coatings

Editorial

Recent Trends in Coatings and Thin Film: Modeling and Application

Rahmat Ellahi [1,2,3]

[1] Fulbright Fellow, Department of Mechanical Engineering, University of California Riverside, Riverside, CA 92521, USA; rahmatellahi@yahoo.com or rellahi@alumni.ucr.edu
[2] Department of Mathematics & Statistics, Faculty of Basic and Applied Sciences, International Islamic University, Islamabad 44000, Pakistan
[3] Center for Modeling & Computer Simulation, Research Institute, King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia

Received: 3 August 2020; Accepted: 7 August 2020; Published: 10 August 2020

Abstract: This special issue took this opportunity to invite researchers to contribute their original research work and review articles to this Special Issue on "Recent Trends in Coatings and Thin Film: Modeling and Application" to be published in Coatings. The goal of this Special Issue was to address challenges and current issues that either advance the state-of-the-art of experimental, numerical, and theoretical methodologies, or extends the bounds of existing methodologies to new contributions that are related to coatings and thin film containing whichever, magnetic, multiphase, material science, nanotechnology, surfaces, interfaces, and mechanical sensing properties. In response to the call for papers, a total of 58 papers were submitted for possible publication. After comprehensive peer review, only 27 papers qualified for acceptance for final publication. The rest of 31 papers could not be accommodated. The submissions may have been technically correct, but were not considered appropriate for the scope of this special issue. The authors are from 17 geographically distributed countries, such as China, Spain, Romania, Turkey, Saudi Arabia, Pakistan, Malaysia, Abu Dhabi, UAE, Vietnam, Korea, Taiwan, Thailand, Lebanon, Egypt, India, and Kuwait, etc. This reflects the great impact of the proposed topic and the effective organization of the guest editorial team of this Special Issue.

Keywords: development and characterization of coatings; applications of thin films; nanostructured materials; surfaces and interfaces; applications of multiphase fluids; mathematical modeling on biological applications; electronics; magnetics and magneto-optics; droplet impact modelling; impedance analysis; rain erosion; ultrasound measurements; viscoelastic modelling; wind turbine blades; computational modelling

1. Introduction

The process of covering the surface of an object or substrate with a very thin layer is known as Coating. This layer can be of some sort of a thin polymer sheet, paint, or lacquer, which can be utilized for protective/decorative purposes. Most of industrial products get-up-and-go through the process of coating not only to prevent corrosion but to make them attractive. As the coating involves the development of a thin film layer that can be lacquer or polymeric on a fabric or substrate etc. Therefore, if the substrate starts and ends the process wound up in a roll, the process can be termed "roll-to-roll" or "web-based" coating. Due to multiple usages of coatings, several theoretical and experimental attempts have been devoted and this special issue is one of them. We hope that this issue will not only address the current challenges, but will also provide an overall picture and up-to-date findings to readers of the scientific community that ultimately benefits the industrial sector regarding its specific market niches and end users.

2. Methodologies and Usages

Two-dimensional, incompressible asymmetric peristaltic propulsion coated with Synovial fluid (non-Newtonian model) with mass transport was investigated in [1]. Because of the coating of the same base-fluid at the surface of the channel, the boundaries become non-porous and exert no slip on the fluid particles. Two illustrative models for the viscosity, namely, shear-thinning (Model 1) and shear-thickening (Model 2), are considered, which reveal the presence and integrity of coating. The perturbation method has been applied to linearize the complicated differential equations. Model 1 predicted higher viscosity values and more significant non-Newtonian behavior than Model 2. It is also observed that the shear-thinning model behaved in quite the opposite manner for the shear thickening model. The converse behavior of Models 1 and 2 occurs due to a curvature of the flow domain. Moreover, Model 1 is not able to capture the correct exponential viscosity dependence on concentration for the whole range of shear rates. On the other hand, the second model shows a strong relationship with accurate power. Solutions are attained for velocity field, concentration profile, and pressure gradient. The novelty of all the essential parameters is analyzed through graphical results. Furthermore, streamlines are also drawn in order to determine the trapping mechanism. The present analysis is beneficial in the study of intrauterine fluid dynamics; furthermore, it is applicable in vivo diagnostic; drug delivery; food diagnostics; protein chips; and, cell chips and packaging, i.e., smart sensors.

Ellahi et al. [2] devoted their efforts to investigate the shiny thin film with a metallic tactile covering of nanoparticles over the surface of a rotating disk. To decorate, glowing silver and gold particles were chosen. Four illustrative base liquids, namely (i) ethanol, (ii) methanol, (iii) ethylene-glycol, and (iv) water were considered with different geometries, which have great importance in industrial use. An emphasis on comparative multi nanofluid analysis was used to make a sound judgment on which one of the fluids best suited the metallic glittering process of spin coating. The film thickness process highly depends on the process of evaporation, which takes some time to settle on the disk's surface. It was found that of the base fluids, the best choices were ethanol alloys with silver. Hence, one can conclude that, from an experimental point of view, if silver alloy is used for coating, then only those liquids can be considered that exhibit ethanol-like properties. The impact of pertinent parameters with different aspects are graphically illustrated in each case

Lu et al. examined the flow of hybrid (nickel–zinc ferrite and ethylene glycol) nanoliquid with entropy optimization and nonlinear thermal radiation coatings past a curved stretching surface [3]. Analysis was carried out in the presence of magnetohydrodynamic, heat generation/absorption, and convective heat and mass flux conditions. A solution of the modeled problem was attained numerically using MATLAB built-in function bvp4c. Impacts of prominent parameters on betrothed distributions were depicted through graphs and they were well supported by requisite discussions. Numerically calculated values of Sherwood number were established in a tabulated form and were scrutinized critically. An excellent concurrence was achieved when the results of the presented model were compared with previously published result; hence, dependable results are being presented. It was observed that concentration field diminished with increasing values of curvature parameter, though the opposite trend was noticed for velocity and temperature distributions. Further, it was detected that Nusselt number decreased with augmented values of radiation and curvature parameters.

Investigation [4] is carried out on the thin film flow of Reiner-Philippoff fluid of boundary-layer type. We have analyzed the flow of thin films of Reiner–Philippoff fluid in the changeable heat transmission and radiation over a time-dependent stretching sheet in two-dimensions (2D). The time-dependent governing equations of Reiner–Philippoff fluid model are simplified with the help of transformation of similarity variables. To investigate the behavior of the Reiner-Philippoff fluid with variable stretching surface for different physical effects, we considered thermophoresis and Brownian motion parameters in the flow. The Homotopy Analysis Method is implemented in the reduced model in order to achieve a solution of the original problem. A numerical convergence of the implemented method is also analyzed. The behavior of temperature, velocity, and concentration profiles have been investigated with the variation of skin friction, Nusselt number, and Sherwood number. A comparative graphical survey is presented for the velocity gradient, under different parameters. An analytical analysis is presented for the time-dependent parameter over thin film flow. The results that we obtained are better than the previously available results. For the survey, the physical representation of the embedded parameters, are discussed in detail and plotted graphically.

The thin film flow of micropolar fluid in a porous medium under the influence of thermophoresis with the heat effect past a stretching plate is analyzed in [5]. Micropolar fluid is assumed as a base fluid and the plate is considered to move with a linear velocity and subject to the variation of the reference temperature and concentration. The latitude of flow is limited to being two-dimensional and it is steadily affected by sensitive fluid film size with the effect of thermal radiation. The basic equations of fluid flow are changed through the similarity variables into a set of nonlinear coupled differential equations with physical conditions. The suitable transformations for the energy equation is used and the non-dimensional form of the temperature field are different from the published work. The effects of radiation parameter are shown graphically and discussed.

The modern optical fiber required a double-layer resin coating on the glass fiber to provide protection from signal attenuation and mechanical damage. The most important plastics resin used in the coating of fiber optics are plasticized polyvinyle (PVC), low/high density polyethylene (LDPE/HDPE), nylon, and polysulfone. Due to abounded application, the polymer flow during optical fiber coating in a pressure type coating die has been simulated under non-isothermal conditions in [6]. The flow dependent on the wire or fiber velocity, geometry of the die, and the viscosity of the polymer. The wet-on-wet coating process is an efficient process for two-layer coating on the fiber optics. In the present study, the constitutive equation of polymer flow satisfies viscoelastic Phan–Thien–Tanner (PTT) fluid, is used to characterize rheology of the polymer melt. Based on the assumption of the fully developed incompressible and laminar flow, the viscoelastic fluid model of two-immiscible resins-layers modeled for simplified-geometry of capillary-annulus where the glass fiber drawing inside the die at high speed. The equation describing the flow of the polymer melt inside the die was solved, analytically and numerically, by the Runge–Kutta method. The effect of physical characteristics in the problem has been discussed in detail through graphs by assigning numerical values for several parameters of interest. As a first attempt, the model PTT fluid as a coating material for double-layer optical fiber coating using the wet-on-wet coating process is considered. At the end, the present study is compared with the published work as a particular case, and good agreement is found.

The main objective of [7] is to elaborate the characteristics of heat transport and magneto-hydrodynamics finite film flow of human blood with Carbon Nanotubes (CNTs) nanofluids over a stretchable upright cylinder. Two kinds of CNTs nanoparticles, namely (i) SWCNTs (single walled carbon nanotubes) and (ii) MWCNTs (multi walled carbon nanotubes), are used with human blood as a base liquid. In addition, a uniform magnetic field has been perpendicularly conducted to the motion of nanoliquid. The transformation of the partial differential structure into a non-linear ordinary differential structure is made by using appropriate dimensionless quantities. The controlling approach of the Homotopy analysis method has been executed for the result of the velocity and temperature. The thickness of the coating film has been kept variable. The pressure distribution under the variable thickness of the liquid film has been calculated. The impacts of different variables and the rate of spray during coating have been graphically plotted. The coefficient of skin friction and Nusselt number have been presented numerically. In addition, it is noticed that the thermal field of a nanoliquid elevates with rising values of ϕ and this increase is more in SWCNTs nanofluid than MWCNTs nanofluid.

Lu et al. proposed the unsteady flow and heat transfer analyses of a viscous-based nanofluid over a moving surface emerging from a moving slot [8]. A new form of boundary layer flow resembles with the boundary layer flow over a stretching/shrinking surface depending on the motion of the moving slot. The governing partial differential equations are transformed to correct similar form using the

Blasius–Rayleigh–Stokes variable. The transformed equations are numerically solved. The existence of dual solutions is observed for a certain range of moving slot parameter. The range of dual solution is strongly influenced by Brownian and thermophoretic diffusion of nanoparticles.

In [9], the three-dimensional nanofluid thin-film flow of Casson fluid over an inclined steady rotating plane is examined. A thermal radiated nanofluid thin film flow is considered with suction/injection effects. With the help of similarity variables, the partial differential equations are converted into a system of ordinary differential equations. The obtained ODEs are solved by the homotopy analysis method with the association of MATHEMATICA software. The boundary-layer over an inclined steady rotating plane is plotted and explored in detail for the velocity, temperature, and concentration profiles. Additionally, the surface rate of heat transfer and shear stress are described in detail. The impact of numerous embedded parameters, such as the Schmidt number, Brownian motion parameter, thermophoretic parameter, and Casson parameter, etc., were examined on the velocity, temperature, and concentration profiles, respectively. The essential terms of the Nusselt number and Sherwood number were also numerically and physically examined for the temperature and concentration profiles. It was observed that the radiation source improves the energy transport to enhance the flow motion. The smaller values of the Prandtl number, augmented the thermal boundary-layer and decreased the flow field. The increasing values of the rotation parameter decreased the thermal boundary layer thickness. These outputs are examined physically and numerically and are also discussed.

This study of [10] aims to scrutinize the thin film flow of a nanofluid comprising of carbon nanotubes (CNTs), single and multi-walled i.e., (SWCNTs and MWCNTs), with Cattaneo-Christov heat flux and entropy generation. The time-dependent flow is supported by thermal radiation, variable source/sink, and magneto hydrodynamics past a linearly stretched surface. The obtained system of equations is addressed by the numerical approach bvp4c of the MATLAB software. The presented results are validated by comparing them to an already conducted study and an excellent synchronization in both results is achieved. The repercussions of the arising parameters on the involved profiles are portrayed via graphical illustrations and numerically erected tables. It is seen that the axial velocity decreases as the value of film thickness parameter increases. It is further noticed that, for both types of CNTs, the velocity and temperature distributions increase as the solid volume fraction escalates.

The study [11] is about the pressure-driven heated bi-phase flow in two slippery walls. The non-Newtonian couple stress fluid is suspended with spherically homogenous metallic particles. The magnetic susceptibility of Hafnium allures is taken into account. The rough surface of the wall is tackled by lubrication effects. The nonlinear coupled partial differential equations along with the associated boundary conditions are first reduced into a set of ordinary differential equations using appropriate transformations and then numerical results were obtained by engaging the blend of Runge–Kutta and shooting techniques. The sway of physical quantities is graphically examined. Excellent agreement within graphical illustration and numerical results is achieved.

The aim of this research work [12] is to increase our understanding of the exhaustion of energy in engineering and industrial fields. The study of nanofluids provides extraordinary thermal conductivity and an increased heat transmission coefficient as compared to conventional fluids. These specific sorts of nanofluids are important for the succeeding generation of flow and heat transfer fluids. Therefore, the investigation of revolutionary new nanofluids has been taken up by researchers and engineers all over the world. In this article, the study of the thin layer flow of Darcy–Forchheimer nanofluid over a nonlinear radially extending disc is presented. The disc is considered as porous. The impacts of thermal radiation, magnetic field, and heat source/sink are especially focused on. The magnetic field, positive integer, porosity parameter, coefficient of inertia, and fluid layer thickness reduce the velocity profile. The Prandtl number and fluid layer thickness reduce the temperature profile. The heat source/sink, Eckert number, and thermal radiation increase the temperature profile. The suggested model is solved analytically by the homotopy analysis method. The analytical and numerical techniques are compared through graphs and tables, and they have shown good agreement. The influences of embedded parameters on the flow problem are revealed through graphs and tables.

In the analysis [13], peristaltic flow was discussed for magnetohydrodynamic Newtonian fluid through the gap between two coaxial tubes, where the viscosity of the fluid is treated as variable. In addition, the inner tube was considered to be at rest, while the outer tube had the sinusoidal wave traveling down its motion. Further, the assumptions of long wave length and low Reynolds number were taken into account for the formulation of the problem. A closed form solution is presented for general viscosity while using the Adomian decomposition method. Numerical illustrations that show the physical effects and pertinent features were investigated for different physical included phenomenon. It was found that the pressure rise increases with an increase in Hartmann number, and frictional forces for the outer and inner tube decrease with an increase in Hartmann number when the viscosity is constant. It was also observed that the size of the trapping bolus decreases with an increase in Hartmann number, and it increases with an increase in amplitude ratio when the viscosity is parameter.

The magnetohydrodynamic flow of a micropolar nanofluid on an exponential sheet in an Extended–Darcy–Forchheimer porous medium have been considered by Lund et al. [14]. The Buongiorno's model is considered in order to formulate a mathematical model with different boundary conditions. The governing partial differential equations of the nanofluid flow are changed into a third order non-linear quasi-ordinary differential equation, using the pseudo-similarity variable. The resulting equation of the boundary value problems are renewed into initial value problems using a shooting method, and then the initial value problems are solved by a fourth order Runge–Kutta method. The effects of various physical parameters on the profiles of velocity, temperature, microrotation velocity, concentration, skin friction, couple stress coefficients, heat, and concentration transfer are graphically demonstrated. A stability analysis has been performed in order to show the stability of the solutions; only the first solution is stable and physically possible, whereas the remaining two solutions are not stable.

The magnetohydrodynamic flow over a shrinking sheet and heat transfer with viscous dissipation has been studied in [15]. The governing equations of the considered problem are transformed into ordinary differential equations while using similarity transformation. The resultant equations are converted into a system of fractional differential boundary layer equations by employing a Caputo derivative, which is then numerically solved using the Adams-type predictor-corrector method. The results show the existence of two ranges of solutions, namely, dual solutions and no solution. Moreover, the results indicate that dual solutions exist for a certain range of specific parameters which are in line with the results of some previously published work. It is also observed that the velocity boundary layer decreases as the suction and magnetic parameters increase.

The aim of [16] is to present an analytical and numerical treatment of a two-dimensional peristaltic channel along with the coating of laminar layers of nanoparticles with non-Newtonian (Williamson) base liquid. In addition to this, convective heat transfer and magnetic field effects also take into consideration. The geometry is considered as an asymmetric two-dimensional channel experiencing sinusoidal waves propagating across the walls. The walls are supposed to have heat convection at the upper wall and the lower wall is having no temperature gradient. The problem is manufactured under the theory of lubrication approach. The mathematical models are evolved using appropriate transformations. The obtained nonlinear differential equations are solved analytically. Graphical features are presented to find the influence of emerging physical parameters on the stream function, velocity of the nanofluid, heat transfer, nanoparticles concentration, pressure gradient, and pressure increase. It is found that the velocity decreases in the lower part while increasing in the upper side of the channel in the presence of nanoparticles. The temperature is becoming large with increasing amount of nanoparticles and heat convection at the boundaries. It is also observed that nanoparticle concentration is getting higher with Brownian motion parameter, but fluid becomes less thermal against the thermophoresis parameter.

The streamlines phenomenon clearly reflects the asymmetry of the channel. The characteristics of viscous fluid can be recovered by switching the Weissenbureg number) to zero.

The impact of second-order slip with thermal and solutal stratification coatings on three-dimensional Williamson nanofluid flow past a bidirectional stretched surface and analytically envisages it by Ramzan et al. [17]. The novelty of the analysis is strengthened by Cattaneo–Christov heat flux accompanying varying thermal conductivity. The appropriate set of transformations is implemented to get a differential equation system with high nonlinearity. The structure is addressed via the homotopy analysis technique. The authenticity of the presented model is verified by creating a comparison with the limited published results and finding harmony between the two. The impacts of miscellaneous arising parameters are deliberated through graphical structures. Some useful tabulated values of arising parameters versus physical quantities are also discussed here. It is observed that velocity components exhibit an opposite trend with respect to the stretching ratio parameter. Moreover, the Brownian motion parameter shows the opposite behavior versus temperature and concentration distributions.

The peristaltic flow of velocity second slip boundary conditions and inclined magnetic field of Jeffrey fluid by means of heat and mass transfer in asymmetric channel was inspected by Saleem et al. [18]. Leading equations that described the existing flow were then simplified under lubrication approach. Therefore, exact solutions of stream function, concentration and temperature were deduced. Further, the numerical solutions of pressure rise and pressure gradient were computed while using Mathematica software. Furthermore, the effect of the second slip parameter was argued via graphs. It has been depicted that this kind of slip is mandatory and very imperative to foresee the physical model. On the other hand, false results will be obtained.

The importance of Hall current coatings in the establishment of Cattaneo–Christov heat flux model in an unsteady aqueous-based nanofluid flow comprising single (SWCNTs) and multi-walled (MWCNTs) carbon nanotubes (CNTs) amid two parallel rotating stretchable disks in reported in [19]. The novelty of the presented model is strengthened with the presence of homogeneous-heterogeneous reactions and thermal stratification effects. The numerical solution of the system of coupled differential equations with high nonlinearity is obtained by applying the bvp4c function of MATLAB software. To corroborate the authenticity of the present envisioned mathematical model, a comparison table is added to this study in limiting case. An excellent harmony between the two results is obtained. The effects of numerous parameters on involved distributions are displayed graphically and are argued logically in the light of physical laws. Numerical values of coefficient of drag force and Nusselt number are also tabulated for different parameters. It is observed that tangential velocity (function of rotation parameter) is increasing for both CNTs. Further, the incremental values of thermal stratification parameter cause the decrease in fluid temperature parameter.

Alghmdi et al. [20] explored the magnetohydrodynamic stretched flow of viscoelastic nanofluids with heterogeneous–homogeneous reactions. Attention in modeling has been specially focused to constitutive relations of viscoelastic fluids. Thermophoresis and Brownian dispersion are utilized to explore the heat and mass transport process. Resulting nonlinear systems are computed for numerical solutions. Findings for temperature, concentration, concentration rate, skin-friction, local Nusselt, and Sherwood numbers are analyzed for both second grade and elastico-viscous fluids.

The role of mixed convective 3D nanoliquid flow by a rotating disk with activation energy and magnetic field is explored in [21]. Flow was created by a rotating disk. Velocity, concentration, and temperature slips at the surface of a rotating disk were considered. The impacts of Brownian diffusion and thermophoretic were additionally accounted for. The non-linear frameworks are simplified by suitable variables. The shooting method is utilized to develop the numerical solution of resulting problem. Plots were prepared just to explore that how concentration and temperature are impacted by different pertinent flow parameters. The Sherwood and Nusselt numbers were additionally plotted and explored. Furthermore, the concentration and temperature were enhanced for larger values of Hartman number. However, the heat transfer rate (Nusselt number) diminishes when the thermophoresis parameter enlarges.

A liquid coating of bubbly flow with peristaltic motion inside elastic walls was investigated by Ijaz et al. [22]. The proposed model is constructed using the two-fluid approach with the most distinctive collaboration among gas, fluid, pressure, and drag forces. The variation in pressure leads to a change in void fraction. The differential controlling conditions affected by the long wavelength of the peristaltic wave and the slow movement are taken into account. Analytical results of the simplified governing equations are obtained using the homotopy perturbation method (HPM). The features of the significant parameters are shown and examined graphically.

As nanofluids have great potential to enhance thermophysical properties and heat transfer performance. Also double diffusion convection plays an important role in natural processes and technical applications. The effect of double convection by diffusion is not limited to oceanography, but is also evident in geology, astrophysics, and metallurgy. For such a vital role of such factors in applications, Alolaiyan et al. [23] have presented the analytical solutions of pumping flow of third-grade nanofluid and described the effects of double diffusion convection through a compliant curved channel. The model used for the third-grade nanofluid includes the presence of Brownian motion and thermophoresis. Additionally, thermal energy expressions suggest regular diffusion and cross-diffusion terms. The governing equations have been constructed for the incompressible laminar flow of the non-Newtonian nanofluid along with the assumption of long wavelength. The obtained analytical expressions for velocity, temperature, and nanoparticle concentration have been sketched for various considerable parameters. The effects of regular buoyancy ratio, buoyancy parameter, modified Dufour parameter, and Dufour-solutal Lewis number have been analyzed along with wall properties and pumping characteristics. This study concludes that fluid becomes hotter with an increase in regular buoyancy ratio and a modified Dufour parameter, but a decrease in temperature is observed for the buoyancy parameter. Moreover, the solutal concentration is behaving inversely against the Defour–Solutal Lewis number.

A mathematical illustration of an application to endoscopy by incorporating hybrid nanoparticles and an induced magnetic field with a rheological fluid model in inspected by Awais et al. [24] for more realistic results. Rheological fluid behavior is characterized by the Ostwald-de-Waele power-law model. A hybrid nanofluid mechanism is considered comprising platelet-shaped nanoparticles, since nanoparticles are potential drug transportation tools in biomedical applications. Moreover, ciliary activity is encountered regarding their extensive applications in performing complex functions along with buoyancy effects. An endoscope is inserted inside a ciliated tube and peristalsis occurred due to ciliary activity in the gap between tube and endoscope. A non-Newtonian model is developed by mathematical formulation, which is analytically tackled using homotopy analysis. The outcomes are interpreted graphically along with the pressure rise and streamlining configuration for the case of negligible inertial forces and long wavelength. A three-dimensional graphical interpretation of axial velocity is also studied. Moreover, tables are prepared and displayed for a more physical insight.

In [25], the authors developed the mathematical model for entropy generation analysis during the peristaltic propulsion of Jeffrey nanofluids passing in a midst of two eccentric asymmetric annuli. The model was structured by implementation of lubrication perspective and dimensionless strategy. Entropy generation caused by the irreversible influence of heat and mass transfer of nanofluid and viscous dissipation of the considered liquid was taken into consideration. A powerful analytical technique handled the governing equations. The comparison of total entropy with the partial entropy was also invoked by discussing Bejan number results. The influence of various associated variables on the profiles of velocity, temperature, nanoparticle concentration, entropy generation, and Bejan number was formulated by portraying the figures. Mainly from graphical observations, they analyzed that, in the matter of thermophoresis parameter and Brownian motion parameter, entropy generation is thoroughly enhanced while inverse readings were reported for the temperature difference parameter and the ratio of temperature to concentration parameters.

Top coating is usually moulded, painted, or sprayed onto the wind blade Leading-Edge surface to prevent rain erosion due to transverse repeated droplet impacts. Wear fatigue failure analysis based on Springer model has been widely referenced and validated to quantitatively predict damage initiation. The model requires liquid, coating, and substrate speed of sound measurements as constant input parameters to analytically define the shockwave progression due to their relative vibro-acoustic properties. The modelling assumes a pure elastic material behavior during the impact event. Recent coating technologies applied to prevent erosion are based on viscoelastic materials and develop high-rate transient pressure build-up and a subsequent relaxation in a range of strain rates. In order to analyze the erosion performance by using Springer model, appropriate impedance characterization for such viscoelastic materials is then required and it represents the main objective of this work to avoid lack of accuracy. In [26], the authors have proposed a modelling methodology that allows one to evaluate the frequency dependent strain-stress behavior of the multilayer coating system under single droplet impingement. The computational tool ponders the operational conditions (impact velocity, droplet size, layer thickness, etc.) with the appropriate variable working frequency range for the speed of sound measurements. Moreover, this research defines in a complementary paper, the ultrasonic testing characterization of different viscoelastic coatings and the methodology validation. The modelling framework is then used to identify suitable coating and substrate combinations due to their acoustic matching optimization and analyze the anti-erosion performance of the coating protection system.

Under droplet impingement, surface leading edge protection (LEP) coating materials for wind turbine blades develop high-rate transient pressure build-up and subsequent relaxation in a range of strain rates. The stress-strain coating LEP behavior at a working frequency range depends on the specific LEP and on the material and operational conditions, as described in this research in a previous work. Wear fatigue failure analysis, based on the Springer model, requires coating and substrate speed of sound measurements as constant input material parameters. It considers a linear elastic response of the polymer subjected to drop impact loads, but it does not account for the frequency dependent viscoelastic effects for the materials involved. The model has been widely used and validated in the literature for different liquid impact erosion problems. In [27], an appropriate definition of the viscoelastic materials properties with ultrasonic techniques is investigated. It is broadly used for developing precise measurements of the speed of sound in thin coatings and laminates. It also allows accurately evaluating elastic moduli and assessing mechanical properties at the high frequencies of interest. In the current work, an investigation into various LEP coating application cases have been undertaken and related with the rain erosion durability factors due to suitable material impedance definition. The proposed numerical procedures to predict wear surface erosion have been evaluated in comparison with the rain erosion testing in order to identify suitable coating and composite substrate combinations. LEP erosion performance at rain erosion testing (RET) technique is used widely in the wind industry as the key metric, in an effort to assess the response of the varying material and operational parameters involved.

3. Future Trends in Fluid Mechanics

The material that advances the state-of-the-art experimental, numerical, and theoretical methodologies or extends the bounds of existing methodologies through new contributions in coatings is still insufficient, even with the completion of this Special Issue. The rheological characteristics with thin films under the influence of different nanoparticles and shapes can help with the development of better applications in industry.

Funding: This research received no external funding.

Acknowledgments: The guest editorial team of Coatings would like to thank all authors for contributing their original work to this special issue, no matter what the final decision on their submitted manuscript was. The editorial team would also like to thank all anonymous professional reviewers for their valuable time, comments, and suggestions during the review process. We also acknowledge the entire staff of the journal's editorial board for

providing their cooperation regarding this Special Issue. We hope that this issue will, not only provide an overall picture and most up-to-date findings to readers from the scientific community working in the field, but would also benefit the industrial sectors in specific market niches and end users.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Riaz, A.; AlOlayan, H.; Zeeshan, A.; Razaq, A.; Bhatti, M.M. Mass Transport with Asymmetric Peristaltic Propulsion Coated with Synovial Fluid. *Coatings* **2018**, *8*, 407. [CrossRef]
2. Ellahi, R.; Zeeshan, A.; Hussain, F.; Abbas, T. Study of Shiny Film Coating on Multi-Fluid Flows of a Rotating Disk Suspended with Nano-Sized Silver and Gold Particles: A Comparative Analysis. *Coatings* **2018**, *8*, 422. [CrossRef]
3. Lu, D.; Ramzan, M.; Ahmad, S.; Shafee, A.; Muhammad, S. Impact of Nonlinear Thermal Radiation and Entropy Optimization Coatings with Hybrid Nanoliquid Flow Past a Curved Stretched Surface. *Coatings* **2018**, *8*, 430. [CrossRef]
4. Ullah, A.; Alzahrani, E.O.; Shah, Z.; Ayaz, M.; Islam, S. Nanofluids Thin Film Flow of Reiner-Philippoff Fluid over an Unstable Stretching Surface with Brownian Motion and Thermophoresis Effects. *Coatings* **2018**, *9*, 21. [CrossRef]
5. Ali, V.; Gul, T.; Afridi, S.; Ali, F.; Alharbi, S.O.; Khan, I. Thin Film Flow of Micropolar Fluid in a Permeable Medium. *Coatings* **2019**, *9*, 98. [CrossRef]
6. Khan, Z.; Rasheed, H.U.; Alharbi, S.; Khan, I.; Abbas, T.; Chin, D.L.C. Manufacturing of Double Layer Optical Fiber Coating Using Phan-Thien-Tanner Fluid as Coating Material. *Coatings* **2019**, *9*, 147. [CrossRef]
7. Alsagri, A.S.; Nasir, S.; Gul, T.; Saeed, I.; Nisar, K.S.; Shah, Z.; Khan, I. MHD Thin Film Flow and Thermal Analysis of Blood with CNTs Nanofluid. *Coatings* **2019**, *9*, 175. [CrossRef]
8. Lu, D.; Mumtaz, S.; Farooq, U.; Ahmad, A. Analysis of Unsteady Flow and Heat Transfer of Nanofluid Using Blasius–Rayleigh–Stokes Variable. *Coatings* **2019**, *9*, 211. [CrossRef]
9. Saeed, A.; Shah, Z.; Islam, S.; Jawad, M.; Ullah, A.; Gul, T.; Kumam, P. Three-Dimensional Casson Nanofluid Thin Film Flow over an Inclined Rotating Disk with the Impact of Heat Generation/Consumption and Thermal Radiation. *Coatings* **2019**, *9*, 248. [CrossRef]
10. Lu, D.; Ramzan, M.; Mohammad, M.; Howari, F.; Chung, J.D. A Thin Film Flow of Nanofluid Comprising Carbon Nanotubes Influenced by Cattaneo-Christov Heat Flux and Entropy Generation. *Coatings* **2019**, *9*, 296. [CrossRef]
11. Ellahi, R.; Zeeshan, A.; Abbas, T.; Hussain, F. Thermally Charged MHD Bi-phase Flow Coatings with non-Newtonian Nanofluid and Hafnium Particles along Slippery Walls. *Coatings* **2019**, *9*, 300. [CrossRef]
12. Dawar, A.; Shah, Z.; Kumam, P.; Khan, W.; Islam, S. Influence of MHD on Thermal Behavior of Darcy-Forchheimer Nanofluid Thin Film Flow over a Nonlinear Stretching Disc. *Coatings* **2019**, *9*, 446. [CrossRef]
13. Akram, S.; Aly, E.H.; Afzal, F.; Nadeem, S. Aly Effect of the Variable Viscosity on the Peristaltic Flow of Newtonian Fluid Coated withMagnetic Field: Application of Adomian Decomposition Method for Endoscope. *Coatings* **2019**, *9*, 524. [CrossRef]
14. Lund, L.A.; Ching, D.L.C.; Omar, Z.; Khan, I.; Nisar, K.S. Triple Local Similarity Solutions of Darcy-Forchheimer Magnetohydrodynamic (MHD) Flow of Micropolar Nanofluid Over an Exponential Shrinking Surface: Stability Analysis. *Coatings* **2019**, *9*, 527. [CrossRef]
15. Lund, L.A.; Omar, Z.; Alharbi, S.O.; Khan, I.; Nisar, K.S. Numerical Investigation of Multiple Solutions for Caputo Fractional-Order-Two Dimensional Magnetohydrodynamic Unsteady Flow of Generalized Viscous Fluid over a Shrinking Sheet Using the Adams-Type Predictor-Corrector Method. *Coatings* **2019**, *9*, 548. [CrossRef]
16. Riaz, A.; Alolaiyan, H.; Razaq, A. Convective Heat Transfer and Magnetohydrodynamics across a Peristaltic Channel Coated with Nonlinear Nanofluid. *Coatings* **2019**, *9*, 816. [CrossRef]
17. Ramzan, M.; Liaquet, A.; Kadry, S.; Yu, S.; Nam, Y.; Lu, D. Impact of Second-Order Slip and Double Stratification Coatings on 3D MHD Williamson Nanofluid Flow with Cattaneo–Christov Heat Flux. *Coatings* **2019**, *9*, 849. [CrossRef]
18. Saleem, N.; Akram, S.; Afzal, F.; Aly, E.H.; Hussain, A. Impact of Velocity Second Slip and Inclined Magnetic Field on Peristaltic Flow Coating with Jeffrey Fluid in Tapered Channel. *Coatings* **2020**, *10*, 30. [CrossRef]
19. Ramzan, M.; Riasat, S.; Kadry, S.; Kuntha, P.; Nam, Y.; Howari, F. Numerical Analysis of Carbon Nanotube-Based Nanofluid Unsteady Flow Amid Two Rotating Disks with Hall Current Coatings and Homogeneous–Heterogeneous Reactions. *Coatings* **2020**, *10*, 48. [CrossRef]

20. Alghamdi, M. On Magnetohydrodynamic Flow of Viscoelastic Nanofluids with Homogeneous–Heterogeneous Reactions. *Coatings* **2020**, *10*, 55. [CrossRef]
21. Alghamdi, M. Significance of Arrhenius Activation Energy and Binary Chemical Reaction in Mixed Convection Flow of Nanofluid Due to a Rotating Disk. *Coatings* **2020**, *10*, 86. [CrossRef]
22. Ijaz, N.; Riaz, A.; Zeeshan, A.; Ellahi, R.; Sait, S. Buoyancy Driven Flow with Gas-Liquid Coatings of Peristaltic Bubbly Flow in Elastic Walls. *Coatings* **2020**, *10*, 115. [CrossRef]
23. Alolaiyan, H.; Riaz, A.; Razaq, A.; Saleem, N.; Zeeshan, A.; Bhatti, M. Effects of Double Diffusion Convection on Third Grade Nanofluid through a Curved Compliant Peristaltic Channel. *Coatings* **2020**, *10*, 154. [CrossRef]
24. Awais, M.; Shah, Z.; Perveen, N.; Ali, A.; Kumam, P.; Rehman, H.U.; Thounthong, P.; Parveen, N. MHD Effects on Ciliary-Induced Peristaltic Flow Coatings with Rheological Hybrid Nanofluid. *Coatings* **2020**, *10*, 186. [CrossRef]
25. Riaz, A.; Gul, A.; Khan, I.; Ramesh, K.; Khan, S.U.; Baleanu, D.; Nisar, K.S. Mathematical Analysis of Entropy Generation in the Flow of Viscoelastic Nanofluid through an Annular Region of Two Asymmetric Annuli Having Flexible Surfaces. *Coatings* **2020**, *10*, 213. [CrossRef]
26. Domenech, L.; Renau, J.; Šakalytė, A.; Sánchez, F. Top Coating Anti-Erosion Performance Analysis in Wind Turbine Blades Depending on Relative Acoustic Impedance. Part 1: Modelling Approach. *Coatings* **2020**, *10*, 685. [CrossRef]
27. Domenech, L.; García-Peñas, V.; Šakalytė, A.; Francis, D.P.; Skoglund, E.; Sánchez, F. Top Coating Anti-Erosion Performance Analysis in Wind Turbine Blades Depending on Relative Acoustic Impedance. Part 2: Material Characterization and Rain Erosion Testing Evaluation. *Coatings* **2020**, *10*, 709. [CrossRef]