UNIVERZITET CRNE GORE
MAŠINSKI FAKULTET
PODGORICA

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Web : www.ucg.ac.me/mf, Mail: mf@ucg.ac.me

Broj: 2089/1
Podgorica, 10.09.2021. godine

UNIVERZITET CRE GORE
CENTAR ZA DOKTORSKE STUDIJE

U prilogu dostavljamo Prijedlog odluke Vijeća Mašinskog fakulteta, sa sjednice održane dana 10.09.2021. godine o predlaganju formiranja komisije za odbranu polaznih istraživanja i ocjenu podobnosti doktorske teme i kandidata mr Vuka Kovijanića.

UNIVERZITET CRNE GORE Mašinski fakultet

DEKAN,
Prof. dr Igor Vušanović

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Broj: 2089
Podgorica, 10.09.2021. godine

Na osnovu člana 64. Statuta Univerziteta Crne Gore, u vezi sa čanom 26 i 27 Pravila doktorskih studija, Vijeće Mašinskog fakulteta u Podgorici, na sjednici održanoj elektronskim putem, dana 10.09.2021. godine, utvrdilo je prijedlog

ODLUKE
o formiranju Komisije za odbranu polaznih istraživanja
i ocjenu podobnosti doktorske teze i kandidata

I Formira se komisija za odbranu polaznih istraživanja i ocjenu podobnosti doktorske teze pod nazivom „Eksperimentalno i numeričko istraživanje prelaznih procesa izazvanih interakcijom vazduha i vode tokom punjenja i pražnjenja cijevnog sistema pod pritiskom" kandidata Vuka Kovijanića, u sastavu:

1. Prof. dr Igor Vušanović,
2. Prof. dr Uroš Karadžić,
3. Doc. dr Milan Šekularac.

II Odluka stupa na snagu kad je verifikuje Senat Univerziteta Crne Gore.

DEKAN,
Prof. dr Igor Vušanović

UNIVERZITET CRNE GORE
Mašinski fakultet
Komisija za doktorske studije
Podgorica, 21. 07. 2021.

- VIJEĆE MAŠINSKOG FAKULTETA –

Poštovani,

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

Komisija za doktorske studije na Mašinskom fakultetu je na elektronskoj sjednici održanoj dana 21. 07. 2021. 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 Igor Vušanović, predsjednik,

2. Prof. dr Uroš Karadžić, 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,

PREDSJEDNIK KOMISIJE ZA
DOKTORSKE STUDIJE

Prof. dr Aleksandar Vujović

UCG

UNIVERZITET CRNE GORE
MAŠINSKI FAKULTET PODGORICA
81000 Podgorica, Džordža Vašingtona bb, žiro račun broj: 510-154-63

MAŠINSKI FAKULTET
KOMISIJA ZA DOKTORSKE STUDIJE

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

Odlukom Senata Univerziteta Crne Gore br. 03-4124/1-1 od 24.12.2019. godine, imenovan sam za mentora na izradi doktorske disertacije kandidatu mr Vuku Kovijaniću.

Pošto su se stekli uslovi za odbranu polaznih istraživanja, i na osnovu razgovora sa kandidatom mr Vukom Kovijanićem, predlažem Komisiju za odbranu polaznih istraživanja za izradu doktorske disertacije pod nazivom:

"Eksperimentalno i numeričko istraživanje prelaznih procesa izazvanih interakcijom vazduha i vode tokom punjenja i pražnjenja cijevnog sistema pod pritiskom"

u sledećem sastavu:

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

U Podgorici, dana 19.07.2021. godine.

MENTOR

Prof. dr Uroš Karadžić

PRIJAVA TEME DOKTORSKE DISERTACIJE

OPŠTI PODACI O DOKTORANTU	
Titula, ime i prezime	Magistar, MSc Vuko Kovijanić
Fakultet	Mašinski fakultet
Studijski program	Mašinstvo
Broj indeksa	2/19
Ime i prezime roditelja	Vladimir/Jelica Kovijanić
Datum i mjesto rođenja	05.11.1986, Beograd, Srbija
Adresa prebivališta	Gavra Vukovića bb, 81000 Podgorica, Crna Gora
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BIOGRAFIJA I BIBLIOGRAFIJA	
Obrazovanje	1. Postdiplomske magistarske akademske studije na Mašinskom fakultetu u Podgorci, Univerzitet Crne Gore, 15.10.2019. godine, ocjena A 2. Postdiplomske specijalističke akademske studije na Mašinskom fakultetu u Podgorci, Univerzitet Crne Gore, 17.09.2010. godine, ocjena C 3. Diplomske osnovne akademske studije na Mašinskom fakultetu u Podgorci, Univerzitet Crne Gore, 20.07.2009. godine, ocjena D
Radno iskustvo	1. 08.07.2019. – danas, Izvršni direktor firme Kronor d.o.o. Podgorica; 2. 01.02.2015. – danas, Ovlašćeni mašinski inženjer u firmi M&J Invest d.o.o. Podgorica; 3. 01.11.2012. – 07.10.2014, Inženjer saradnik u firmi Hidroenergija Montenegro d.o.o. Podgorica; 4. 29.10.2010. – 31.10.2012, Inženjer saradnik u firmi Sistem d.o.o. Podgorica;
Popis radova	1. Vilotijević V., Karadžić U., Vujadinović R., **Kovijanić V.**, Božić M., (2021). An improved techno-economic approach to determination of more precise installed parameter for small hydropower plants, in publication process 2. **Kovijanić V.** (2019). Functional application for calculation of basic parameters for small hydropower plants. *Master thesis.* University of Montenegro, Faculty of Mechanical Engineering, Podgorica, Montenegro. 3. Karadžić U., **Kovijanić V.**, Vujadinović R. (2014). Possibility for hydro energetic utilization of relatively researched water streams. *Water Resources*, 41(6), 774-781. 4. **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.

NASLOV PREDLOŽENE TEME	
Na maternjem jeziku	Eksperimentalno i numeričko istraživanje prelaznih procesa izazvanih interakcijom vazduha i vode tokom punjenja i pražnjenja cijevnog sistema pod pritiskom
Na engleskom jeziku	Experimental and numerical investigation of transients caused by the interaction of air and water during filling and emptying of a pressurized pipe system

Obrazloženje teme

U cilju obezbjeđivanja sigurnosti, pouzdanosti i dobrih performansi projektovanog sistema, neophodno je sprovoditi analize hidrauličkih prelaznih procesa izazvanih dvokomponentnim strujanjem zarobljenog vazduha i vode u cijevnim sistema pod pritiskom. Dvokomponentna strujanja sa interakcijom zarobljenog vazduha i vode javljaju se u industrijskim sistemima, kao što su hidroelektrane, pumpne stanice, distributivni vodovodni i kanalizacioni sistemi, itd. U ovoj disertaciji, primjenom računske dinamike fluida (CFD) sa modelom zapremine fluida (VOF), izvršiće se numeričko modeliranje, eksperimentalno istraživanje i simulacija prelaznih procesa izazvanih dvokomponentnim strujanjem vazduha i vode tokom brzog punjenja i pražnjenja horizontalne cijevi za različite početne uslove, tj. različite veličine vazdušnih džepova, vrijednosti početnog pogonskog pritiska i dimenzija otvora na kraju posmatranog sistema. Cilj ovog istraživanja je šire sagledavanje postojeće literature iz oblasti prelaznih procesa, te davanje odgovora na i dalje nedovoljno istražena pitanja koja se javljaju uslijed brzog punjenja i pražnjenja cijevi, uključujući sveobuhvatnije fizičko razumijevanje nagle promjene pritiska u cijevnim sistemima koji sadrže zarobljeni vazduh, kao i poboljšanje numeričkog modeliranja prelaznog dvokomponentnog strujanja u cijevima.

Pregled istraživanja

Pojava zarobljenog vazduha u hidrauličnim sistemima je najčešće rezultat nepotpunog uklanjanja vazduha tokom postupka punjenja, djelovanja vazdušnog ventila koji propušta vazduh tokom prelaznog talasa niskog pritiska, postepenog oslobađanja rastvorenog vazduha, kao i stvaranja vrtložnog strujanja na usisu i sl. (**Martin**, 1976; **Liou & Hunt**, 1997). Kretanje vazduha duž cjevovoda može biti sporo tokom punjenja, pa se vazdušni stub može zarobiti u blizini zatvorenog ventila ili na najvišoj tački sistema razdvajajući tako dva vodena stuba (**Bergant i dr.**, 2018). U hidrauličkim sistemima vazduh se uglavnom može nalaziti u vidu nepokretnih džepova ili pokretnih mjehurića različitih veličina, koji u zavisnosti od njihove veličine i lokacije, konfiguracije cjevnog sistema, mogu stvoriti štetne, ali i korisne hidrauličke efekte (**Martin** 1976). Pojava različitih efekata navodi na zaključak da prisustvo zarobljenog vazduha gotovo neizbježno stvara stepen neizvjesnosti ili nepredvidivosti u vezi sa prelaznim odgovorom posmatranog sistema (**Zhou i dr.**, 2018). Homogeno raspoređeni mjehurići vazduha ili zarobljeni vazdušni džepovi u cijevnim sistemima pod pritiskom mogu značajno smanjiti brzinu prostiranja talasa pritiska, jer slobodan vazduh povećava elastičnost vode i shodno tome, doprinosi smanjenju brzine, promjeni oblika, slabljenju i trajanju talasa pritiska (**Wylie i dr.**, 1993). Međutim, karakteristika vazdušnih džepova je smanjena inercija i visoka kompresibilnost, što omogućava naglo ubrzanje mase fluida, koja za rezultat ima povećanje porasta pritiska. Naglo ubrzanje stuba tečnosti prema zapremini zarobljenog vazduha koji je na atmosferskom pritisku predstavlja jedan od najozbiljnijih slučajeva pojave porasta pritiska (**Martins i dr.**, 2012). Vazdušni džepovi mogu negativno uticati na smanjenje hidrauličkog kapaciteta i efektivne površine cijevi, dok dvokomponentno strujanje

vazduha iv ode može smanjiti efikasnost hidrauličkih postrojenja (**Maddahian i dr.**, 2020). Punjenje može stvoriti opasne skokove pritiska kada se vazdušni džepovi brzo kompresuju, a vazdušni ventili ne izbace dovoljnu količinu vazduha (**Zhou i dr.**, 2013; **Wang i dr.**, 2019). Postupak pražnjenja može proizvesti vrijednosti subatmosferskog pritiska zbog ekspanzije vazdušnih džepova, ako vazdušni ventili ne mogu propustiti količinu vazduha sa sličnim odnosom ispražnjene vode (**Coronado-Hernandez dr.**, 2018). Najčešći metod za eliminisanje zarobljenog vazduha je implementacija vazdušnih ventila duž sistema, na pozicijama istaknutih visinskih tačaka ili na drugim mjestima gdje se zarobljeni vazduh može pojaviti.

1. Punjenje cjevovoda

Vršni privremeni pritisci izazvani kompresijom vazdušnim džepom su aktivno ispitivani eksperimentalno i teorijski. **Holley** je još 1969. godine u svom eksperimentalnom istraživanju pokazao da se pri naglom punjenju može dogoditi udar visokog pritiska u prisustvu zarobljenog vazdušnog džepa. (**Liu, Zhou i dr.**, 2011, **Bucur i dr.**, 2016, **Zhou i dr.**, 2018, **Tijsseling i dr.**, 2019) izveli su eksperimente sa zarobljenim vazdušnim džepovima u zatvorenim i u odzračenim cjevovodima, gdje su potvrdili da zarobljeni vazduh može izazvati ozbiljne skokove pritiska tokom naglog punjenja. Složenost postupka punjenja uzrokuje poteškoće i izazove u numeričkim simulacijama. Postojeće numeričke metode za simulaciju prelaznih procesa sa zarobljenim vazduhom su obično jednodimenzione (1D) i mogu se podijeliti u dvije kategorije: model krutog vodenog stuba (RWCM) i model elastičnosti vode (EWM). Prva metoda, RWCM, zanemaruje kompresibilnost fluida i elastičnost zidova cijevi, dok druga, EWM metoda uzima u obzir oboje, a zarobljeni vazdušni džep se kod obje metode tretira kao idealan gas (**Zhou i dr.**, 2011). **Martin** (1976) je razvio jednostavan model krutog vodenog stuba u kojem je stišljivost vode bila zanemarena. **Fuertes** (1999) i **Zhou i dr.**, (2002c) su pobolšali Martinov model sa modelom vazdušne faze i gubitkom energije. **Liu i Suo** (2004. i 2005.) predložili su cjeloviti model krutog vodenog stuba koji je uključio praktične faktore, kao što su gubitak energije na ulazu uzvodno, vrijeme otvaranja ventila i promjena nadmorske visine cjevovoda. **Streeter i Wylie** (1993), **Chaiko i Brinckman** (2002) uključili su kompresibilnost vode i riješili jednačinu kontinuiteta i jednačinu promjene količine kretanja pomoću metode karakteristika (MOC) kreirajući elastični model. Ovi istraživači su razmatrali elastičnost vode, kao i zvučne efekte u vazdušnoj fazi i predložili su najcjelovitiji numerički model za problem zarobljenog vazdušnog džepa na kraju cijevi. Poboljšanja EWM-a su dali **Covas i dr.** (2003) koji su uključili efekte nestacionarnog trenja i viskoelastičnost zida cijevi. **Lee i Martin** (1999), su uvidjeli da RWCM nije pogodan za upotrebu kod sistema sa malim vazdušnim džepom, kao i za visoke ulazne pritiske, dok EWM pokazuje dobro generalno slaganje sa eksperimentalnim rezultatima za vršni pritisak. **Bergant i dr.**, (2018) su u svom istraživanju ugradili vazdušni džep kao granični uslov u diskretni gasni kavitacioni model (DGCM) koji uzima u obzir efekte nestacionarnog trenja. **Wang i dr.** (2018) su istraživali kako različiti modeli trenja, stacionarni, kvazi stacionarni i nestacionarni modeli trenja utiču na efektivne veličine tokom punjenja horizontalne cijevi sa zarobljenim vazduhom. Dobijeni rezultati numeričkih simulacija i eksperimentalnih ispitivanja su potvrdili snažan uticaj efekta nestacionarnog trenja na istoriju promjene pritisaka. Opisani 1D modeli zanemaruju dinamičku interakciju na mjestu veze koja se uspostavlja između vazduha i vode, te nijesu u stanju da efikasno simuliraju kretanje i položaj vazdušnog džepa prilikom njegove interakcije sa vodom. Ovakvi modeli imaju tendenciju da tačno predvide prvi vršni pritisak, dok se preostali obrasci oscilacija pritiska ne mogu predvidjeti

sa prihvatljivom tačnošću. Pregledom literature u poslednjih 10 godina, može se zaključiti da je računska dinamika fluida (CFD) sa modelom zapremine fluida (VOF) imala solidan uspjeh u simulaciji brzog punjenja cijevi sa zarobljenim vazdušnim džepom. Visoka tačnost i sveobuhvatne informacije koje pružaju CFD modeli u simulacijama, bili su glavna motivacija za njenu upotrebu. CFD modeli se baziraju na tri osnovna fizička principa: zakon očuvanja mase (jednačina kontinuiteta), II Njutnov zakon (zakon promjene količine kretanja) i zakon očuvanja energije (**Besharat i dr.**, 2019), **Hirt i Nichols** (1981) su prvi predložili VOF model, kojeg su kreirali za dva ili više fluida koji se ne miješaju na mjestu njihovog dodirivanja (interfejsa). **Liu i Zhou** (2009) su istraživali brzo punjenje zatvorene horizontalne cijevi koji sadrži zarobljeni vazduh koristeći (VOF) model u 2D, CFD simulaciji. **Zhou i Liu** (2011) su razvili 1D model i VOF 2D i 3D model za simulaciju brzog punjenja i uočili da su se CFD modeli bolje uklopili od predstavljenog 1D modela u fizičkoj relevantnosti i numeričkoj tačnosti, sa rezultatima iz prošlih eksperimentalnih istraživanja. **Martins i dr.** (2012) su izvršili opsežno prikupljanje eksperimentalnih podataka i uporedili ih sa numeričkim rezultatima 2D-VOF modela u CFD-u, te zaključili dobro poklapanje. **Martins i dr.** (2017) su primjenom VOF metode izvršili simulaciju brzog punjenja vertikalne cijevi sa zatvorenim krajem, koja je komplementarna eksperimentalnim testovima izvedenim u objektu koji koristi **Martins** (2012) za različite početne uslove pritisaka, veličine vazdušnog džeta i manevra ventila. **Li i Zhu** (2018) su koristili VOF metodu za simulaciju prelaznog pritiska vazdušnog džepa prilikom brzog punjenja horizontalne cijevi sa otvorom na njenom kraju dok su **Zhou i dr.** (2018) koristili VOF model za 3D simulaciju polja protoka za slučaj punjenja vertikalne cijevi sa otvorom za ispuštanjem vazduha na njenom kraju. Iako su rezultati numeričkog modela potvrđeni eksperimentalnim rezultatima studije **Zhou i dr.** (2002) i dalje se javljaju nedoumice i nova pitanja za dalja istraživanja u ovoj oblasti.

2. Pražnjenje cjevovoda

Održavanje vodovodnih sistema zahtijeva sprovođenje postupaka koji uključuju pražnjenje cjevovoda, prilikom kojeg se protok vode zamjenjuje protokom vazduha. Kada je gravitacioni protok vode prespor, ili u slučajevima gdje nije moguće isprazniti cijev zbog talasastog uzdužnog profila cjevovoda, voda se iz sistema izbacuje vazduhom pod pritiskom, dok kod cjevovoda koji imaju konstantan pad sile gravitacije pokreću pražnjenje. U naftovodnim sistemima, za operaciju pražnjenja prilikom uklanjanje tečnih proizvoda, potrebna je injekcija inertnog gasa poput azota (**Martinoia et al.**, 2012). Proces pražnjenje cjevovoda karakteriše ekspanzija vazdušnog džepa koja proizvodi talase ekstremnih vrijednosti subatmosferskih pritisaka, koji mogu dovesti do izvijanja i oštećenja cijevi. **Collins i dr.** (2012) su proučavali efekat smanjenje pritiska pri jakom privremenom pritisku u cjevovodima, demonstrirajući svojstvenost destruktivnog efekta ovog fenomena, sa kojim se mora postupati oprezno. Dosadašnje studije su relativno malo pažnje posvetile procesima pražnjenja u odnosu na procese punjenja. Prva proučavanja ulaska vazduha i kretanja mjehurića vazduha pri gravitacionom pražnjenju cijevi izvršio je **Zukoski** (1966) i **Benjamin** (1968). **Vasconcelos i Vright** (2008) su proučavali pražnjenje horizontalne cijevi sa uzvodnim konstantnim pritiskom obezbijeđenog pomoću rezervoara komprimovanog vazduha, za slučaj brzog otvaranja ventila na donjem kraju cijevi. **Laanearu i dr.** (2012) su sproveli eksperimentalna i numerička istraživanja pražnjenja horizontalnog cjevovoda velikih razmjera pod pritiskom, sa različitim vrijednostima pogonskih pritisaka komprimovanog vazduha i uslovima ograničenja na kraju cjevovoda, kako bi pratili kretanje fronta vazduh-voda kroz cjevovod. U

određenim studijama je kreiran jednostavan numerički model kontrolnih zapremina, koji uzima u obzir gubitak mase vodenog stuba, i koji je imao kašnjenje za stvarno izmjerenim oscilacijama protoka i pritisaka. **Karadžić i dr.** (2015) su izveli eksperimentalna istraživanja pražnjenja horizontalnog cjevovoda malih razmjera za različite početne vrijednosti pogonskog pritiska vazduha sa uzvodne strane sistema. **Tijsseling i dr.** (2016) su predstavili poboljšani 1D model za brzo pražnjenje u cevovodima sa promenljivom brzinom vode, sa trendom protoka i pritiska koji ima jednostavan obrazac sa ograničenim oscilacijama. **Coronado-Hernández i dr.** (2018) su izveli model krutog vodenog stuba (RWCM) za analizu prelaznih procesa koji se javljaju tokom pražnjenja cjevovoda sa vertikalnim koljenom na njegovom kraju, sa vazduhom pod pritiskom. Predstavljeni model je pokazao dobro slaganje sa eksperimentalnim rezultatima koje je sproveo **Laanearu i dr.** (2012) i bolje je predvidio prelazne vrijednosti protoka i pritiska od drugih modela. **Besharat i dr.** (2019) su pomoću (CFD) 2D modela izvršili simulaciju procesa pražnjenja u jednoj cijevi sa konstantnim padom, bez mogućnosti upuštanja vazduha sa zarobljenim džepom sa gornje strane. Rezultate simulacije potvrdili su eksperimentalnim rezultatima. U svom istraživanju otkrili su pojavu povratnog vazduha u eksperimentalnoj instalaciji tokom postupka pražnjenja cijevi. Prema sazanjanju autora, u okviru istraživanja ove disertacije će po prvi put biti primjenjena računska dinamika fluida sa uključenim VOF modelom za numeričko rješavanje i simulaciju pražnjenja cijevi sa upuštanjem vazduha pod pritiskom sa uzvodne strane sistema.

Cilj istraživanja

Ciljevi istraživanja ove disertacije su:

- Eksperimentalno i numeričko istraživanje efekata interakcije vode i vazduha tokom punjenja i pražnjenja cjevovoda za različite početne i granične uslove.
- Procjena primjenjivosti računske dinamike fluida (CFD) sa uključenim VOF modelom za istraživanje dinamičkog ponašanja zarobljenog vazdušnog džepa tokom operacija punjenja i pražnjenja cjevovoda upoređivanjem sa eksperimentalnim rezultatima.
- Prikaz simulacije efekata interakcije vode i vazduha tokom izazvanih dvokomponentnih prelaznih procesa punjenja i pražnjenja hidrauličkog sistema, korišćenjem VOF modela.

Materijali, metode i plan istraživanja

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

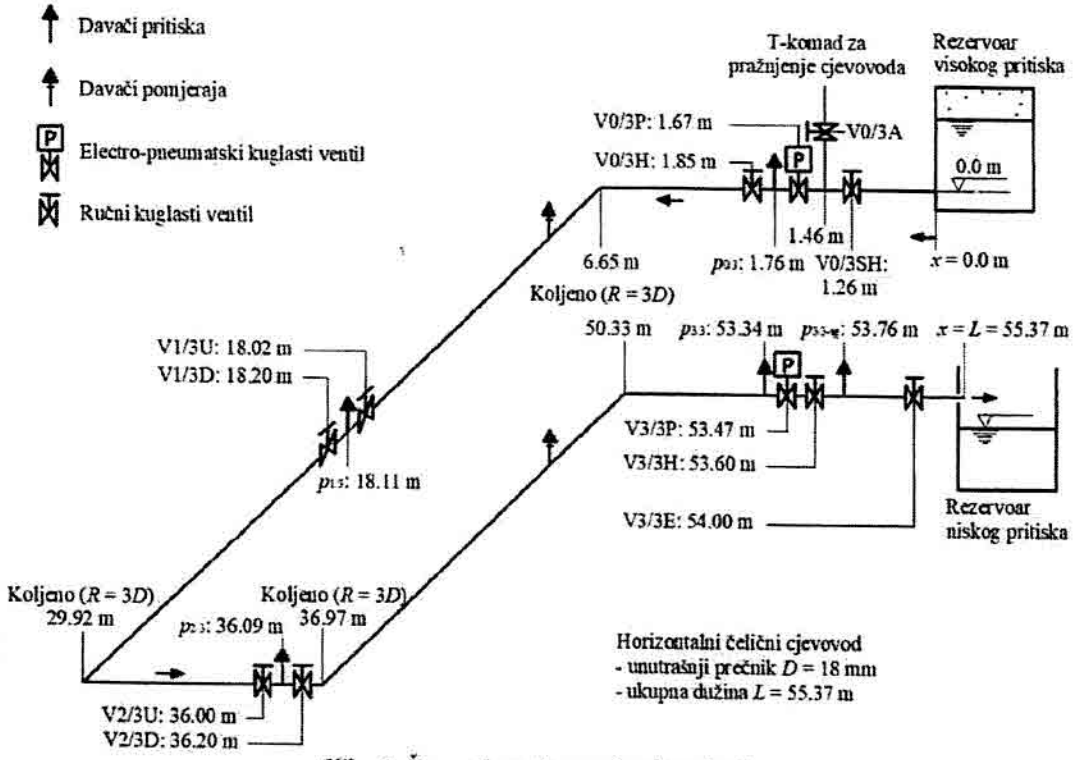
Opsežna analiza dosadašnjih istraživanja prelaznih procesa izazvanih interakcijom vazdušnih džepova i vode tokom punjenja i pražnjenja hidrauličkih sistema pod pritiskom, dovešće do sveobuhvatnijeg fizičkog i teorijskog razumijevanja prirode, odnosa, uzroka i posledica ovih procesa u okviru oblasti primijenjene mehanike fluida. U cilju pravilnog razumijevanja ovog složenog fenomena, istraživanje će biti obavljeno u strogo kontrolisanim laboratorijskim uslovima na eksperimentalnoj instalaciji u prostorijama Laboratorije za energetiku Mašinskog fakulteta u Podgorici, pri čemu će se obaviti i provjera pretpostavki usvojenih u numeričkom modelu. Numerički model će biti kreiran u softverskom paketu ANSYS Fluent.

Istraživački postupak u ovoj disertaciji obuhvata eksperimentalno ispitivanje, numeričko modeliranje i simulaciju prelaznih procesa tokom interakcije zarobljenog vazduha i vode uslijed punjenja i pražnjenja horizontalnog cjevovoda za različite početne i granične uslove. Primjenom računske dinamike fluida (CFD) sa uključenim VOF modelom kreiraće se numerički model za predviđanje talasa pritiska i kretanja vazdušnog džepa, a njegova validacija izvršiće se poređenjem sa rezultatima dobijenim na osnovu ispitivanja na eksperimentalnoj instalaciji čiji su opis i šema

dati u nastavku. Rezultati dobijeni eksperimentima, kao i numeričkim modelom, biće analizirani sa aspekta uticaja početnih i graničnih uslova na prelazni talas pritiska. Simulacijom će biti prikazano kretanje, položaj i promjena oblika vazdušnih džepova unutar posmatranog sistema.

Eksperimentalna instalacija za ispitivanje hidrauličkih prelaznih procesa - fenomena hidrauličkog udara, kavitacije i razdvajanja strujnog toka, interakcije fluida i strukture cjevovoda (FSI - fluid structure interaction), punjenja i pražnjenja cjevovoda, kao i nestacionarnog trenja je projektovana i napravljena na Mašinskom fakultetu u Podgorici u Laboratoriji za energetiku 2011. godine, a 2018. godine urađena su određena unapređenja u cilju povećavanja njenih istraživačkih mogućnosti. Instalacija se sastoji od cjevovoda koji povezuje rezervoar visokog pritiska uzvodno sa rezervoarom niskog pritiska na nizvodnoj strani (čelični cjevovod ukupne dužine L=55.37 m; unutrašnjeg prečnika d=18 mm; debljine zida cjevovoda e=2 mm; najveći dozvoljeni pritisak u cjevovodu je $p_{max\ wk}$= 25 MPa). – Slika. 1. Četiri grupe ventila postavljene su duž cjevovoda uključujući početnu i krajnju tačku. Grupa ventila ispred uzvodnog rezervoara (pozicija 0/3) sastoji se od elektro-pneumatskog i ručnog kuglastog ventila, a ventilske grupe duž cjevovoda (pozicije 1/3 i 2/3), koje se nalaze na istoj međusobnoj udaljenosti, sastoje se od dva ručna kuglasta ventila (ventili V0/iU i V0/iD; i = 1, 2). U svakoj ventilskoj grupi se nalazi blok sa senzorima dinamičkog i apsolutnog pritiska. Na instalaciji postoji i T-komad sa dva ventila na uzvodnoj ventilskoj grupi koji služi za izvođenje eksperimenata pražnjenja cjevovoda komprimovanim vazduhom pod pritiskom. Za potrebe eksperimenata punjenja i pražnjenja cjevovoda izrađeni su komadi različitih otvora (prečnika otvora od 1 do 14 mm) koji se mogu montirati na kraju sistema. Na instalaciji se nalaze 4 koljena (90°) sa poluprečnikom R=3D. Cjevovod je učvršćen protiv aksijalnih pomjeranja u 37 tačaka (blizu ventilskih grupa i koljena). Oslonci se mogu opustiti za potrebu izvođenja eksperimenata koji uključuju FSI efekte. Vazdušni pritisak u uzvodnom rezervoaru (ukupne zapremine $\forall_{HPT}$ = 2 m^3; maksimalni dozvoljeni pritisak u rezervoaru $p_{HPTmax;\ all}$ = 2.2 MPa) može se podešavati do 800 kPa. Pritisak u rezervoaru prilikom svakog eksperimenta je konstantan zahvaljujući visoko preciznom regulatoru pritiska koji pripada grupi za snabdijevanje komprimovanim vazduhom. Duž cjevovoda pod pritiskom postavljena su četiri davača dinamičkog pritiska i četiri davača apsolutnog pritiska, koji se nalaze u ventilskim grupama (Slika 1.). Dinamički pritisci na pozicijama $p_{0/3}$, $p_{1/3}$, $p_{2/3}$ i $p_{3/3}$ se mjere pomoću Dytran 2300V4 visokofrekventnog pijezoelektričnog davača (mjerenje pritiska u opsegu 0÷69 bar, osjetljivost 5 mV/ 0.069 bar, preciznost ±0.1%), a apsolutni pritisci pomoću Keller PAA-M5 HB davača pritiska (mjerenje pritiska u opsegu 0÷30 bar, osjetljivost 10 mV/ 0.03 bar, preciznost ±0.1%). Referentni nivo za sve pritiske mjerene u cjevovodu i rezervoaru je na početku horizontalnog čeličnog cjevovoda (visina 0 m na Slici 1). Temperatura vode se neprekidno mjeri pomoću termometra koji je montiran u posudi za skupljanje vode. Elektro-pneumatski ventili (V3/3P and V0/3P) su upravljani filtriranim komprimovanim vazduhom, dovedenim plastičnim crijevom od regulatora pritiska, čiji je pritisak nezavisan u odnosu na pritisak u sistemu. Prelazni procesi mogu se izazvati brzim zatvaranjem ili otvaranjem ventila na nizvodnom kraju, koristeći ili V3/3P ili V3/3H ili pomoću ventila na uzvodnom kraju V0/3P. Ventili V3/3P i V3/3H opremljeni su senzorom (opseg mjerenja: 0° do 90°, frekventni odziv: > 10 kHz) koji mjeri promjenu ugla ventila (α) tokom zatvaranja ili otvaranja. Pored toga, prelazni procesi se mogu izazvati zatvaranjem ili otvaranjem ručnih ventila duž cjevovoda (ventili V0/3H; Vi/3U i Vi/3D; i =1, 2). Na rezervoaru visokog pritiska i na nizvodnom kraju cjevovoda, postavljena su dva davača statičkog pritiska ($p_{0/3\text{-}sg}$ i $p_{3/3\text{-}sg}$; opseg pritiska: od 0 MPa do 1 MPa, preciznost: ±0.5 %). Ovi davači se koriste za procjenu početnih uslova u sistemu. Za podešavanje protoka kroz instalaciju koristi se ručni kuglasti ventil (V3/3E). Protok (brzine veće od 0.3 m/s) se mjeri pomoću elektromagnetnog mjerača protoka (preciznost: ± 0.2%). Svi izmjereni podaci prikupljaju se pomoću mjerno-upravljačkog sistema

(compact DAQ platforma proizvođača National Instruments) koji je povezan sa računarom, odakle se ujedno upravlja elektro-pneumatskim ventilima.



Slika 1. Šema eksperimentalne instalacije

Na eksperimentalnoj instalaciji planirano je izvođenje eksperimenata koji obuhvataju:

1. Interakciju zarobljenog vazdušnog džepa i vode tokom punjenja horizontalne cijevi koja je zatvorena na donjem kraju sistema za različite kombinacije početnih uslova (zapremina zarobljenog vazdušnog džepa, pritisak u rezervoaru visokog pritiska i vrijeme zatvaranja ventila).
2. Interakciju zarobljenog vazdušnog džepa i vode tokom punjenja horizontalne cijevi koja je otvorena na donjem kraju sistema za različite kombinacije početnih uslova (zapremina zarobljenog vazdušnog džepa, pritisak u rezervoaru visokog pritiska, dimenzija otvora i vrijeme zatvaranja ventila).
3. Interakciju vazduha i vode tokom pražnjenja horizontalne cijevi sa komprimovanim vazduhom za različite kombinacije početnih uslova (pogonski pritisak, dimenzija otvora i vrijeme otvaranja ventila).

Svaki eksperiment će se izvoditi po tri puta za iste početne i granične uslove, kako bi se obezbijedila ponovljivost eksperimenata. Natpritisak u rezevoaru visokog pritiska će se varirati od 0 do 4 bara.

Očekivani naučni doprinos

Naučni doprinos ove disertacije se ogleda u popunjavanju postojećih praznina u literaturi posvećenoj proučavanju dvokomponentnih prelaznih procesa tokom punjenja i pražnjenja cjevovoda pod pritiskom, putem numeričkog modeliranja i eksperimentalnog ispitivanja efekata

koji nastaju usled istih. Po prvi put će se primijeniti računska dinamika fluida sa uključenim VOF modelom za numeričko rješavanje i simulaciju pražnjenja cijevi sa vazduhom pod pritiskom sa uzvodne strane sistema. Pored vodovodnih sistema, primjena ovog istraživanja se ogleda i kod naftnih sistema koji se prazne ubrizganvanjem gasa. U okviru eksperimentalnog dijela istraživanja biće primijenjen širi raspon početnih i graničnih uslova u odnosu na dosadašnje studije. Ovo istraživanje će dovesti do boljeg razumijevanja efekata koji nastaju usled interakcije vazduha i vode tokom punjenja i pražnjenja cjevovoda. Gledano iz praktičnog ugla, kreirani numerički model u ovoj disertaciji će imati izuzetan značaj za sadašnje i buduće studente Mašinskog fakulteta u Podgorici, ali i šire, koji će njegovom primjenom moći da simuliraju prelazne procese koji se javljaju tokom punjenja i pražnjenja cjevovoda.

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SAGLASNOST PREDLOŽENOG/IH MENTORA I DOKTORANTA SA PRIJAVOM		
Odgovorno potvrđujem da sam saglasan sa temom koja se prijavljuje.		
Mentor	Prof. dr Uroš Karadžić	
Doktorant	MSc Vuko Kovijanić	

IZJAVA

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

U Podgorici,
19.07.2021.

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Vuko Kovijanić je mašinski inženjer iz oblasti hidroenergetike, sa višegodišnjim iskustvom u projektovanju, izvođenju, nadzoru i upravljanju hidroenergetskim objektima i postrojenjima za proizvodnju električne energije. Tokom svoje karijere je radio kao lider na projektima malih hidroelektrana, kroz koje je pored svoje struke stekao napredno znanje i iskustvo iz povezanih oblasti: obnovljivih izvora energije, hidrologije, ekologije, geodezije, hidro-tehnike, elektro- tehnike i ekonomije. Trenutno je na doktorskim studijama na kojima se bavi istraživanjem hidrauličkih prelaznih procesa u sistemima pod pritiskom.
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- Izrada analize rentabilnosti projekata OIE;
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Objavljeni radovi:

- Vilotijević V., Karadžić U., Vujadinović R., **Kovijanić V.,** Božić M., (2021). An improved techno-economic approach to determination of more precise installed parameter for small hydropower plants, in publication process (*u procesu objavljivanja*).
- Karadžić U., **Kovijanić V.**, Vujadinović R. (2014). Possibility for hydro energetic utilization of relatively researched water streams. *Water Resources*, 41(6), 774-781.

Radovi sa konferencija:

- **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.

Naučno-istraživački projekti:

- Katastar malih vodotoka sa mogućnošću iskorišćenja hidroenergetskog potencijala, finansirano od EBRD-a. (član radnog tima) (2011-2012)

Rad na računaru:

- MS Office paket (Word, Excel, PowerPoint, Access)
- Matlab, Visual Basic paket, Ansys Fluent, Abaqus
- Adobe Ilustration
- AutoCad, Civil, ArcGIS, MapInfo, GoogleEarth

Poznavanje jezika:

- **Maternji jezici** – crnogorski, srpski, hrvatski
- **Drugi jezici** – engleski (srednji nivo, B2)

Licence i sertifikati:

- Licenca ovlašćenog inženjera za obavljanje djelatnosti izrade tehničke dokumentacije i građenja objekta br. UPI 107/7 – 1783/2

- Licenca ovlašćenog inženjera za složene inženjerske objekte, i to za proizodni elektro-energetski objekat (elektrane snage 1MVA i više, hidroelektrane, termoelektrane, vjetroelektrane, solarne elektrane i dr.) br. 005-302/20 – 2035/2

- Sertifikat za završeni napredni profesionalni trening iz obnovljivih izvora energije – hidroenergetika, izdat od strane Bayern International i TUM-Tech u saradnji sa Bavarskim Ministarstvom ekonomije, energetike i tehnologije. (Jun 2018.)

UNIVERZITET CRNE GORE
MAŠINSKI FAKULTET
MAŠINSTVO
Broj dosijea: **2/2019**

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 Kovijanić Vladimir Vuko, izdaje se

UVJERENJE O POLOŽENIM ISPITIMA

Student **Kovijanić Vladimir Vuko**, rođen **05-11-1986** godine u mjestu **Podgorica**, opština **Podgorica**, Republika **Crna Gora**, upisan je studijske **2019/2020** 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	"B"	(vrlodobar)	8.00
3.	1	METODE NAUČNO-ISTRAŽIVAČKOG RADA	"A"	(odličan)	6.00
4.	2	DVOFAZNI TOK	"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" (9.79)**
- ukupan broj osvojenih ECTS kredita **38.00** ili **63.33%**
- indeks uspjeha **6.20**.

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: 1781
Podgorica, 19.07.2021 godine

M. P.

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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

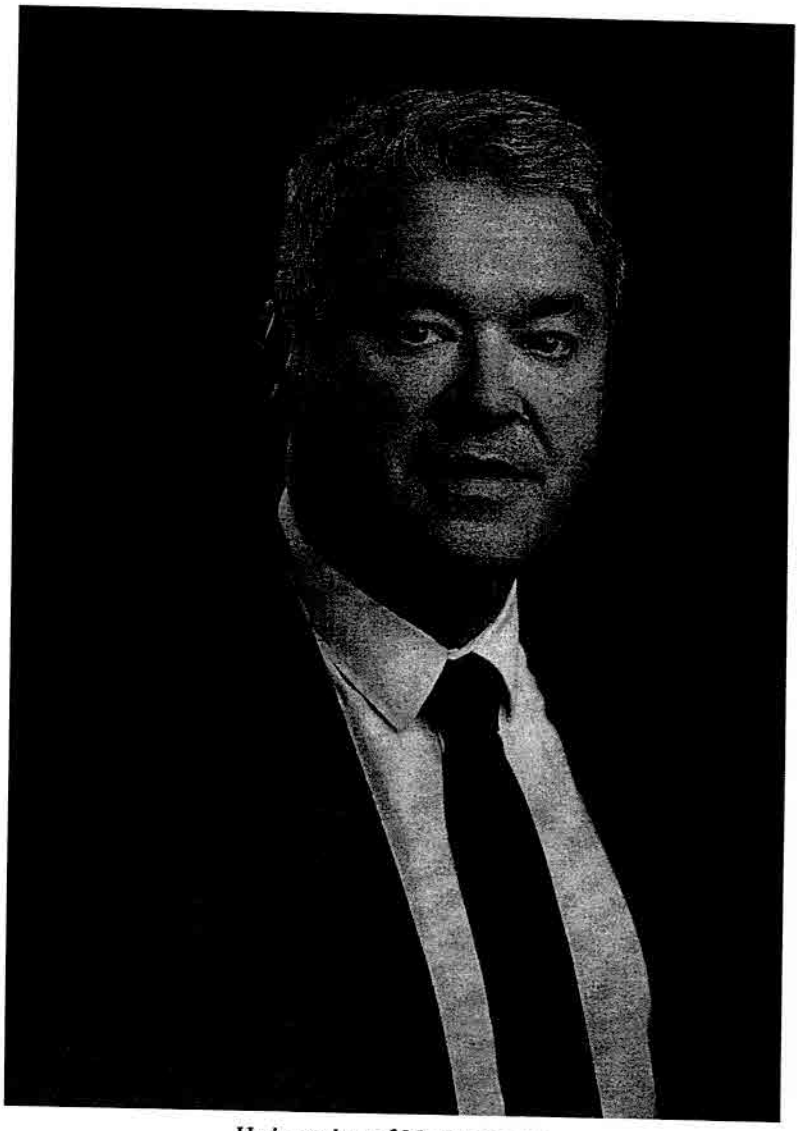
O D L U K U
O IZBORU U ZVANJE

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

CURRICULUM VITAE

Igor Vušanović



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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 was the mathematical and numerical modeling of different transport phenomena processes. One of the purest examples is solidification of multicomponent alloys. Concentration equation is additionally accompanied to the standard set of equations (flow and energy equation) and therefore additional thermodynamic modeling is necessary to get closed set ready to be solved. This additional model is known in literature as microsegregation model and in multicomponent system is usually based on two different sets of equations: generic conservation equations of enthalpy and concentration and comprehensive phase diagram that describes relation between phases that precipitates during the freezing process.

Next research interest is developing of different numerical techniques for solving standard set of transport equations. Recently we developed solution based on CVFEM numerical scheme (**C**ontrol **V**olume **F**inite **E**lement **M**ethod) which was applied in case of geothermal modeling of "U" type heat exchangers. Heat pumps as a devices is one of the key global solutions to the path of decarbonization in household and building stock in every city. We are interested to explore possibilities to use the soil as a heat sink and source for

heat pump systems, on sustainable way to preserve existing plants and keeping soil energy balances in both summer and winter season.

Another field that we are interested in our group is dynamic modeling of heat and cooling demands for building stock and household, in order to construct and design so called zero energy buildings (ZEB). Numerical techniques for this comprehensive modeling is based on solving of basic heat transfer equations of heat transfer, using periodic behavior of heat load in buildings and unsteady cooling, and solving of phenomena of heat island in cities.

Next field of interest is energy planning toward the implementation of RES in energy system in Montenegro. We are interested to see behavior of baseload in Montenegro and how this demand can be fitted with different types of renewable energy sources.

In the field of RES we are also interested for modeling of low frequent noise generated with wind turbines. This renewable energy source devices produce noise caused by turbulent flow and can affect leaving creature and birds in near surrounding. Our mission is to build a comprehensive models and have a basic knowledge to response on this important issue in next couple of decades.

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. Satya N. Atluri, Distinguished Professor, at the Department of Mechanical Engineering at Texas Tech University, Texas, USA.
2. Vaughan R. Voller, Professor, Department of Civil, Environmental and Geo – Engineering University of Minnesota, Minnesota, USA
3. Matthew J. M. Krane, Associate Professor, Materials Engineering, Purdue University, West Lafayette, IN, USA
4. Velimir Radmilović, Professor, National Center for Electron Microscopy, Lawrenc Berk ley National Laboratory, Berkeley, CA, 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 27 years, I have conducted studies about:

- 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,
- Modeling of heat transfer in vertical U type heat exchangers,
- Modeling of dynamic behavior toward the zero energy buildings,

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 temper-

atures, 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. J. Coleman, M.Krane, I. Vušanović, "Investigation of grain suspension in horizontal direct chill casting", *submitted to Materials Science and Technology*, Nov. 2020.
2. B. Hrnčić, A. Pfeifer, F. Jurić, N. Duić, V. Ivanović, I. Vušanović, "Different Investment Dynamics in Energy Transition Towards a 100% Renewable Energy System", *Submitted to Energy*, 2021.
3. I. Vušanović, V. R. Voller, "Reduced Complexity Solidification Models", *Int. Journal of Heat and Mass Transfer*, 169 (2021) 120923, https://doi.org/10.1016/j.ijheatmasstransfer.2021.120923.
4. Pireci, M., Vušanović, I., Analysis of the use of different standards for estimation of energy efficiency measures in the building sector, J. sustain. dev. energy water environ. syst. – *JSDEWES*, 1080375, DOI: http://dx.doi.org/10.13044/j.sdewes.d8.0375
5. 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)
6. 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. 427-439
7. 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, doi:10.1088/1757-899X/117/1/012062.
8. 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.
9. V. R. Voller, I. Vušanović "Frequency Analysis of Macrosegregation Measurements and Simulations", *International Journal of Heat and Mass Transfer* 79 (2014) 468–471.
10. 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).
11. 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.
12. 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.
13. 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*** *(2012) 012056, DOI: 10.1088/1757-899X/27/1/012056.*
14. 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.*
15. 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.

16. 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** (2012) 012069.
17. 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.
18. 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.
19. 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.
20. 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.
21. 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.
22. 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.
23. 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.
24. 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.
25. 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. I. Vušanović, "Challenges in modeling of solid movement in solid-liquid phase change systems", *ICCES: International Conference on Computational & Experimental Engineering and Sciences, January 6 – 10th, 2021, Phuket, Thailand.*
2. I. Vušanović, V.R. Voller, "Computations of steady state alloy solidification in a cavity", *6th International Conference on Computational Methods for Thermal Problems, THERMACOMP2020, N. Massarotti, P. Nithiarasu, and I. Vušanović (Eds.)*, Budva, Montenegro, Septembar 2021.
3. B. Hrnčić, A. Pfeifer, V. Ivanović, I. Vušanović, "Energy transition towards achieving a 100% renewable energy system: Case study of Montenegro", *4th SEE SDEWES conference*, Sarajevo, Bosnia & Herzegovina, June 2020.
4. M. Pireci, I. Vušanović, V. Ivanović "Analysis of use of different standards for estimations of energy efficiency measures in building sector, *4th SEE SDEWES conference*, Sarajevo, Bosnia & Herzegovina, June 2020.
5. 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.
6. 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.*
7. 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.*
8. 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.)*
9. I. Vušanović, "Transient permeability in macrosegregation of static casting in binary al-loys: Use of CDF statistical model for analysis ",*Modeling of Casting, Welding and Advanced Solidification Processes (MCWASP XV 2015)* Awaji Island, Japan, *June* 2015.
10. 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.
11. 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.)*
12. 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.)*
13. 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.

14. 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.*
15. 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
16. 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.*
17. 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*
18. 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*
19. 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*
20. 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*
21. 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*
22. I. Vušanović, "Energy efficiency in building sector: solutions for heating and air conditioning in Montenegro", *Third International Conference GNP 2010,* Žabljak, Montenegro, 2010.
23. 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.
24. 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.
25. 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.*
26. M. Šekularac, I. Vušanović, "Mathematical modeling of HVAC instalations", *Klima Forum 2007,* Godovič, Slovenia, *September 2007*
27. I. Vušanović, I. Vujošević, "Energy efficiency strategy in Montenegro – implementation and challenges", *Klima Forum 2007,* Godovič, Slovenia, *September 2007.*
28. I. Vušanović, B. Šarler, "Modeling of micro and macro segregation in DC casting of ternary Al based alloys", *EUROMAT 2007,* Nurnberg, Germany, *September 2007.*
29. 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).

30. 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.*
31. 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.*
32. N. Kažić, I. Vušanović, "Exergy and HVAC", *Klima forum 2006,* Godovič, Slovenia, *September 2006.*
33. 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.
34. 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.
35. 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.
36. 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.
37. 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.
38. 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.
39. 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.
40. I. Vušanović, "Numerical modeling of phase change in ice-water system by using modify entalphy method", 10th *Symposium YU - TERM '97*, Zlatibor, 1997.
41. 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.
42. I. Vušanović, V. Stevanovic, M. Studovic, "Transferring of waves in evaporator channel with disturbances of intake fluid flow", 24th *Congress KGH*, Belgrade, 1993.
43. I. Vušanović, V. Stevanovic, M. Studovic, "Mathematical model of forced and natural circulation – Modular approach", 23rd *Congress KGH*, Belgrade, 1992.

D. <u>Papers published in the proceedings of domestic conferences (in Serbian)</u>

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, "Modeliranje i optimizacija potrošnje energije u rezidencijalnim objektima u realnom vremenu (**MOPEREV**)", Ministarstvo nauke Crne Gore, 2021 – 2022.
2. 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.
3. 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.*
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. D. Gobin, B. Šarler, I. Vušanović, ˝ Advances in simulation capabilities for solidification systems˝, Programme ECO-NET 2005.

11. I. Vušanović, "Development of ternary microsegregation models for direct-chill casting and twin-roll strip casting of Al based alloys, *IMPOL d.d., 2004.*
12. 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. Maliq Pireci, "Uporedna analiza proračuna korišćenjem standarda MEST EN ISO 13790 i software-a RETScreen za potrebe analiza energetske efikasnosti objekata", University of Montenegro, Faculty of Mechanical Engineering, December 2019. (A).
2. Marko Đekić, "Energy use analysis of residential building equipped with heat pumps in Montenegro", University of Montenegro, Faculty of Mechanical Engineering, October 2017. (A).
3. Esad Tombarević, " Modelling of phase change in ice storage with horizontal pipe", University of Montenegro, Faculty of Mechanical Engineering, March 2009. (A).
4. 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)
5. Uroš Karadžić, "Analysis fluid transients phenomena in hydraulic systems", University of Montenegro, Faculty of Mechanical Engineering, October 2004. (A)
6. 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)

7. Boris Hrnčić, "Mathematical modelling and multi-criterion optimization of transient heat transfer in building sector in Montenegro", PhD thesis, University of Montenegro, Faculty of Mechanical Engineering, in progress.... (A)
8. Vidosava Vilotijević, "Numerical simulations and field data analyses of aerodinamical noise generation by wind turbine, PhD thesis, University of Montenegro, Faculty of Mechanical Engineering, in progress.... (A)
9. 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)
10. 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 multi-component 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.*

I. Monography, Books on which I. Vušanović participated as an author, co – author and editor

1. S. N. Atluri, I. Vušanović (eds), "Computational and Experimental Simulations in Engineering", *Mechanisms and Machine Science 97, Proceedings of ICCES 2020. Volume 2,* SPRINGER Nature, 2021.
2. S. N. Atluri, I. Vušanović (eds), "Computational and Experimental Simulations in Engineering", *Mechanisms and Machine Science 97, Proceedings of ICCES 2020. Volume 1,* SPRINGER Nature, 2021.
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3. I. Vušanović, M. Janjić, V. Lubarda, "50 godina Mašinskog fakulteta Univerziteta Crne gore: 1970 – 2020, *Univerzitet Crne Gore Cetinjska br. 2,* ISBN 978-9940-527-54-9, Podgorica, 2020.

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O D L U K U
O IZBORU U ZVANJE

Dr Uroš Karadžić bira se u akademsko zvanje redovni profesor Univerziteta Crne Gore za **oblast Termo i hidro energetika,** na Mašinskom fakultetu Univerziteta Crne Gore, na neodređeno vrijeme.

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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.** (2020). Mechanical engineering and hydro energetics. *Eds. Igor Vušanović, Mileta Janjić, Vlado Lubarda, Monograph 50 years of mechanical engineering studies in Montenegro, University of Montenegro, Faculty of Mechanical Engineering,* Podgorica, Montenegro. pp. 96-97, ISBN 978-9940-527-54-9 (in Montenegrin) 2. **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. Bergant A., Hässig S., **Karadžić U.**, Urbanowicz K., Tijsseling A. (2021). Developments in multiple-valve water hammer control. *IOP Conf. Series: Earth and Environmental Science*, Vol. 774, doi: 10.1088/1755-1315/774/1/012008.
2. Urbanowicz K., Bergant A., **Karadžić U.**, Jing H., Kodura A. (2021). Numerical investigation of the cavitating flow for constant water hammer number. *IOP Conf. Series:* Journal of Physics: Conf. Series, Vol. 1736, doi: 10.1088/1742-6596/1736/1/012040.
3. Urbanowicz K., Bergant A., Duan H.F., **Karadžić U.**, Sobkow D. (2021). Alternative numerical solution of transient flow in viscoelastic pipes. *IOP Conf. Series:* Journal of Physics: Conf. Series, Vol. 1736, doi: 10.1088/1742-6596/1736/1/012038.
4. Brđanin R., **Karadžić U.**, Bergant A., Ilić J. (2021). Influence of actuator pressure on electro-pneumatic valve closure time and pipe pressure rise. *IETI Transactions on Engineering Research and Practice*, Vol. 5, Issue 1, pp 1-7, doi 10.6723/TERP.202102_5(1).0001
5. Brđanin R., **Karadžić U.**, Bergant A., Ilić J. (2019). Recent developments in unsteady pipe flow experimentation at the University of Montenegro. *IOP Conf. Series: Earth and Environmental Science*, Vol.405, doi: 10.1088/1755-1315/405/1/012019
6. **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.
7. 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
8. 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.
9. 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.

10. 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.
11. 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)
12. 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.
13. 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.
14. **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)
15. **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.
16. 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)
17. **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., **Karadžić U.**, Bergant A., Ilić J. (2021). Experimental investigations of FSI mechanisms in pipeline systems. *DEMI 2021 - 15th International Conference on Accomplishments in Mechanical and Industrial Engineering,* Banja Luka, Republic of Srpska, BiH, 28-29 May, pp 195-200. 2. Brđanin R., **Karadžić U.**, Bergant A., Božić I. (2021). FSI effects caused by electro-pneumatically operated ball valve. 6th *IAHR Europe Congress*, Warsaw, Poland, 15-18 February. 3. Brđanin R., **Karadžić U.**, Bergant A., Ilić J. (2020). Influence of actuator pressure on electro-pneumatic valve closure time and pipe pressure rise. 5th *International Scientific Conference on Mechanical Engineering Technologies and Applications COMETa 2020*, Jahorina, Republic of Srpska, BiH, 26th – 28th November, pp 389-395. 4. 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. 5. 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. 6. 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. 7. **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. 8. 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.

9. **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.

10. 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.

11. 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.

12. **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.

13. 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.

14. 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.

15. 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.

16. 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.

17. 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.

18. **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.

19. 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.

20. **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.

21. **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.

22. **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. **Karadžić, U.**, Brđanin R. (2020). Experimental and numerical investigations of water hammer at the University of Montenegro. 5th *International Scientific Conference on Mechanical Engineering Technologies and Applications COMETa 2020*, Jahorina, Republic of Srpska, BiH, 26th – 28th November.

	Mentoring:	2. 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. ***1. PhD Thesis*** ***2. Master Thesis*** 1. Kovijanić, V. (2019). Functional application for calculation of basic parameters of small hydro power plants. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Montenegrin) 2. Vilotijević, V. (2018). Determination of the installed flow in small hydro power plants. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 3. 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) 4. 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) 5. Bulatović, V. (2014). Experimental and numerical

		investigations of water hammer effects. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 6. Kuljić, S. (2012). Numerical calculation of water supply system Nevesinje. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 7. Giljen, Z. (2011). Hydraulic transients modelling on Piva HPP. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 8. Jokić, S. (2011). Development of the experimental installation for water hammer investigation. *UCG, Faculty of Mechanical Engineering*, Podgorica, Montenegro. (in Serbian) 9. 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

	February 2020 by now **Full Professor at Faculty of Mechanical Engineering in the field of Thermal and Hydro Energetics** **January 2015 – February 2020** **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	**10.06.2021.**
Signature	Date

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Broj / Ref 03 - 4204

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		

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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Gmail: milan.sekularac.mne@gmail.com;
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Web: http://www.ucg.ac.me/objava/blog/17838/objava/1
Youtube: https://www.youtube.com/channel/UCOuNe9mBexARTVf7Yiaw89w/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-proffiicient)

Language	Reading	Speaking	Writing
Serbian-	Native	Native	Native

croatian-montenegrin			
English	5	5	5
Italian	5	5	4
German	1	1	1

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 proffiicient: 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**

I currently teach or I've taught 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,
- Fluid transport
- Energy consumption and efficiency
- 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: English, Italian, German

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