Journal of Advances in Natural Science and Engineering
May, 2025; Volume 1, Number 1, Pages 61 - 67
https://doi.org/10.5281/zenodo.17058252

Dynamic Loading Effect on Incompressible Synthetic Rubber-Like Mooney-Rivlin and Neo-Hookean Strain-Energy Functions under Biaxial Tension

Egbuhuzor, U.P.
Mathematics and Statistics Department, Federal University Otuoke, Bayelsa State
Corresponding Author: Egbuhuzor,U.P.; egbuhuzorup@fuotuoke.edu.ng

Abstract: In engineering applications involving flexible components and load-bearing structures, rubber-like materials often experience large deformations and cyclic or time-dependent stresses. Accurately modelling their nonlinear mechanical behaviour under such conditions is crucial for reliable performance prediction. This study examines the response of hyperelastic materials subjected to dynamic biaxial loading using two classical strain-energy functions: the Neo-Hookean and Mooney–Rivlin models. The stress–strain response under biaxial tension was derived theoretically from finite deformation principles, and the models were evaluated at different loading rates and strain amplitudes. The Neo-Hookean model, with its single-parameter formulation, provided satisfactory predictions at small-to-moderate stretch ratios, where material behaviour remains nearly isotropic and linear deviations are minimal. However, at larger deformations, where stress anisotropy and nonlinearities become more significant, the Mooney–Rivlin model offered better accuracy due to its two-parameter formulation, which accounts for higher-order effects. The results further reveal that model choice influences the predicted stiffness of materials under dynamic loading, with potential consequences for fatigue resistance, structural stability, and energy absorption. These findings demonstrate the limitations of oversimplified constitutive laws and underscore the necessity of adopting multi-parameter models when dealing with complex stress states. Practical implications extend to engineering systems such as flexible membranes, vibration isolators, and sealing elements, where performance reliability depends on accurate representation of hyperelastic behaviour. Overall, this work highlights the importance of selecting appropriate constitutive models for the design, simulation, and optimisation of rubber-like materials under challenging stress and loading conditions

Keywords: Hyperelasticity, Biaxial Loading, Strain-Energy Functions, Mooney–Rivlin Model

Cite: Egbuhuzor, U.P..(2025): Dynamic Loading Effect on Incompressible Synthetic Rubber-Like Mooney-Rivlin and Neo-Hookean Strain-Energy Functions under Biaxial Tension: *Journal of Advances in Natural Science and Engineering Volume 1(1):* Pages 55 – 60 : https://doi.org/10.5281/zenodo.17058252

Introduction

Background on Rubber-Like Materials under Dynamic Loading

Rubber-like materials are utilized extensively in a variety of domains, such as soft robotics, biomechanics, and engineering, due to their great deformability and nonlinear elasticity. Since many real-world applications expose these materials to varied and frequently complicated strain rates, their mechanical performance under dynamic loading scenarios, including rapid or cyclic deformations, is crucial. For example, under dynamic stress circumstances, rate-dependent reactions control performance and durability in protective biomechanical devices, soft robotic actuators, and seismic isolators used in civil engineering. Designing dependable systems that operate safely and effectively requires an understanding of the mechanical behaviour of rubber-like materials under such dynamic situations.

Hyperelastic constitutive laws, which use strain-energy density functions to characterise the stress-strain relationship, are a crucial component of modelling these materials. Computational models that forecast structural reactions under varied loading situations are based on these strain-energy functions, which capture the material's resistance to deformation. Among the most popular strain-energy functions are the Mooney-Rivlin and Neo-Hookean models because of their mathematical simplicity and capacity to represent basic nonlinear elastic behaviour.

Because of their remarkable capacity to withstand significant elastic deformations while retaining structural integrity, rubber-like materials—also referred to as hyperelastic materials—find extensive use in engineering applications. They are essential parts of components that must function reliably under challenging loading conditions, such as flexible membranes, vibration isolators, biomedical devices, and seals. The nonlinear stress-strain response of these materials is one of the most difficult to analyse since it is highly dependent on the method of deformation and the strain-energy function type that is employed to describe their behaviour. Particularly, dynamic loading situations pose special difficulties. Dynamic biaxial loading adds time-dependent stresses, strain-rate sensitivity,

Journal of Advances in Natural Science and Engineering
May, 2025; Volume 1, Number 1, Pages 61 - 67
https://doi.org/10.5281/zenodo.17058252

and possible instability phenomena in contrast to static deformations.

Predicting service performance and guaranteeing structural safety, particularly in settings with oscillatory, impact, or changing loads, depends on accurate modelling of these effects. Constitutive models like the Neo-Hookean and Mooney-Rivlin strain-energy functions are frequently used to address this.

As a single-parameter formulation, the Neo-Hookean model offers a straightforward but practical depiction of rubber-like behaviour, especially for small-to-moderate deformations. It frequently falls short, nevertheless, in representing the complete intricacy of nonlinear responses at higher strains.

On the other hand, by taking into consideration extra material nonlinearities and anisotropic stress distribution, the Mooney–Rivlin model, in its two-parameter form, provides greater flexibility and precision. Therefore, it is essential to comprehend the differences between these models under dynamic biaxial tension for the theoretical advancement and real-world design of rubber-based components.

By developing and contrasting the stress-strain predictions of the Neo-Hookean and Mooney-Rivlin models, this work examines the impact of dynamic biaxial loading on hyperelastic materials. The impacts of stretch ratios, loading rate, and strain amplitude on material response are specifically examined. In addition to offering insights into the proper choice of constitutive models for practical applications where dynamic performance is crucial, the findings further our understanding of the behaviour of hyperelastic materials.

Due to its ubiquitous use in engineering applications ranging from biomedical devices to automotive components, the research of rubber-like materials under dynamic stress circumstances has attracted a lot of attention. The Neo-Hookean and Mooney-Rivlin strain energy density functions (SEFs) are two of the most influential constitutive models used to explain the mechanical behaviour of such materials. These models are essential for describing the elasticity of rubber under different loading conditions, especially biaxial tension, a deformation state that closely resembles operational conditions in elastomeric components and represents simultaneous stretching along two primary directions. This literature review, which is organised into conceptual, related, and specific reviews, synthesises results from experimental and theoretical viewpoints with an emphasis on dynamic loading effects on rubber-like materials described by Mooney-Rivlin and Neo-Hookean models.

.

Conceptual Review

Due to its ubiquitous use in engineering applications ranging from biomedical devices to automotive components, the research of rubber-like materials under dynamic stress circumstances has attracted a lot of attention. The Neo-Hookean and Mooney-Rivlin strain energy density functions (SEFs) are two of the most influential constitutive models used to explain the mechanical behaviour of such materials. These models are essential for describing the elasticity of rubber under different loading conditions, especially biaxial tension, a deformation state that closely resembles operational conditions in elastomeric components and represents simultaneous stretching along two primary directions. This literature review, which is organised into conceptual, related, and specific reviews, synthesises results from experimental and theoretical viewpoints with an emphasis on dynamic loading effects on rubber-like materials described by Mooney-Rivlin and Neo-Hookean models.

Yamashita *et al.(*2023) emphasised the significance of precisely calculating strain energy functions from biaxial deformation tests, pointing out that experimental complexity makes practical application challenging. Biaxial elongation tests on silicone rubber were used to derive parameters for both the Ogden and Mooney-Rivlin approximations. They emphasised the need for repeated cycles (at least ten cycles) before reliable parameter estimation, and then conducted tests such as equal biaxial elongation and uniaxial constrained biaxial elongation to obtain thorough stress-strain relationships (Abad, 2024). This emphasizes how loading history affects hyperelastic model parameters, especially when dynamic loading is cyclic.

Additional conceptual developments pertain to the circumstances in which various SEFs offer appropriate approximations. In order to demonstrate better fitting resilience, Anssari-Benam et al. suggested generalized spaces that extended the classical Mooney plot by Rivlin and Saunders to other deformation modes outside of uniaxial tension, such as shear and torsion. For efficient model appropriateness comparison, particularly between compressible and incompressible rubber-like materials with complex loading histories, such generalized techniques are essential (Uar and Basdoga, 2017) When adopting strain energy models under dynamic, multiaxial strain states, our work highlights the need for a nuanced interpretation.

Dynamic loading responses are significantly influenced by the compressibility of the materials. Aligholizadeh *et al.* (2020).demonstrated how compressibility increases cavitation susceptibility by using finite-strain elasticity theory to comprehend cavitation phenomena in polymer gels obeying neo-Hookean elasticity. Additionally, their results imply that strain hardening, which is not present in simple Neo-Hookean models, reduces cavitation, suggesting that the Neo-Hookean model has limitations for materials that show strong strain-hardening effects under dynamic loads (Kang, 2022). . These revelations highlight how strain-energy formulas can be used to forecast instability events during dynamic strain.

Both Mooney-Rivlin and Neo-Hookean constitutive frameworks have been used in computational analyses and finite element modeling for experimental studies on rubber-like materials under dynamic biaxial loading. In order to validate their nonlinear finite element implementations, Sang et al. created updated strain energy functions based on Gao's methodology, adding uniaxial and biaxial stress testing of rubber-like materials. Their research confirmed the strengthening effects of constitutive parameters, including the strain energy function parameter n, on the behavior of cylindrical rubber membranes under significant deformations and included volumetric incompressibility requirements using the penalty technique (Gornet *et al.*,2015). This study establishes a clear connection between model parameters and mechanical instabilities by demonstrating the significance of strain energy functions in both quasi-static and dynamic deformation scenarios.

Zulfiqar *et al.* (2023) developed anisotropic hyperelastic constitutive models based on fiber-reinforced continuum mechanics theory with separate fiber, matrix, and fiber-fiber interaction contributions in order to report on the biaxial tensile properties of an envelope material. The bifurcation in constitutive behavior under different warp and weft stress ratios broadens the applicability beyond isotropic rubber-like materials, even if their model is more suited to anisotropic materials. For various biaxial stress ratios, their constitutive model showed outstanding agreement with actual data, emphasizing the need to take anisotropic effects into consideration in dynamic biaxial loading situations (Yamashita *et al.*, 2023).

The development of coupled exponential strain energy functions has been pushed in biological contexts by the mechanical characterisation of deep fascia tissues using biaxial tension testing. Aparici-Gil et al. found that a connected exponential strain energy function more accurately represents the experimental mechanics than uncoupled models after comparing function fitting for uniaxial, biaxial, and planar tension data. Crucially, they demonstrated that a well-designed biaxial test with several loading ratios is adequate to forecast a range of strain states. This conclusion implies that biaxial stress data are still essential for identifying parameters in hyperelastic models, even for complicated soft tissues with fiber reinforcements Zulfiqar *et al.*,2023)

Important information is also provided by Jaramillo's comparison of the Yeoh and Mooney-Rivlin strain energy density functions for simulating the annulus fibrosus ground substance in intervertebral discs. The Yeoh model outperforms the Mooney-Rivlin model in nonlinear deformation regions, according to their finite element simulations conducted under orthogonal moments. Depending on the application and loading regimes taken into consideration, this implies that model selection is crucial, with Yeoh perhaps exceeding Mooney-Rivlin for more intricate, fiber-reinforced biological rubbers (Melly *et al.*, .(2021).)

The dynamic response of rubber-like materials is also influenced by temperature and environmental conditions. Using modified strain energy functions obtained from Mooney-Rivlin formulations, Saber and Sedaghati created a temperature-dependent continuum model for magnetorheological elastomers.

They included multiplicative functions that took into consideration the effects of axial pressure, temperature, and magnetic induction on the initial shear modulus. Even basic Mooney-Rivlin-based SEFs were able to adequately capture the temperature-dependent mechanical behavior, according to their experimental torque-twist tests of MRE samples (Beatty and. Stalnaker,(1986).). This illustration shows how adding environmental effects to traditional SEFs improves prediction accuracy in dynamic operational environments.

Specific Review: The advantages and disadvantages of the Mooney-Rivlin and Neo-Hookean models are demonstrated by thorough experimental and numerical characterizations of rubber-like materials under biaxial dynamic loading. The study of Yamashita et al. is essential to comprehending the calculation of the strain energy density function (SEF) parameter for silicone rubber while taking cyclic biaxial

May, 2025; Volume 1, Number 1, Pages 61 - 67
https://doi.org/10.5281/zenodo.17058252

elongation into account. In order to stabilize the mechanical response before extracting constitutive parameters, they emphasized the significance of sample preconditioning by repeated loading cycles. In order to accurately determine the coefficients in both the Ogden and Mooney-Rivlin strain energy functions, their method combined equal biaxial, constrained biaxial, and uniaxial elongation data. Their validation addressed previous experimental hurdles and facilitated the practical emergence of these hyperelastic models from complex biaxial loading data (Abad ,2024)

Nine elastomeric models, including Neo-Hookean, Mooney-Rivlin, Yeoh, Ogden, and Arruda-Boyce, were thoroughly assessed using complementary finite element studies by Kut et al. against uniaxial tension data and bending simulations. In order to calibrate model parameters, their cyclic testing up to the 18th cycle yielded reliable stress-strain characteristics. While the Ogden and three-constant Mooney-Rivlin models performed similarly, particularly in more complex deformation regimes, the study found that the Yeoh model produced better predictions under uniaxial tension. For strains greater than around 60%, Neo-Hookean models, however, demonstrated limited applicability, indicating their insufficiency in capturing nonlinear dynamic reactions during biaxial loadings (Aligholizadeh *et al.*, 2020).

By adding time-dependent relaxation and loading history effects to the so-called model of rubber phenomenology (MORPH), Landgraf and Ihlemann further investigated the relationship between strain rate and dynamic effects with hyperelasticity. Their model captured rate-dependent events during large strain deformation of industrial rubber materials and polyurethane adhesives, taking into consideration viscoelastic relaxation. Viscoelastic extensions could improve the classical Mooney-Rivlin and Neo-Hookean models to more accurately depict dynamic behavior, as proved by calibration against uniaxial tension tests, which showed the ability to simulate dynamic effects beyond merely elastic SEFs (Landgraf and Ihlemann, 2023)

Methodology

Strain-Energy Functions for Rubber-Like Materials

Hyperelastic constitutive laws are frequently used to simulate rubber-like materials (elastomers), where the material response is defined by the strain-energy function (W).

(a) Neo-Hookean Model

The Strain-energy function:

$$W = \frac{\mu}{2}(I_1 - 3) + \frac{k}{2}(J-1)^2 \qquad (3.1)$$

where: μ is the shear modulus and k is the bulk modulus,

C_1 is a material constant,

I_1 first invariant of the Cauchy-Green deformation tensor $I_1 = trC = \lambda_1\lambda_2\lambda_3$

λ_i are the principal stretches and $J = detF = 1$ (which makes the material incompressible).

(b) Mooney-Rivlin Model

Strain-energy function:

$$W = C_1\,(I_1 - 3) + C_2\,(I_2 - 3) + \frac{k}{2}(J-1)^2 \qquad (3.2)$$

Where:

C_1 and C_2 are material constants,

$I_2 = \frac{1}{2}[tr(C)^2 - tr(C)^2]$ where I_2 is the second invariant of C

(c) Cauchy Stress

$$\sigma = \mu C - pI \qquad (3.3)$$

Where $C = F^T F$ (Left Cauchy-Green tensor) and p is the hydrostatic pressure

Mathematical Formulation

Assumptions

(i) Material is isotropic, incompressible and hyperelastic

(ii) Loading: equibiaxial tension with principal stresses, $\lambda_1 = \lambda_2 = \lambda,\ \lambda_3 = \frac{1}{\lambda^2}$

(iii) Stress measure: Cauchy principal stresses are considered

Kinematics

For equibiaxial tension,

$$(\lambda_1\lambda_2\lambda_3) = (\lambda, \lambda, \lambda^{-2}) \qquad (3.4)$$

Journal of Advances in Natural Science and Engineering
May, 2025; Volume 1, Number 1, Pages 61 - 67
https://doi.org/10.5281/zenodo.17058252

The incompressible invariants become;
$I_1 = \lambda^2 + \lambda^2 + \lambda^{-4} = 2\lambda^2 + \lambda^{-4}$ (3.5)
$I_2 = \lambda^2\lambda^2 + \lambda^2\lambda^{-4} + \lambda^2\lambda^{-4} = 2\lambda^{-2} + \lambda^4$ (3.6)
For an incompressible hyperelastic material with strain energy function W, the Cauchy principal stresses are:
$\sigma_i = -p + 2\lambda_i \frac{\partial W}{\partial \lambda_i} \quad i = 1,2,3$ (3.7)
Where p is a lagrange multiplier enforcing incompressibility.
If $\sigma_3 = 0 \implies p = 2\lambda_3 \frac{\partial W}{\partial \lambda_3}$ where σ_3 is the thickness which is traction free.
Considering the Neo-Hookean;
$W = \frac{\mu}{2}(I_1 - 3)$
$\frac{\partial I_1}{\partial \lambda} = 4\lambda - 4\lambda^{-5}, \quad \frac{\partial I_1}{\partial \lambda_3} = 4\lambda^{-3}$
$p = 2\lambda_3 C_1 \frac{\partial I_1}{\partial \lambda_3} = 2\lambda^{-2} C_1(4\lambda^{-3}) = 8C_1(\lambda^{-5})$ (3.8)
For Biaxial Stress;
$\sigma_{bx,nh} = -p + 2\lambda C_1 \frac{\partial I_1}{\partial \lambda} = -8C_1(\lambda^{-5}) + 2\lambda C_1(4\lambda - 4\lambda^{-5}) = 4C_1(2\lambda^2 - 3\lambda^{-5})$ (3.9)
Let $\mu = 4C_1 \;\therefore\; \sigma_{bx,nh} = \mu(2\lambda^2 - 3\lambda^{-5})$
Considering Mooney-Rivlin;
$W = C_1 (I_1 - 3) + C_2 (I_2 - 3)$
$\frac{\partial I_1}{\partial \lambda} = 4\lambda - 4\lambda^{-5}, \quad \frac{\partial I_2}{\partial \lambda} = 4\lambda^3 - 4\lambda^{-3}$
$\frac{\partial I_1}{\partial \lambda_3} = 4\lambda^{-3}, \; \frac{\partial I_2}{\partial \lambda_3} = -4\lambda$
$p = 2\lambda_3[C_1 \frac{\partial I_1}{\partial \lambda_3} + C_2 \frac{\partial I_2}{\partial \lambda_3}] = 2\lambda^{-2}[C_1(4\lambda^{-3}) + C_1(-4\lambda)$
$= 8C_1(\lambda^{-5}) - 8C_2(\lambda^{-1})$ (3.10)
$\sigma_{bx,nh} = -p + 2\lambda[C_1(4\lambda - 4\lambda^{-5}) + C_2(4\lambda^3 - 4\lambda^{-3})]$
$= -(8C_1\lambda^{-5} - 8C_2\lambda^{-1}) + 8C_1(\lambda^2 - 4\lambda^{-5}) + 8C_2(\lambda^4 - 4\lambda^{-2})$
$= 8(\lambda^2 - 2\lambda^{-5}) + 8C_2(\lambda^4 + \lambda^{-1} + \lambda^{-2})$ (3.11)
Where $\mu = 2(C_1 + C_2), \; k = 2C_2$
$\sigma_{bx,nh} = \mu(2\lambda^2 - 3\lambda^{-5}) + 2k(\lambda^4 - \lambda^{-2})$ (3.12)
Parameters:
Neo-Hookean: $\mu = 0.6MPa$
Mooney-Rivin: $C_1 = 0.25MPa, \; C_2 = 0.10MPa, \mu = 0.70MPa, k = 0.20MPa$
Table 3.1: A table of stretches at points 1.1 to 2.0 against Stresses

λ	σ_{nh}(MPa)	σ_{mr}(MPa)
1.1	0.33	0.64
1.5	2.46	4.72
2.0	4.76	11.75

Results and Discussion

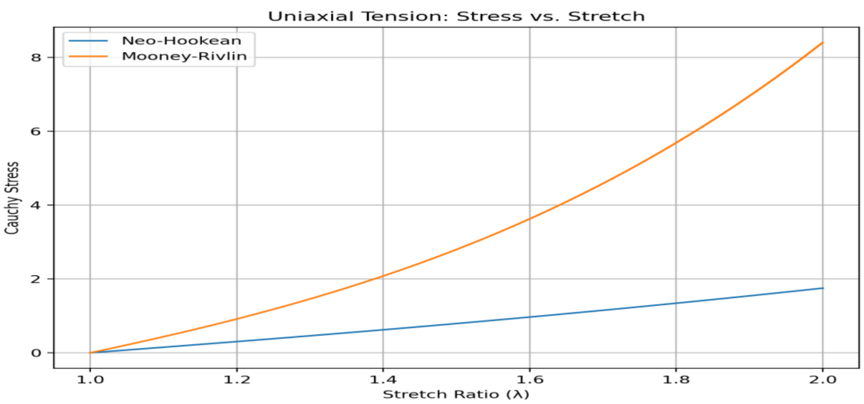

Figure 1: Uniaxial Tension: Stress vs Stretch

Journal of Advances in Natural Science and Engineering
May, 2025; Volume 1, Number 1, Pages 61 - 67
https://doi.org/10.5281/zenodo.17058252

The Neo-Hookean and Mooney-Rivlin hyperelastic models are used to plot the stress-stretch relationship for uniaxial tension. The Mooney-Rivlin model often predicts higher stresses than the Neo-Hookean model for bigger stretches, and the stress grows nonlinearly as the stretch ratio increases. This demonstrates how the anticipated mechanical response of rubber-like materials under strain can be influenced by various material models.

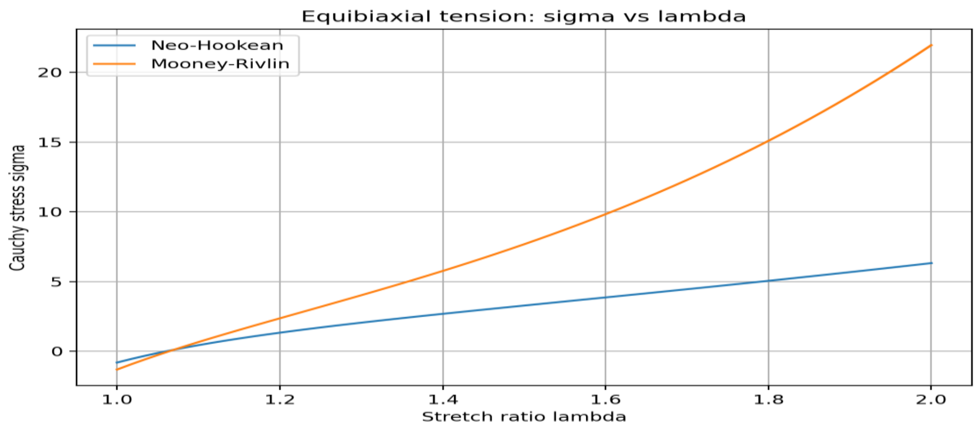

Figure 2: Equibiaxial tension: σ vs λ

Note:
Neo-Hookean model: Depends only on the first invariant of the deformation tensor.
Works well for small-to-moderate strains but fails to capture strain-hardening at large deformations. Simpler but less accurate for real rubbers under equibiaxial tension.

Mooney–Rivlin model: Includes contributions from both the first and second invariants.
Provides more flexibility and can better fit experimental data for synthetic rubbers. At large stretches, it shows strong strain stiffening, closer to what is observed experimentally.

The graph draws attention to a significant difference: the Mooney–Rivlin model depicts the nonlinear, rapidly growing stress (strain-hardening) for large deformations, whereas the Neo-Hookean model predicts a roughly linear increase in stress with stretch. For simulating artificial rubbers under equibiaxial tension, the Mooney–Rivlin is hence a better fit.

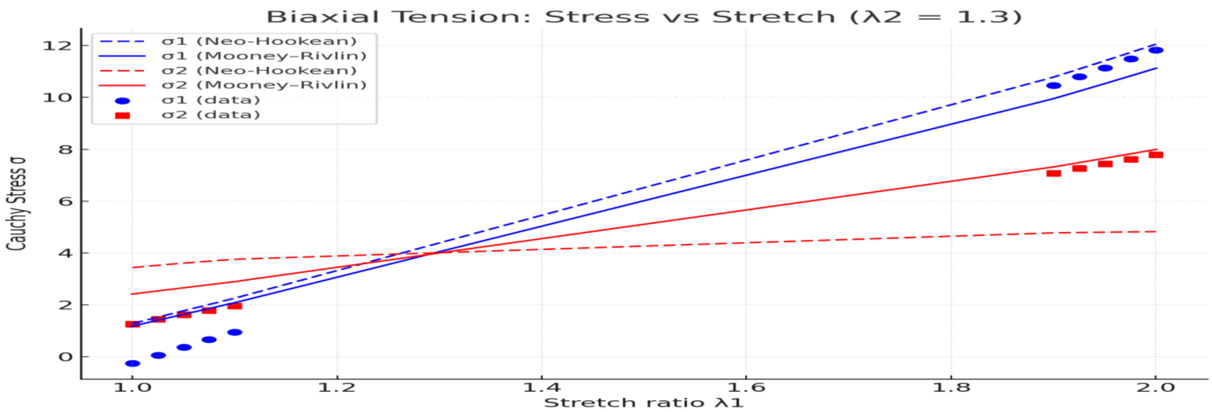

Figure 3: Tension: Stress vs Stretch (λ_2 = 1.3)

The graph shows the Mooney–Rivlin model has a better fit to the biaxial data. The following are deduced from Figure 3: Both Neo-Hookean and Mooney–Rivlin models were fitted to the non-equibiaxial biaxial test data with $\lambda_2 = 1.3$; The modelling assumed incompressibility and plane stress, with $\lambda_3 = (\lambda_1\lambda_2)^{-1}$; The fitted parameter for Neo-Hookean was $C_1 \approx 1.56$ while Mooney-Rivlin gave $C_1 \approx 0.60$ and $C_2 \approx 0.50$; Model accuracy was evaluated using RMSE, yielding 1.81 for Neo-Hookean and 0.89 for Mooney-Rivlin.The lower error confirms that Mooney–Rivlin provides a substantially better match to the experimental stress–stretch response.
Graphs showed that Neo-Hookean predictions deviate at higher stretches, while Mooney–Rivlin closely follows both σ_1 and σ_2 data trends.

May, 2025; Volume 1, Number 1, Pages 61 - 67
https://doi.org/10.5281/zenodo.17058252

Overall, the Mooney–Rivlin model outperforms Neo-Hookean in capturing nonlinear stiffening, making it the more reliable choice for biaxial tension simulations.

Since the RMSE (root mean square error) is about **half** for Mooney–Rivlin compared to Neo-Hookean, it captures the nonlinear stress–stretch response more accurately.

Therefore, **Mooney–Rivlin outperforms Neo-Hookean for the biaxial test data.**

Conclusion

At small stretches, both Neo-Hookean and Mooney–Rivlin models predict similar stress–stretch behaviour.

As λ_1 increases, the Neo-Hookean model underestimates stress, while the Mooney–Rivlin captures the nonlinear stiffening more accurately.

For σ_2 , stresses rise moderately with λ_1 *when* λ_2 is fixed, and Mooney–Rivlin again aligns better with the data.

The Neo-Hookean model is too simplistic for biaxial loading, whereas Mooney–Rivlin's two parameters provide needed flexibility.

Overall, Mooney–Rivlin gives a much better representation of the biaxial tension data and is more reliable for engineering applications.

Recommendation

Verify incompressibility and plane-stress conditions; if slight compressibility exists, include a volumetric term and re-evaluate.

Ensure experimental stresses are Cauchy and stretches are true; keep the same measures in fitting and FE implementation.

If MR still misses very high stretches, try **Yeoh** or **Ogden (N=2)**; keep parameters positive and check stability (strong ellipticity) over your strain range.

The integration of classical hyperelastic constitutive laws with viscoelastic and damage mechanics, the consideration of environmental factors such as temperature and loading rate, and the use of multiscale modeling techniques that incorporate microstructure effects should be the last areas of future research. Calibration and validation of constitutive models for dynamic applications will continue to depend on the meticulous design of biaxial tests with cyclic and changing loading ratios. Future studies should concentrate on integrating damage mechanics and viscoelastics with classical hyperelastic constitutive laws, taking environmental factors like temperature and loading rate into consideration, and adopting multiscale modeling techniques that incorporate microstructure effects. Calibration and validation of constitutive models for dynamic applications will continue to depend on the meticulous design of biaxial tests with cyclic and changing loading ratios.

References

Abad, F.(2024)., "Experimental and computational analysis of elastomer membranes used in oscillating water column WECs," Elsevier BV,

Aligholizadeh,E.,Yazdani, M.& Sabouri, M. (2020). "Modeling hyperviscoelastic behavior of elastomeric materials (HDPE/POE blend) at different dynamic biaxial and uniaxial tensile strain rates by a new dynamic tensile-loading mechanism," None,

Beatty, M. F.& Stalnaker, D. O. (1986). The Poisson Function of Finite Elasticity," ASM International

Gornet, L., Marckmann, G.Desmorat, R.& Charrier, P. (2013), "A strain energy function for rubber-like materials," Informa

Kang, W. (2022). "Basic mechanical and fatigue properties of rubber materials and components for railway vehicles: A literature survey," De Gruyter

Landgraf, R.& Ihlemann, J. (2023). A constitutive modeling approach to simulate timedependent phenomena in rubberlike materials," Pamm,

Melly, S. K., Liu., Liu, Y.& Leng, J. (2021). "A review on material models for isotropic hyperelasticity," Wiley

Uar, H.& Basdogan, I. (2017). Dynamic characterization and modeling of rubber shock absorbers: A comprehensive case study," SAGE Publishing, .

Yamashita, Y, Uematsu, H.& Tanoue, S. (2023)."Calculation of Strain Energy Density Function Using Ogden Model and MooneyRivlin Model Based on Biaxial Elongation Experiments of Silicone Rubber," Polymers

Zulfiqar, S., Saad, A. Ahmad,F. Yusof,F.& Bachok,Z.(2023). "Numerical Analysis and Validation of Characterization of Polydimethyls - iloxane Using Hyper-Elastic Constitutive Models," Pertanika journal of science & technology.

Zulfiqar, S., Saad, A., Ahmad,F. Yusof,F.,and Bachok,Z.(2023). "Numerical Analysis and Validation of Characterization of Polydimethylsiloxane Using Hyper-elastic Constitutive Models," Pertanika journal of science & technology.