Montenegro and Ministry of Science of China, in the frame of Montenegrin - Chinese Science & Technology cooperation BI – CHN/2014 – 2016.
5. I. Vušanović, B. Šarler, " Advanced modeling of continuous casting of steel", Financed and supported by Ministry of Science of Montenegro and Ministry of Science, Education and sport of Slovenia, BI – SCG/2012 – 2013.
6. I. Vušanović, B. Šarler, "Multiscale modeling of continuous casting of steel", Financed and supported by Ministry of Science of Montenegro and Ministry of Science, Education and sport of Slovenia, BI – SCG/2010 – 2011.
7. I. Vušanović, B. Šarler, " Modeling of micro and macrosegregation of ternary aluminium alloys obtained through DC casting and twinroll casting", Financed and supported by Ministry of Science of Montenegro and Ministry of Science, Education and sport of Slovenia, BI – SCG/06-07.
8. I. Vušanović, B. Šarler, "Modeling of phase change phenomena in Al alloys", Financed and supported by Ministry of Science of Montenegro and Ministry of Science, Education and sport of Slovenia, BI – SCG/04-05.
9. D. Gobin, B. Šarler, I. Vušanović, " Advances in simulation capabilities for solidification systems", Programme ECO-NET 2005.
10. I. Vušanović, "Development of ternary microsegregation models for direct-chill casting and twin-roll strip casting of Al based alloys, *IMPOL d.d., 2004.*

11. I. Vušanović, "Measuring and Simulation of Energetic Processes", *CDP+ Project No. 011 (2) supported and financed by WUS Austria, 2005.*

F. Graduate students supervisions

F.1 Master thesis – Advisor (A) and Committee member (M)

1. Marko Đekić, "Energy use analysis of residential building equipped with heat pumps in Montenegro", University of Montenegro, Faculty of Mechanical Engineering, October 2017. (A).
2. Esad Tombarević, " Modelling of phase change in ice storage with horizontal pipe", University of Montenegro, Faculty of Mechanical Engineering, March 2009. (A).
3. Milan Šekularac, "Analysis of dynamic of operation of a HVC system heat pump – air conditioning unit", University of Montenegro, Faculty of Mechanical Engineering, July 2008. (A)
4. Uroš Karadžić, "Analysis fluid transients phenomena in hydraulic systems", University of Montenegro, Faculty of Mechanical Engineering, October 2004. (A)
5. Sanja Radović, "Investigation of controlled cooling in continuous rolling of iron bars", University of Montenegro, Faculty of Metallurgy and Technology, University of Montenegro, December 2004. (M)

F.2 Ph.D thesis – Advisor (A) and Committee member (M)

6. Esad Tombarević, "Analysis of unsteady heat transfer in the geothermal u-tube borehole heat exchangers" PhD thesis, University of Montenegro, Faculty of Mechanical Engineering, July 2016. (A)
7. Uroš Karadžić, "Modelling of complex boundary conditions for transients in hydraulic systems", University of Montenegro, Faculty of Mechanical Engineering, November 2008. (M)

G. Lectures

1. I. Vušanović, "Horizontal direct chill castings of aluminum alloys : challenges and perspectives ", University of Ljubljana, Faculty of Mechanical engineering, September 2019 (invited lecture).
2. I. Vušanović, "Current Challenges in Modeling Solidification Processes", Warren Lecture Series at Department of Civil, Enviromental and Geo – Engineering, University of Minnesota, September 2017 (invited lecture).
3. I. Vušanović, "Modeling issues in transport phenomena with phase change in multicomponent systems ", Nanjing University, February 2014 (invited lecture)
4. I. Vušanović, " Micro and Macrosegregation during the DC casting in ternary Al", University Pierre & Marie CURIE, Fast Laboratory, September 2006, (seminar);
5. I. Vušanović, " Micro-macrosegregation in ternary alloys - review of previous work and future challenges", University of Birmingham, School of Engineering, June 2006, (invited lecture);
6. I. Vušanović, "Numerical and experimental modeling of macrosegregation in ternary aluminum alloys, Nova Gorica Polytechnic, March, 2004 (invited lecture)

H. Strategies Expertise on which I. Vušanović participated as an author or co – author (on serbo-croatian)

1. N. Kažić, P. Vukoslavčević, D. Ivanović, I. Vušanović, U. Karadžić, V. Ivanović, E. Tombarević, M. Šekularac, "Elaborat za rješavanje problema zagadjenosti u Pljevljima, Centar za Energetiku, Mašinski fakultet UCG, Jun 2015.
2. I. Vušanović, "Crna Gora u XXI stoljeću u eri kompetitivnosti, Podprojekat ENERGIJA, *Crnogorska Akademija Nauka i Umjetnosti (CANU),* Podgorica, April 2010 (u izradi).
3. H. Birkeland, K. O. Nerland, V. Rodić Igor Vušanović, "Montenegro - Prestudy Energy Efficiency and Renewable Energy Agency in Montenegro", *NORSK ENERGY,* Project No. 04 – 28499, *April 2008.*
4. I. Vujošević, I. Vušanović, F. Daganaud, "Energy Efficiency Strategy for Montenegro with action plan for 2005 – 2006", *Technical assistance to the Ministry of Economy and EPCG,* Podgorica, *April 2005.*
5. I. Vušanović, V. Ćulafić, R. Bulatović, D. Bajić, M. Janjić, "Elaborat Stručne Komisije u Vezi havarije na Autoklavu Ra15 u Fabrici Glinica u KAP-u", *Mašinski fakultet Univerziteta Crne Gore,* Podgorica, *Novembar 2004.*

Milan ŠEKULARAC PhD mech.eng. - Curriculum Vitae

1. **CURRENT POSITION**
   Assistant Professor at Faculty of Mechanical Engineering,
   Laboratory for Fluid Mechanics and Energy Processes
   University of Montenegro

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Youtube: https://www.youtube.com/channel/UCOuNe9mBex9RTVf7Yiaw89w/videos

2. **EDUCATION**

Grad and undergrad

- PhD mech. eng. ***„Analysis of flow fields in complex ventilation systems of traffic tunnels"***, *Mechanical Engineering Faculty, University of Montenegro, 2015;*
- MSc. mech.eng. ***„Analysis of the dynamics in a HVAC system consisting of heat pump with air-handling unit"***, *Mechanical Engineering Faculty, University of Montenegro, 2008;*
- Dipl.-Ing. mech.eng. ***„Numerical simulation of heat and mass transfer in Czochralski crystal growth process under the efect of radial-axial magnetic field "***, *Mechanical Engineering Faculty, University of Montenegro, 2005;*

Postdocs & recent trainings

- **STANFORD UNIVERSITY Cardiovascular Biomechanics Computation (Prof. Dr Alison Marsden) CFD of blood flow**
  Fulbright Visiting scholar in 2016, at the "Cardiovascular Biomechanics Computation Lab" of Prof.Dr Alison Marsden, Stanford University. Outline: 3D-CAD model generation from MRI data, boundary conditions modelling through multiscale approach, and FEA simulation of blood flow of a database of pediatric patients affected by a cardiovascular disorder (Kawasaki aneurisms on coronary arteries). The ultimate goal: better understanding of flow criteria for prescription of anticoagulation therapies, and possible surgical treatments;
- **VUB UNIVERSITY in Brussels - Combustion in Open Foam at the group BURN – Prof. Dr Francesco Contino**
  Related to my interests in CFD of fire scenarios and general combustion problems in the Open Foam framework

3. **RESEARCH PROJECTS**
   1. **Analysis of flow and fire scenarios in traffic tunnel ventilation design.** National research project lead by Prof.Dr.Petar Vukoslavčević. A combined CFD and experimental assessment of turbulent flows in ventilated tunnels, axial ducted fans, and the fire safety scenarios. Experimental research conducted on a scaled Lab. model of a ventilated traffic tunnel that I designed and built myself, equipped with appropriate scaled axial ducted fan models.
   2. **Development of Hot-Wire Anemometry circuits for hot-wire measurement technology.** Lead by Prof.Petar Vukoslavčević, aimed at the development of an updated design of these circuits with optimized performance, increased frequency response, even better signal-to-noise rations and measurement sensitivity. Applications in velocity and temperature measurements in turbulent flows. Experimental verification utilizing state-of-the-art-hot wire probes, and sensors of

2.5, 1 and 0.6 micrometer diameter. Optimization of the hotwire probe design through experiments and CFD.

3. **Flow fields in rotating turbomachinery.** Joint work by Laboratory for Turbomachinery and Energy Systems, University of Belgrade and my Lab. Development of laser and hot-wire anemometry measurement technology and CFD approaches to assess the complex flow fields in rotating machinery, primarily axial fans.
4. **Undergrad research experiences.** Institute of Fluid Mechanics - LSTM, University of Erlangen - Nuremberg, Germany. A numerical simulation of heat and mass transfer in the "Czochralski" crystal growth process, under the effect of a radial-axial (cusp shaped) magnetic field, where I used a LSTM's research CFD code to compute the flow and heat transfer, the shape of the solid-liquid interface, in an industry case crucible furnace geometry.

4. LANGUAGE SKILLS

(1-basic to 5-profficient)

Language	Reading	Speaking	Writing
Serbian-croatian-montenegrin	Native	Native	Native
English	5	5	5
Italian	5	5	4
German	2	2	2

5. SKILLS

a) General computer skills

- Text editors: Microsoft Office, LATEX, Sublime, Emacs
- Programming proficient: MATLAB / Octave / C
- Programming basic: C++ / Python
- Graphics: TecPlot, ANSYS CFD-Post, Paraview
- CAD profficient: 3D AutoCAD
- CAD basic skills: CATIA

b) CFD – Computational Fluid Dynamics

Using commercial tools:

- ANSYS Workbench CFD environment software: Ansys Mesher, FLUENT, CFX, CFD-Post post-processing

Open Source CFD tools:

- Self-written codes for numerical solution of flows with heat transfer using finite volume approach, in Matlab
- Open Foam CFD basic skills, current field of interest
- FASTEST 3D (german open source academic CFD solver) used it for flow and heat transfer simulations on a workstation computer.
- SimVascular (Stanford) for Cardiovascular biomechanics – blood flow CFD (and vessel deformation) computation FEA solver with CAD pre-and post-processing tools (Paraview), current field of interest

c) Experimental fluid dynamics, heat transfer, and HVAC skills

- **Experimental fluid mechanics**

"Hot-wire" or thermal anemometry under the guidance of Prof.Petar V. Vukoslavčević, a leading expert in the field and Lab founder. Calibration and measurements of hotwire probes for measurement of velocity (and temperature) in turbulent flows. Utilisation of in-house Fortran

codes for calibration and processing of hot-wire anemometry measurements. Self-written Matlab codes for processing of measurement data, signal-processing and graphic processing in Matlab and TecPlot. Experience in use of Data Translation's DAQ hardware and their DAQ software.

- **Ventilation and fire safety**
  Research on flow field and fire scenarios in a Lab model of a traffic tunnel, using hot-wire probe for air-velocity, Pitot tubes, differential pressure transducers and thermocouple DAQ system. Realization of fires-scenario experiments, utilising a buthane burner and temperature DAQ equipment. CFD of tunnel-fire scenarios.
- **HVAC, Renewable Energy, and Energy Efficiency**
  - An experimental study on a laboratory HVAC system performance and its time-dynamics. Monitoring of the characteristic temperatures within a vapour – compression cycle heat pump with an air-handling unit system. Numerical simulation of the system's performance and operation with respect to time, using a self-made MATLAB code simulating the heat pump cycle utilizing a R407C refrigerant coupled to an air handling unit operation in time.
  - CFD assessment of a ground to air heat exchanger for passive heating, in the given climatic conditions of the capital city, both in summer and winter use.
  - Energy use performance assessment and energy audits in buildings. Algorithms for calculation of cooling loads and energy indicators. Measurements of flow, pressure, temperature, and COP on HVAC installations. Certified energy auditor.

d) Lecturing

Held the following courses:

- Thermodynamics,
- Applied Thermodynamics,
- Heat and Mass Transfer,
- Numerical methods for fluid - thermo dynamics (CFD),
- Air-conditioning,
- Measurement and simulation of energy processes,
- Introduction to engineering drawing geometry - CAD.

6. CURRENT WORK

- CFD in reactive flows: Flow in a fire scenario of a traffic tunnel, with longitudinal ventilation. Effects of radiation heat losses on temperature field development and ventilation efficiency. Multiscale approach in long tunnels, use of ANSYS solver and the Open Foam. Mixture-fraction approach in modelling reactive flow. Combustion in Open Foam.
- Hot-wire anemometry circuit design updates: experimental verifications.
- Cardiovascular biomechanics: Flows in coronary arteries. CAD model generation from MRI & CT scan medical image data. FFR computation;

7. FURHER INTERESTS

- IGA (isogeometric analysis) multiscale approaches and optimisation methods;
- Heat transfer applications

8. PUBLICATIONS

- *Šekularac, B. Milan, Janković. Experimental and Numerical Analysis of Flow Field and Ventilation Performance in a Traffic Tunnel Ventilated by Axial Fans; Theoretical and Applied Mechanics Journal, Academy of Sciences and Arts of Serbia, 2017.*
- *Šekularac, B. Milan, Jankovic, Z. Novica, Vukoslavcevic, V.Petar. Ventilation Performance and Pollutant Flow in a UnidirectionalTraffic Road Tunnel. Thermal Science Journal, DOI: 10.2298/TSCI160321117S. 2016.*

- *Šekularac, B. Milan. Experimental Determination of Tunnel Ventilation Ducted Fan Performance. Thermal Science Journal, DOI.10.2298/TSCI 140624108S. 2014.*
- *Šekularac, B.Milan, Vukoslavčević, V.Petar. One Approach to Experimental and Numerical Investigation of Longitudinally Ventilated Road Tunnels. ICTTE Conference on Traffic and Transport Engineering, Belgrade. Nov.2012.*
- *Šekularac, M, Radulović, P. Energy Efficiency of Ventilation Systems of Longitudinally Ventilated Traffic Tunnels (in serbian). International conference on Alternative energy sources and energy efficiency, CANU – Montenegrin Academy of Sciences and Arts. Oct.2011.*
- *Šekularac M, Tombarević E. Analysis of Geothermal Heat Exchanger „AirtoGround" in the Climatic Conditions of Podgorica City (in serbian). International conference on Alternative energy sources and energy efficiency, CANU – Montenegrin Academy of Sciences and Arts. Oct.2013.*
- *Vukoslavčević P., Šekularac M., Wallace J., Balaras E., Beratlis N. The accuracy of crossstream velocity gradients measured by a multisensor hotwire probe. American Physical Society, 62nd Annual Meeting of the APS Division of Fluid Dynamics, Nov. 2224, 2009.*
- *Tombarević E., Šekularac M. 2DAnalysis of the Cooling Potential of Underground Waters of Podgorica City (in serbian). International conference on Alternative energy sources and energy efficiency, CANU – Montenegrin Academy of Sciences and Arts. Oct.2009.*
- *Šekularac M., Vušanović I. System Dynamics of a Heat Pump with Climatic Chamber in Cooling Regime of Operation (in serbian). Journal of KGH, Serbian Society of Airconditioning, Heating and Refrigeration Engineers. Belgrade, Sept. 2008.*
- *Vuksanović D., Kažić N., Šekularac M. Analysis of Energy Efficiency of One Office Building in Podgorica. COSMO EE Conference, 2010.*

9. OTHER INTERESTS / sports / culture / volunteer /

Languages: German, Italian

Sports

- Competitor in archery, national champion, various regional, central-European, US regional, competitor and medal winner, competitor at 3 World and 1 European Championships in Target and Field archery. Competitor in several disciplines (archery styles) and tournament formats;
- Founder and currently Director of National Archery Association, Club coach;
- Alpine skiing enthusiast and hiker in mountains;
- Swimming.

Other

- Design of archery equipment (composite limbs, different components).