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Preface

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ABSTRACT
Preface Special Issue on Fluid Flow: Analysis and Numerics

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GEOMETRIC OPTIMIZATION BASED ON THE CONSTRUCTAL DESIGN OF PERFORATED THIN PLATES SUBJECT TO BUCKLING

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ABSTRACT
Elastic buckling is an instability phenomenon that can occur if a slender and thin-walled plate is subjected to axial compressive load. It is well known that the presence of holes in structural plate elements is almost inevitable in inspection, maintenance, and service purposes, or to reduce the structural weight. In this paper constructal design was employed to optimize the geometry of thin perforated plates submitted to elastic buckling. Simply supported rectangular perforated plates were analyzed

with three different shapes of centered holes: elliptical, rectangular, and diamond. The purpose was to obtain the optimal geometry that maximizes the critical buckling load. The ratio between the height and length of the plate was kept constant, while the ratio between the characteristic dimensions of the holes was optimized for several hole volume fractions (φ). A finite-element model was used to assess the plate buckling load, and the Lanczos method was applied to the solution of the corresponding eigenvalue problem. When $\varphi \leq 0.20$ the optimum geometry is the diamond hole, reaching maximum buckling loads around 80.0,21.5, and 17.4% higher than a plate without perforation and plates with elliptical and rectangular holes, respectively. For intermediate and higher values of φ, the elliptical and rectangular holes, respectively, led to the best performance. The optimal shapes were obtained according to the constructal principle of minimization of distribution of imperfections, showing that the constructal design also can be employed to define the optimized geometries in the mechanics of material problems.

Keywords: constructal design, buckling of perforated plate, critical load, geometric optimization
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A LATTICE MONTE CARLO ANALYSIS ON CHEMICAL REACTION WITH MOVING BOUNDARY

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ABSTRACT
The current paper aims to simulate combined mass diffusion and chemical reaction. Two solid reactants are brought into contact and the product is formed at the interface. Chemical reaction is assumed to occur instantaneously, thus the reaction rate is limited only by the interdiffusion of the two solid constituents. First, parametric studies for a range of constant diffusivities are performed and simple relations for the growth of the product phase are obtained. It is found that the thickness of the product layer increases proportionally to the square root of the product of diffusivity and time. In the second part of the analyses the formation of NiAl by interdiffusion of nickel and aluminum is simulated. This self-propagating exothermic reaction is of great interest for joining temperature-sensitive components. Within the limits of these calculations, the concentration dependence of the diffusion coefficients of nickel and aluminum is considered in order to improve the accuracy of the simulation.

Keywords: lattice Monte Carlo, self-propagating exothermic reactions, mass diffusion, concentration dependence
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1D AND 2D MODELING AND SIMULATION OF RADIAL COMBUSTION PROPAGATION ON Fe_2O_3/Al THERMITE SYSTEMS

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ABSTRACT
In previous works, a one-dimensional model was built to simulate the nonsteady radial combustion propagation on thin disk-shaped samples of Fe_2O_3/aluminum thermite mixtures and was successfully tested. Now, the purpose is to extend the referred model to the more sensible two-dimensional features of the samples, maintaining the main characteristics of the previous

model: zero-order kinetics, conductive/radiative heat transfer, assumption of phase transitions, temperature and composition dependency for all system properties during propagation. Therefore, an adaptive numerical algorithm that conjugates a method of lines (MOL) strategy based on finite differences space discretizations, with a collocation scheme based on increasing level dyadic grids is applied for the solution of the problem. The particular integration method proves to cope satisfactorily with the steep traveling thermal wave in 1D and 2D spatial domains, either for trivial uniform mixing conditions, as in complex examples developed to feature more sophisticated circumstances, such as nonhomogeneous reactant mixing, which realistically replicate the observed experimental conditions.

Keywords: combustion, Fe_2O_3 aluminum thermite, modeling, adaptive methods, finite differences, method of lines, dyadic grids, nonhomogeneous mixtures
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EFFECTS OF RADIAL FINS ON THE LAMINAR NATURAL CONVECTION OF A NANOFLUID IN CONCENTRIC ANNULI

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ABSTRACT
The laminar natural convection of the Cu-water nanofluid between two horizontal concentric cylinders with four radial fins attached to the inner cylinder is studied numerically. The governing equations with the respective boundary conditions are solved by using the finite volume method and the SIMPLER algorithm. The computations are performed for various Rayleigh numbers, fin lengths, and thermal conductivity ratios. The results presented in this study are for a range of Rayleigh numbers from 10^3 to 10^5, dimensionless lengths of the fins between 0.1 to 0.4, and two thermal conductivity ratios, namely, 100 and 654. It is observed from the results that the average Nusselt number decreases with increasing the fins' lengths. However, the heat transfer rate and the average Nusselt number increase by increasing the fins' thermal conductivity at high Rayleigh numbers.

Keywords: natural convection, nanofluid, annuli, radial fin
pages 151-158

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NATURAL CONVECTION IN A NANOFLUID-FILLED SQUARE CAVITY WITH AN ARC-SHAPED HEATED BAFFLE

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ABSTRACT
Buoyancy driven natural convection in a nanofluid-filled square cavity induced by an arc-shaped heated baffle is analyzed numerically. Upper and bottom walls of the cavity are insulated and the remaining two walls have constant temperature; their values are lower than the baffle's temperature. The calculations were performed for various values of Rayleigh number (10^4 « (Ra) « 10^6) dimensionless arc length (0.25 « S « 0.75), shape parameter of the baffle (π/4 « Θ « π), types of nanoparticles (Cu, Al_2O_3) in a wide range of solid volume fraction of nanoparticles (0 « φ « 0.15). It is found that the net heat transfer can be enhanced by increasing the Rayleigh number, baffle length, and shape parameter. As the baffle length is increased for a fixed Rayleigh number, the average Nusselt number increases and for a fixed baffle length when the Rayleigh numbers are increased, the average Nusselt number also increases. The addition of copper and alumina Nanoparticles has produced a remarkable enhancement of the heat transfer. The average Nusselt number increases with increasing solid volume fraction of nanoparticles, especially at low Rayleigh numbers. Adding $Al_2 O_3$ increases the heat transfer rate but the influence of adding Cu nanoparticles to pure water on the heat transfer rate is much more pronounced because of its higher value of thermal conductivity compared to Al_2O_3. The difference in the average Nusselt number using different nanoparticles is negligible at low solid volume fractions, but as the volume fraction of nanoparticles increases, the difference for the mean Nusselt number becomes larger. This is similar to results which were obtained by other authors.

Keywords: buoyancy, arc-shaped baffle, cavity, nanofluid, Cu-water, Al_2O_3-water, natural convection, enhancement factor, Nusselt number, finite volume method
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MODELING OF VIRTUAL PARTICLES OF THE BIG BANG

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ABSTRACT
In this work, a mathematical model in four dimensions proposed to predict the behavior of the transport phenomena of mass (energy) in the space-time continuum through a metric tensor in the Planck scale is presented. The Ricci tensor was determined with the aim of measuring the turbulent flow of a mass with a large gravitational field similar to that which is believed to have existed in the Big Bang. Computing the curvature of space-time through tensor analysis, we predict a vacuum solution of the Einstein field equations through numerical integration with approximate solutions. A quantum vacuum is filled with virtual particles of enormous superficial gravity of black holes and wormholes as predicted by other authors. By generating the geodesic equations, we obtain the relativistic equation, which is the carrier of information pertaining to the behavior of the entropy of matter The results of the measurements of the evolution of the mass during its collapse and evaporation allow us to argue the evidence of virtual particles including all the values (and beyond) of the experimental search by other authors for gauges and Higgs bosons. We conclude that the matter behaves as virtual particles, which appear and disappear in Planck time at speeds greater than that of light, representing those that probably existed during the Big Bang.

Keywords: black hole physics, quantum wormholes, dense matter, elementary particles, Higgs boson, radiation mechanisms, thermal, turbulence, Planck scale
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