UNIVERSITY OF EAST SARAJEVO

FACULTY OF MECHANICAL ENGINEERING

7th INTERNATIONAL SCIENTIFIC CONFERENCE

COMETa 2024

„Conference on Mechanical Engineering Technologies and Applications“

PROCEEDINGS

14th-16th November East Sarajevo, RS, B&H

COMETα 2024

7th INTERNATIONAL SCIENTIFIC CONFERENCE

14th - 16th November 2024
Jahorina, B&H, Republic of Srpska

University of East Sarajevo
Faculty of Mechanical Engineering
Conference on Mechanical Engineering Technologies and Applications

---

P R O C E E D I N G S

East Sarajevo, B&H, RS
14th – 16th November, 2024

PROCEEDINGS OF THE 7th INTERNATIONAL
SCIENTIFIC CONFERENCE
”Conference on Mechanical Engineering
Technologies and Applications”
COMETa2024, East Sarajevo, 2024

Organization:	University of East Sarajevo Faculty of Mechanical Engineering East Sarajevo
Publisher:	University of East Sarajevo Faculty of Mechanical Engineering East Sarajevo
For publisher:	PhD Saša Prodanović, associate professor
Editors:	PhD Biljana Marković, full professor PhD Miroslav Milutinović, full professor PhD Davor Milić, assitant professor
Technical treatment and desing:	MSc Jelica Anić, senior assistant MSc Jovana Blagojević, senior assistant MSc Krsto Batinić, senior assistant MSc Srđan Samardžić, assistant
Printing:	1st
Register:	ISBN 978-99976-085-2-9 COBISS.RS-ID 141688065

REVIEWERS

PhD Aleksandar Košarac, FME UES (B&H)
PhD Aleksandar Živković, FTS Novi Sad (Serbia)
PhD Aleksije Đurić, FME UES (B&H)
PhD Angela Fajsi, FTS Novi Sad (Serbia)
PhD Biljana Marković, FME UES (B&H)
PhD Bogdan Marić, FME UES (B&H)
PhD Borislav Savković, FTS Novi Sad (Serbia)
PhD Branimir Grgur, FTM Belgrade (Serbia)
PhD Branimir Krstić, University of Difence, Military Academy (Serbia)
PhD Cviejtin Mlađenović, FTS Novi Sad (Serbia)
PhD Davor Milić, FME UES (B&H)
PhD Dejan Jeremić , FME UES (B&H)
PhD Dragan Milčić, FME Nis (Serbia)
PhD Dragan Pršić, FMCE Kraljevo (Serbia)
PhD Dušan Golubović, FME UES (B&H)
PhD Dušan Gordić, FE Kragujevac (Serbia)
PhD Goran Orašanin, FME UES (B&H)
PhD Jasmina Pekez, TF “Mihajlo Pupin” Zrenjanin (Serbia)
PhD Jelena Jovanović, FME Podgorica (MNE)
PhD Milan Banić, FME Niš (Serbia)
PhD Milan Rackov, FTS Novi Sad (Serbia)
PhD Milan Rapajić, FTS Novi Sad (Serbia)
PhD Milan Tica, FME Banja Luka (B&H)
PhD Milan Zeljković, FTS Novi Sad (Serbia)
PhD Milija Kraišnik, FME UES (B&H)
PhD Milomir Šoja, FEE UES (B&H)
PhD Miloš Matejić, FE Kragujevac (Serbia)
PhD Miloš Milovančević, FME Nis (Serbia)
PhD Mirko Blagojević, FE Kragujevac (Serbia)
PhD Miroslav Milutinović, FME UES (B&H)
PhD Miroslav Stanojević, FME Belgrade (Serbia)
PhD Mladen Tomić, FTS Novi Sad (Serbia)
PhD Mladomir Milutinović, FTS Novi Sad (Serbia)
PhD Nebojša Radić, FME UES (B&H)
PhD Nenad Grahovac, FTS Novi Sad (Serbia)
PhD Nikola Tanasić, FME Belgrade (Serbia)
PhD Nikola Vučetić, FME UES (B&H)
PhD Radoslav Tomović, FME Podgorica (MNE)
PhD Ranka Sudžum, FME UES (B&H)
PhD Saša Prodanović, FME UES (B&H)
PhD Saša Živanović, FME Belgrade (Serbia)
PhD Silva Lozančić , Faculty of Civil Engineering Osijek (Croatia)
PhD Slaviša Moljević, FME UES (B&H)
PhD Slobodan Lubura, FEE UES (B&H)
PhD Slobodan Tabaković, FTS Novi Sad (Serbia)
PhD Snežana Nestić, FE Kragujevac (Serbia)
PhD Spasoje Trifković, FME UES (B&H)
PhD Srđan Vasković, FME UES (B&H)
PhD Stojan Simić, FME UES (B&H)
PhD Uroš Karadžić, FME Podgorica (MNE)
PhD Vladimir Milovanović, FE Kragujevac (Serbia)

PhD Vladimir Stojanović, FMCE Kraljevo (Serbia)
PhD Vlado Medaković, FME UES (B&H)

INTERNATIONAL SCIENTIFIC COMMITTEE

PhD Biljana Marković, FME UES (B&H) – president
PhD Adisa Vucina, FMEC Mostar (B&H)
PhD Aleksandar Aleksic, FE Kragujevac (Serbia)
PhD Aleksandar Jovovic, FME Belgrade (Serbia)
PhD Aleksandar Košarac, FME UES (B&H)
PhD Aleksija Đurić, FME UES (B&H)
PhD Bogdan Maric, FME UES (B&H)
PhD Borut Kosec, NTF Ljubljana, (Slovenia)
PhD Branimir Krstic, Military academy, University of Defence in Belgrade (Serbia)
PhD Budimirka Marinović, FPM UES (B&H)
Phd Balasaheb M. Patre, SGGS IET (India)
PhD Vladimir Popović, FME Belgrade (Serbia)
PhD Vladimir Stojanović, FMCE Kraljevo (Serbia)
PhD Vladimir Milovanović, FE Kragujevac (Serbia)
PhD Vlado Medaković, FME UES (B&H)
PhD Vlatko Cingoski, FEE "Goce Delcev" University (North Macedonia)
PhD George Nenes, UOWM (Greece)
PhD Goran Janevski, FME Niš (Serbia)
PhD Goran Šimunović, MEFSB (Croatia)
PhD Grigor Stambolov, TU FIT (Bulgaria)
PhD Davor Milić, FME UES (B&H)
PhD Damjan Klobcar, FME Ljubljana (Slovenia)
PhD Danijela Tadić, FE Kragujevac (Serbia)
PhD Darko Knezevic, FME Banja Luka (B&H)
PhD Dejan Jeremić, FME UES (B&H)
PhD Dragan Milcic, FME Niš (Serbia)
PhD Dragan Pršić, FMCE Kraljevo (Serbia)
PhD Dragan Spasic, FTS Novi Sad (Serbia)
PhD Dušan Golubović, FME UES (B&H)
PhD Zdravko Krivokapić, FME (MNE)
PhD Zlatko Nedelkovski, FTS MTU (North Macedonia)
PhD Zoran Trifunov, FTS MTU (North Macedonia)
PhD Zorana Tanasic, FME Banja Luka (B&H)
PhD Ibrahim Plančić, FME UZ (B&H)
PhD Ivan Bajsić, University of Novo mesto (Slovenia)
PhD Ivan Samardžić, MEFSB (Croatia)
PhD Izet Zekiri, MTU (North Macedonia)
PhD Indiran Thirunavukkarasu, Manipal Institute of Technology (Indija)
PhD Isak Karabegovic, FTS Bihać (B&H)
PhD Jozsef Nyers, The Obuda University Budapest (Hungary)
PhD Kyros Yakinthos, Aristotle University of Thessaloniki (Greece)
PhD Lozica Ivanovic, FE Kragujevac (Serbia)
PhD LJubiša Dubonjić, FMCE Kraljevo (Serbia)
PhD Mathias Liewald, IFU (Germany)
PhD Megan Cordill, ESI MS, AAS (Austrian)
PhD Milan Rakita, Purdue University (SAD)
PhD Milan Rackov, FTS Novi Sad (Serbia)
PhD Milan Tica, FME Banja Luka (B&H)

ORGANIZING COMMITTEE

GENERAL SPONSOR

Ministry of Scientific and Technological Development and Higher Education Republic of Srpska

SPONSORS

GasTeh

TOPOMATIKA

Tehnoprogres®

IZIT

numikon
programska rješenja i oprema d.o.o.

ГАС
ПРОМЕТ

САРАЈЕВО-ГАС А.Д.

IMBIH

Alumil

SQS
SISTEM QUALITA, S d.o.o

GRIJANJEINVEST

HE NA DRINI
VIŠEGRAD

РУДНИК И
ТЕРМОЕЛЕКТРАНА
ГАЦКО

РУДНИК И ТЕРМОЕЛЕКТРАНА УГЉЕВИК

TRB

INVEST GRADNJA

ORAO 1944

SERVITECBALKAN

The conference has been supported by:

IFToMM

International Federation for the Promotion of Mechanism and Machine Science

ADEKO

Association for Design, Elements and Constructions

UNIVERSITETI NËNË TEREZA
УНИВЕРЗИТЕТ МАЈКА ТЕРЕЗА
MOTHER TERESA UNIVERSITY

САМИТ

Union of Mechanical Engineers and Technicians of Republic of Srpska

Countries from which conference participants come

PREFACE

Mechanical engineering, as one of the basic engineering disciplines, represents the key to understanding and improving many aspects of modern society. From the development of energy-efficient systems, through advanced materials and production technologies, to robotics and automation, mechanical engineering is at the very heart of innovation, which drives the global economy and contributes to a better quality of life. Contemporary trends in mechanical engineering, such as the application of artificial intelligence, additive technology, digital transformation, minimizing the impact of industrial processes on the environment, etc. widely open new horizons and opportunities for our profession. Through mutual cooperation, interdisciplinary approaches and the integration of new technologies, we can find solutions that will shape the future of industry and society. Today, our profession faces numerous challenges, which are the result of accelerated technological development. They are at the same time extremely complex, but also very inspiring and require not only technical expertise, but also creativity, cooperation and a constant desire for new scientific achievements. Therefore, we must be able to recognize and implement new approaches, methodologies and technologies. Moreover, only a holistic approach in the application of knowledge in various engineering fields, and especially in the field of mechanical engineering, is a safe way into the future. Finally, in today's world, which is rapidly changing under the influence of global economic, environmental and social factors, it is important that all of us, who deal with the field of mechanical engineering from various aspects, do not forget our responsibility. In this context, engineering ethics, quality of work and continuous education play a crucial role.

Although the scientific research process is crucial for economic progress, we must not forget the importance of educating new generations of mechanical engineers. The conference COMETa 2024 is precisely an extraordinary opportunity to further encourage young researchers and students to actively engage in scientific activities through the development of their ideas. In this sense, academic institutions have a great responsibility to provide quality education and research programs to future generations.

Recognizing the importance of the broad field of mechanical engineering for the overall industrial development of society, the work of the conference will take place through 5 sections. The program is focused on the following thematic areas:

Manufacturing technologies and advanced materials,
Applied mechanics and mechatronics,
Machine design, simulation and modeling,
Product development and mechanical systems,
Energy and thermotechnic,
Renewable energy and environmental,
Maintenance and technical diagnostics,
Quality, management and organization.

Also, as part of the conference program, one round table and two workshops will be held, whose topics relate to the generation of ideas and proposals for future project activities that must inevitably be based on innovation, quality, and upcoming machine technologies, which is actually in accordance with the Development strategy of science and technology of the Republic of Srpska for the period 2023-2029, in which education, science, technology, research, innovation, and digitization are recognized as key prerequisites for achieving a sustainable economy.

Many experts, researchers, university professors, businessmen and students from various fields of mechanical engineering have registered to participate in this edition of conference COMETa 2024. The topics that will be discussed by the scientific and professional public will certainly contribute to the acquisition of new knowledge and open up a lot of space for future innovations. 77 papers will be published in the Conference proceedings, including 3 plenary lectures. The fact that numerous participants from abroad have been registered for the conference COMETa 2024 this year is especially pleasing.

Namely, 262 authors come from 16 countries. The review team is composed of 53 colleagues from the country and abroad. This is certainly the result of strenuous activities that were aimed at raising the international reputation and visibility of the conference in the regional, but also in the wider academic and scientific research area, which will be one of our primary goals in the future.

We are sure that the work at the conference COMETa 2024 will be fruitful and that each of you, after its end, will leave with new ideas, knowledge and contacts that will contribute to your further professional development. This is an opportunity not only to learn from each other, but also to build the foundations for future research projects and industrial innovations together. In addition, we believe that in the coming days we will have the chance to get to know each other better, discuss common challenges and establish new forms of cooperation. In this sense, we would like to point out that all your proposals and suggestions are more than welcome and will be carefully considered by the Organizing and Scientific Committee in order to improve the organization of the next conferences.

Finally, on behalf of the Organizing and Scientific Committee of the conference COMETa 2024, we express our great gratitude to all authors, reviewers, universities and faculties, business entities, and national and international institutions and organizations that supported the organization of the conference. Special thanks go to the Ministry of Scientific and Technological Development and Higher Education of the Repubilc of Srpska, the City of East Sarajevo, the Municipalities of East New Sarajevo, East Ilidža and Pale, without whose help the organization and work of the conference certainly could not be at the level that its status deserves.

East Sarajevo, November 13th, 2024.

President of the Scientific Committee

PhD Biljana Marković,
full professor

President of the Organizing Committee

PhD Milija Kraišnik,
Associate Professor

C O N T E N T

APPLIED MECHANICS AND MECHATRONICS

MACHINE DESIGN, SIMULATION AND MODELING

PRODUCT DEVELOPMENT AND MECHANICAL SYSTEMS

ENERGY AND TERMOTECHNIC

RENEWABLE ENERGY AND ENVIRONMENTAL PROTECTION

MAINTENANCE AND TECHNICAL DIAGNOSTICS

QUALITY, MANAGEMENT AND ORGANIZATION

SPONSORS CONFERENCE COMETa 2024

COMETa 2024
7th INTERNATIONAL SCIENTIFIC CONFERENCE
14th - 16th November 2024
Jahorina, B&H, Republic of Srpska
University of East Sarajevo
Faculty of Mechanical Engineering
Conference on Mechanical Engineering Technologies and Applications

FINITE ELEMENT ANALYSIS OF CYLINDRICAL SURFACE CONTACT

Snežana Vulović[1], Vladimir Milovanović[2], Miloš Pešić[3], Marko Topalović[4], Miroslav Živković[5]

Abstract: The two most common methods for solving contact problems using the finite element method are the Lagrange multiplier method and the penalty method. The Lagrange multiplier method treats contact forces as independent variables (Lagrange multipliers), and the contact non-penetration conditions are exactly satisfied. The penalty method satisfies contact conditions using penalty parameters, and the contact non-penetration conditions are approximately satisfied. The aim of this study is a comparative analysis of contact mechanics which is conducted using the finite element method (FEM). The penalty method is used for contact problem-solving. The primary objective is to evaluate the differences in results and computational efficiency between the two types of finite elements used and to determine the influence of the finite element mesh size on results.

Keywords: Contact mechanics, Cylindrical convex surfaces, Finite element method

1 INTRODUCTION

Contact mechanics plays a critical role in numerous engineering applications, including machine design, automotive engineering, the railway industry, and biomedical implants. Chapter [1] discusses contact phenomena in scenarios like metal formation, vehicle crashes, and gear systems, exploring various solution strategies. It covers one-point contact examples, the variational formulation of contact, finite element discretization, 3D contact formulations, and practical considerations such as

1 *Snežana Vulović, Senior Research Associate, Institute for Information Technologies, University of Kragujevac, 34000 Kragujevac, bb Jovana Cvijića Street, Serbia, vsneza@kg.ac.rs*
2 *Vladimir Milovanović, Associate Professor, Faculty of Engineering, University of Kragujevac, 34000 Kragujevac, 6 Sestre Janjić Street, Serbia, vladicka@kg.ac.rs*
3 *Miloš Pešić, Research Assistant, Institute for Information Technologies, University of Kragujevac, 34000 Kragujevac, bb Jovana Cvijića Street, Serbia, milospesic@uni.kg.ac.rs, (CA)*
4 *Marko Topalović, Research Associate, Institute for Information Technologies, University of Kragujevac, 34000 Kragujevac, bb Jovana Cvijića Street, Serbia, topalovic@kg.ac.rs*
5 *Miroslav Živković, Full Professor, Faculty of Engineering, University of Kragujevac, 34000 Kragujevac, 6 Sestre Janjić Street, Serbia, miroslav.zivkovic.mfkg@gmail.com*

constraint equations and modeling issues like slave/master body selection and removing rigid-body motions. Understanding how surfaces interact under load is essential for optimizing the performance, durability, and safety of mechanical systems. One of the most effective approaches for analyzing contact problems is the finite element method (FEM) [2], which allows for a detailed simulation of stress distribution, deformation, and pressure between contact surfaces.

The mechanics of Rail-Wheel contact study [3] is a critical area in Railway Engineering, where numerical methods like Finite Element Analysis (FEA) are often used due to limitations in analytical models for complex geometries. This study emphasizes a more accurate 3D FEA approach to Rail-Wheel contact problems, showing strong alignment with real-life scenarios.

As for biomedical implants goes results in the paper [4] show that roughness wavelength and clearance significantly influence pressure distribution and contact area, highlighting the importance of avoiding overly loose or tight hip implants for optimal design, regardless of material combinations.

In contact analysis, two primary methods are employed to enforce contact constraints: the Lagrange multiplier method and the penalty method [5]. The Lagrange multiplier method ensures that contact non-penetration conditions are exactly satisfied by treating the contact forces as independent variables. The penalty method allows for approximate satisfaction of the contact conditions by introducing penalty parameters that penalize constraint violations. Both methods offer unique advantages, with trade-offs in terms of computational complexity, accuracy, and convergence stability.

The authors in [6] conducted research on tetrahedral finite elements, which are simpler to generate compared to 3D hexahedral and shell elements, thereby reducing the required engineering time.

This paper aims to conduct a comparative analysis of contact mechanics using FEM, with a focus on the penalty method for solving contact problems. Two finite element models, one utilizing 3D hexahedral elements and the other using shell elements, were developed to study the contact between cylindrical convex surfaces. These surfaces, tangent at a 90° angle, are subjected to a 50 kN pressure force. The study investigates the impact of varying mesh densities on stress and pressure distribution in the contact region and evaluates the differences in results and computational efficiency between the two types of finite elements. The selected parameters for monitoring the results are stress and pressure in the contact region, as they play a critical role in understanding the mechanical interactions and material behavior under load. These parameters provide insights into potential points of failure, material deformation, and the overall performance of the constructions under operational conditions. In the paper [7] authors examined various FE models with different dimensions, load values, element types, and mesh densities. It focuses on how these variations affect stress values and node displacements in the contact regions while keeping boundary conditions and loading modes consistent across the FE models.

This research provides valuable insights into the accuracy and computational demands of different modeling approaches by comparing the results obtained with varying densities of mesh and element types. The obtained results offer practical recommendations for improving the precision of contact analysis in finite element simulations, particularly in terms of mesh generation and contact region definition. Additionally, the study highlights the impact of mesh density and element type on the overall accuracy and efficiency of the simulations.

2 THEORETICAL BASIS

The Lagrange multiplier method is a strategy for optimizing a function subject to equality constraints. Given an objective function $f(x)$ that needs to be optimized under the constraint $g(x) = 0$, a scalar multiplier λ is introduced. The Lagrange multiplier transforms the constrained optimization problem into an unconstrained one by defining the Lagrangian function $L(x, \lambda)$. Solving this involves finding points where the gradients of the Lagrangian for both x and λ are zero. This method treats the contact forces as independent variables (Lagrange multipliers), ensuring that contact non-penetration conditions are exactly satisfied.

The penalty method addresses constrained optimization by adding a penalty term to the objective function. This term imposes a cost for violating the constraints, converting the problem into an unconstrained one. The modified objective function becomes:

$$P(x) = f(x) + \frac{1}{2} r \cdot g(x)^2 \tag{1}$$

Where r is the penalty parameter, which penalizes constraint violations. In the context of contact problems, the penalty method approximately satisfies contact conditions by introducing a penalty parameter that controls the severity of constraint violations. As $r \to \infty$ the solution better adheres to the constraints, but too high a penalty parameter can lead to numerical instability.

3 FE MODELS

Two finite element models were developed to study the contact between cylindrical convex surfaces, which are tangent to each other and form a 90° angle. The finite element models were developed to simulate the stress and pressure distribution in the contact region under a 50 kN pressure load. Both plates are made of steel and have identical material properties: 2.1 x 10^5 MPa as Young Modulus, 7.85 x 10^6 kg/mm^3 as density, and 0.3 as Poisson ratio. The numerical analysis was performed in the Nastran software, while the pre and post-processing were carried out in Femap software [8]. The FE model – left (Figure 1), consists of 216 3D hexahedral finite elements and 1728 nodes, and the FE model – right (Figure 1), consists of 216 shell elements and 864 nodes.

The first finite element model employs 3D hexahedral elements, which can accurately capture complex geometries and stress variations within the contact area. This finite element model, as shown in Figure 1 – left, provides a solid representation of the volume and material behavior of the cylindrical surfaces. By utilizing 3D hexahedral elements, the finite element model achieves a high degree of accuracy in representing the physical interaction between the contacting surfaces, particularly in areas with high-stress gradients.

The second finite element model, shown in Figure 1 – right, is developed using shell elements, which are computationally more efficient due to their lower dimensionality compared to 3D hexahedral elements. In this study, the shell element model is employed to evaluate whether this simpler representation can still capture the essential contact behavior between the cylindrical surfaces while offering faster computational times compared to the 3D hexahedral finite element model. Figure 1 illustrates the problem setup, including the corresponding loads (50 kN pressure force) and constraints.

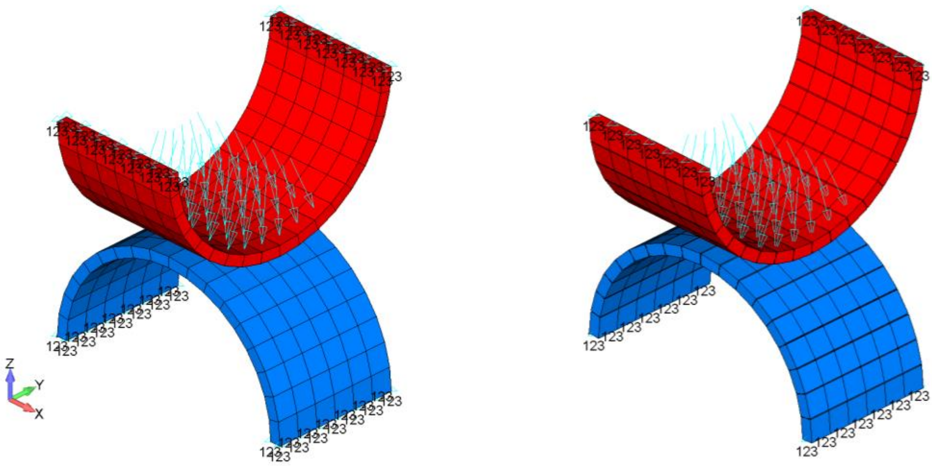

Figure 1 *Finite element model for contact examination between two cylindrical convex surfaces; 3D – hexahedral finite elements – left; b) shell elements – right [9]*

For each finite element model, three different finite element sizes were used: 5 mm x 5 mm x 5 mm, 10 mm x 10 mm x 5 mm, and 20 mm x 20 mm x 5 mm.

3.1 Results and Discussion

Figure 2 shows diagrams that represent stress and pressure values in the contact region depending on mesh density.

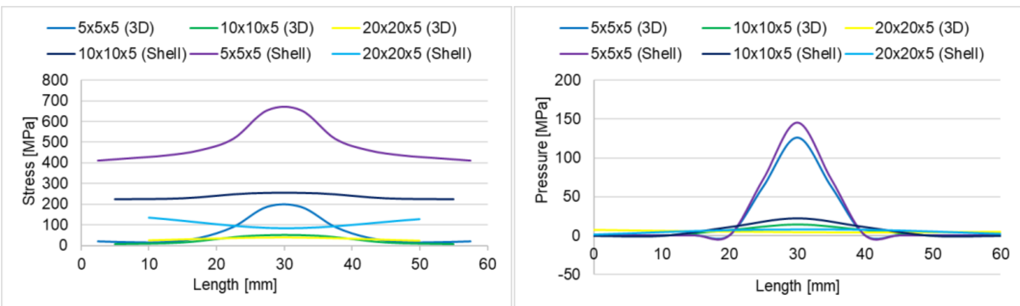

Figure 2 *Changes in stress and pressure values in the contact region depending on mesh density; left – stress values, right – pressure values*

As shown in the diagrams in Figure 2 – left, the stress value in the contact region increases with the increase in mesh density, and vice versa. Finer meshes, such as the 5 mm x 5 mm x 5 mm mesh, capture localized stress concentrations more accurately due to their ability to better resolve the complex geometry and stress gradients at the contact interface. In contrast, as the mesh density decreases FE model may underrepresent the peak stress values, leading to less accurate predictions. The stress value is observed to be significantly higher when the mesh density is 5 mm x 5 mm x 5 mm, indicating that a finer mesh provides a more precise and detailed representation of the stress distribution in regions of high contact stress.

A similar trend is observed for the contact pressure value, as illustrated in Figure 2 – right. As the mesh density increases, the contact pressure value rises, reflecting a more accurate computation of the pressure distribution across the contact surfaces. A finer mesh, such as the 5 mm x 5 mm x 5 mm mesh, by offering a higher resolution in the contact region, is better suited to model the localized pressure peaks that occur due to the applied load. A coarser mesh, such as the 20 mm x 20 mm x 5 mm mesh, smoothing out these peaks, underestimating the true contact pressure values. This increase in pressure values with finer mesh density demonstrates the necessity of using a sufficiently refined mesh to capture the details of contact mechanics accurately.

4 CONCLUSION

As observed from the diagrams, the results obtained from the numerical analysis using 3D hexahedral finite elements and shell elements exhibit notable variations. These differences underscore the impact of element type on the accuracy and reliability of contact simulations. To enhance the precision of the analysis and ensure more reliable results, several key recommendations should be followed:

- Optimal analysis results are achieved when the mesh density is uniform across both the master and slave segments of the contact interface. This uniformity ensures that the contact conditions are consistently represented across the entire interface, minimizing potential discrepancies caused by varying mesh resolutions. Discrepancies in mesh density between the contact segments can lead to inaccurate stress and pressure predictions, affecting the overall quality of the analysis.
- When modeling contact regions using shell elements, it is crucial to pay careful attention to the front and back sides of the shell. Shell elements are often used to represent thin structures and may not capture the full three-dimensional behavior of contact interactions if not properly configured. Ensuring that the shell elements are correctly oriented and adequately represent the contact surfaces is essential for accurate simulations.
- It is essential to avoid merging nodes at the contact interface. Merging nodes can inadvertently simplify the contact representation and may lead to unrealistic results, particularly in terms of stress concentrations and contact pressures. Maintaining separate nodes at the interface ensures that the contact conditions are modeled correctly, preserving the accuracy of the simulation.

The analysis indicates that more reliable and accurate results in contact mechanics are generally obtained when the contact regions are defined using 3D hexahedral finite elements. This element type provides a more detailed and precise representation of the contact geometry and interactions compared to shell elements. The finer resolution offered by hexahedral elements allows for better capture of localized stresses and pressures, leading to more accurate predictions of contact behavior. While 3D hexahedral elements may require higher computational resources, their ability to provide detailed results justifies their use in scenarios where precision is critical.

By adhering to these recommendations and choosing the appropriate element type, researchers and engineers can enhance the accuracy and reliability of contact analysis, ultimately leading to better-informed design decisions and improved performance of engineering systems.

ACKNOWLEDGMENT

This research is partly supported by the Ministry of Science, Technological Development and Innovation, Republic of Serbia, Agreement No. 451-03-66/2024-03/200378, and by the Science Fund of the Republic of Serbia, #GRANT No 7475, Prediction of damage evolution in engineering structures - PROMINENT.

REFERENCES

[1] Kim, NH. (2015). Finite Element Analysis for Contact Problems. In: Introduction to Nonlinear Finite Element Analysis. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-1746-1_5

[2] Kojić, M., Slavković, R., Živković, M., Grujović, N. (2010). Metod konačnih elemenata 1, Mašinski fakultet, Kragujevac, Serbia.

[3] Arslan, M.A., Kayabaşi, O. (2012) 3-D Rail-Wheel contact analysis using FEA, Advances in Engineering Software, 45/1, p.p. 325-331.

[4] Ilincic, S., Tungkunagorn, N., Vernes, A., Vorlaufer, G., Fotiu, PA., Franek, F. (2011). Finite and boundary element method contact mechanics on rough, artificial hip joints. Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology; p.p. 1081–91. https://doi.org/10.1177/1350650111406776

[5] Vulović, S. (2008). Нумеричке методе решавања контактних проблема пеналти методом, Doktorska disertacija, Mašinski fakultet, Kragujevac.

[6] Maas, SA., Ellis, BJ., Rawlins, DS., Weiss, JA. (2016). Finite element simulation of articular contact mechanics with quadratic tetrahedral elements. Journal of Biomechanics;49: p.p. 659–67. https://doi.org/10.1016/j.jbiomech.2016.01.024

[7] Pešić, M., Milovanović, V., Jelić, L., Jović, N. (2020). A Comparative Study of Linear Contact Problems in Software Simcenter Femap with Nastran. Proceedings of the 5th International Scientific Conference “Conference on Mechanical Engineering Technologies and Application” COMETa 2020; p.p. 156-163.

[8] Femap, Finite Element Modeling and PostProcessing Application FEMAP v2021.2, Siemens.

[9] Pešić, M. (2020). Решавање контактних проблема коришћењем софтверског пакета Simcenter Femap with Nastran, Master rad, Fakultet inženjerskuh nauka, Kragujevac.

CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

621.03(082)(0.034.2)

МЕЂУНАРОДНА научна конференција "Примијењене технологије у машинском инжењерству", COMETa (7 ; Источно Сарајево ; 2024)

Proceedings [Elektronski izvor] / 7th International Scientific Conference "Conference on Mechanical Engineering Technologies and Applications" COMETa 2024, East Sarajevo, 14th - 16th November, 2024] ; [editors Biljana Marković, Miroslav Milutinović, Davor Milić]. - Onlajn izd. - Ел. зборник. - East Sarajevo : University of East Sarajevo Faculty of Mechanical Engineering, 2024

Način pristupa (URL): https://cometa.ues.rs.ba/. - Насл. са насл. екрана. - Ел. публикација у PDF формату опсега XVI, 652 стр. - Опис извора дана 13.11.2024. - Библиографија уз сваки рад.

ISBN 978-99976-085-2-9

COBISS.RS-ID 141688065

ISBN 978-99976-085-2-9
COBISS.RS-ID 141688065