Key Words: Hydronic radiant cooling, stratum ventilation, thermal comfort, air quality, computational fluid dynamic.

GENETIC ALGORITHM APPLICATION FOR AN AXIAL TURBINE STATOR AND ROTOR CASCADE OPTIMIZATION

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Abstract

Gas turbines have many applications in different industries. The axial turbine is one of the most challenging components of gas turbines for industrial and aerospace applications. With the ever-increasing requirement for high aerodynamic performance blades, two and three dimensional aerodynamic shape optimization is of great importance. In this paper, an automatic design procedure is presented for single point optimization of an axial flow turbine stator and rotor cascades. In this method, the genetic algorithm, the blade geometry generator, a computational mesh generator and the flow field solver are related. The objective function is the total pressure loss of the flow passing through the stator or rotor blade cascades. Particular modifications are performed with a limited number of optimization parameters, by changing stator and rotor blade thickness distribution. The stator and rotor airfoils are regenerated by adding a smooth perturbation of Wagner shape functions to the thickness distributions. Because of the symmetric geometry of the turbine blade cascade, periodic boundary conditions are used for simulations. Furthermore, three-dimensional and turbulent flow field investigations are numerically performed employing a compressible Navier-Stokes solver and the k-e (RNG) turbulence model. The experimental results of initial stator cascade are used for validation of numerical results. The experimental investigation is performed in the Gas Turbine Laboratory of Sharif University of Technology. The maximum deviation of numerical results from cascade test data is 1.14 percent. This optimization strategy resulted in a reduction of 1.5% total pressure loss in the rotor and 3.0% in the stator, for a prescribed incidence angle, while the cross sectional area of the modified stator and rotor blades increased, 1.3% and 2.0%, compared with the initial ones, respectively. It should be noted that for the rotor blade cascade, a multi-point optimization is required, based on a comparison of the original and modified loss-incidence angle chart results.

Key Words: Stator, rotor, optimization, total pressure loss.

Abstract
All materials are made up of sub-bodies, which constitute their substructure or microstructure. The size of a sub-body may vary from atomic dimensions to a macroscopic scale, such as grain size. Depending upon the nature and accuracy of the physical phenomena to be modeled, the average distance of the sub-bodies plays a central role. This distance may vary from the order of the lattice parameter (10-8 cm in perfect crystals), to a few millimeters, as in granular solids. The boundary and initial conditions bring into play another characteristic, length. Such models, entitled nonlocal theories, have been proposed for the past four decades. The solutions of various critical problems have verified our hopes and expectations in that, by means of nonlocal models, it will be possible to make accurate predictions of physical phenomena at submicroscopic scale. In the present study, the anti-plane stress field of multiple cracks is obtained using the solution of screw dislocation in an infinite elastic plane, based on nonlocal elasticity. The distribution dislocation technique is used to model the crack problem with screw dislocation distribution. Unlike the classical elasticity solution, a lattice parameter enters into the problem, which makes the stresses finite in the screw dislocation solution in the infinite elastic plane in nonlocal theory, which has no singularity at the dislocation tip, and which is consistent with theoretical results. Similarly, the crack problem using the distribution dislocation theory is solved with no singularity at the crack tip. The kernel in the related equation is of the Cauchy type, and to determine the distribution of dislocations, which generates traction along the crack line, the Gauss-Chebyshev quadrature has been used. Several numerical examples to illustrate the accuracy and capability of the solution have been calculated, where the effect of crack length, lattice parameter and constant is calculated as a variable parameter, which includes all of them. Stress at the crack tip and its graphs are depicted and the results obtained are compared with classical results in this field.

Key Words: Non-local elasticity, crack, distribution dislocation, screw dislocation, anti-plane, infinite plane.

VENTILATION AND THERMAL PERFORMANCE IN A HYBRID SYSTEM OF HYDRONIC RADIANT COOLING AND STRATUM VENTILATION IN A RESIDENTIAL ROOM

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Abstract
Providing thermal comfort and proper air quality are two main factors when determining the type of HVAC system. The study of new concepts in air conditioning systems is very important and necessary, in order to achieve optimal thermal comfort and air quality.
Stratum ventilation and hydronic radiant cooling systems are two modern air conditioning systems considered in the present study, and a hybrid usage of these systems has been studied. The purpose of this study is the evaluation and comparison of the effect of physical-thermal and geometric parameters on thermal comfort and indoor air quality, in order to offer practical suggestions for improving these important parameters. Therefore, thermal and physical parameters, such as air change per hour, inlet air temperature and radiant cooling panel temperature, and also, geometrical parameters, such as cooling ceiling ratio and exhaust location, have been evaluated. In the present investigation, the cooling load ratio, removed by the stratum ventilation and hydronic radiation cooling systems to satisfy thermal comfort and proper air quality, is determined. The results show that despite combined hydronic radiation cooling and conventional displacement ventilation in which the exhaust location is a trivial parameter, the exhaust location, in the present hybrid system of hydronic radiation cooling and stratum ventilation, is the most important parameter in achieving thermal comfort and proper air quality. Increasing the ACH has a significant impact on improving thermal comfort and air quality indices, although this effect at high ACH (Air Change per Hour) is reduced. In addition, increasing the cooling ceiling ratio improves thermal comfort. On the other hand, indoor air quality is reduced because of its influence on air flow patterns and increased return air flow near the surface of the panel. In addition, when 30 to 40 percent cooling load is removed by stratum ventilation, the best condition of thermal comfort and proper air quality is provided. Finally, the present study has introduced a hybrid system of hydronic radiant cooling and stratum ventilation as a new approach to achieve combined thermal comfort and proper air quality.

nanofiber/carbon fiber/epoxy cross ply laminated composites are fabricated in different vapour grown carbon nanofiber weight loadings, and the percentages of deformations are measured carefully. The results show that adding 1 wt of vapour grown carbon nanofiber to the composites can reduce the out of plane deformation of un-symmetric laminates up to 48%. Finally, the finite element method and the classical lamination theory (CLT) are used to validate the experimental observations. The results of this comparison show good agreement between the modeling and the experimental results. The results indicate that the addition of low contents of CNF causes the coefficient of thermal expansion of the matrix to decrease and the matrix Young's modulus to increase, which, in turn, leads to a considerable reduction in micro and macro thermal residual stresses. This reduction will decrease the unwanted deformed shape of the cross ply un-symmetric laminated composites.

Key Words: Un-symmetric cross ply polymeric composites, carbon nanofiber, coefficient of thermal expansion, young's modulus.

INVESTIGATION INTO THE EFFECT OF ELECTRODE FORCE AND TIME ON RESIDUAL STRESS RESULTING FROM RESISTANCE SPOT WELDING OF ALUMINUM SHEETS

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Abstract
Nowadays, application of light materials, such as aluminum sheeting, plays a very important role in various automotive and aerospace industries. Resistance spot welding is a widely used method in assembly lines of such industries. The main purpose of this study is to investigate the effect of electrode force and time on residual stresses produced by the resistance spot welding of aluminum alloy, 6061-T6. In this study, a two-dimensional electro-thermo-mechanical finite element model with axial symmetry has been employed to predict the temperature, nugget size and distribution of residual stress in the resistance spot welding process. For more realistic analysis, temperature dependent physical and mechanical properties have been defined for the electrodes and sheets. The simulation results have been compared with the results obtained from experimental tests. For validation, the nugget size and residual stresses were compared. The diameter of the nugget was measured by metallographical observation, and the residual stresses were measured by an X-ray diffraction method at three points of the nugget in three equal samples. The studies show that the highest amount of tensile residual stress occurs at the intersection of the sheets and at the center of the nugget; by moving away from the center along the nugget radius, residual stresses diminish. To study, numerically, the electrode force effect and its time, a set of parametric studies was designed. These parameters are current, current time, and either force or its time. The results indicate that by increasing the electrode force and its time, the residual stresses increase. But the effect of electrode force is less than its time on residual stresses. This fact refers to higher heat transfer and cooling rate at the welding zone. An increase in forcing time causes a higher cooling rate, and more columnar dendrite structure can be observed in the nugget area. This will create concentrated residual stresses at the nugget zone.

Key Words: Resistance spot welding; residual stress; finite element method; electrode force; force time.

ANTI-PLANE STRESS ANALYSIS OF MULTIPLE CRACKS IN AN INFINITE PLANE IN NONLOCAL THEORY

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EXPERIMENTAL STUDY OF FREQUENCY OF TAYLOR BUBBLES IN GAS-LIQUID TWO-PHASE FLOW IN A LARGE BEND

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Abstract

Gas-liquid two-phase flow occurs frequently in many cases of industry, depending on the geometry of the duct, and the topography of the interface which creates different flow regimes. The Taylor bubble regime is one of the most possible patterns that exist over a wide range of gas-liquid flow rates. It is characterized by the motion of an elongated bubble among a continuous zone of liquid. The transient and intermittent nature of this regime causes sequence changes of pressure inside the channel and increases the fatigue and corrosion of the channel wall. In the present research, for its high importance, the frequency of Taylor bubbles was investigated in a large bend with three consecutive inclinations. At first, the flow regimes and flow diagrams of the inclined sections, as well as the horizontal section, in the upstream of the bend, were considered. It was noted that the Taylor bubble area stayed unchanged without the channel slope effect, and three areas were also coincident. As the bubbles merge and the bubble collapse phenomenon does not occur, the slope change of the channel does not affect the Taylor bubble frequency. A detailed explanation is given on Taylor bubble formation in the bend due to slug flow, which was generated on the upstream of the bend. The effect of gas and liquid flow rates on Taylor bubble frequency in the bend, as well as slug frequency at upstream of the bend, was also conducted in the present study. The results showed that an increase in gas flow rate decreases the Taylor bubble frequency in the whole range of liquid flow rates. In the flows with $Re_{sl} < 22000$, close correspondence exists between Taylor bubble frequency at the bending location and slug frequency at the upstream of the bend, and the increase in liquid flow rate decreases bubble frequency. However, the opposite result was found during flows with $Re_{sl} > 22000$. Finally, correlations were proposed to evaluate Taylor bubble frequency, based on phase superficial Reynolds number. These correlations are important for flow regime evaluation, in addition to the lack of similar subject matter in the literature .

Key Words: Two-phase flow, bubble frequency, plug regime, taylor bubbles, inclined cchannel.

REDUCTION IN DEFORMATION OF UNSYMMETRICAL CROSS-PLY LAMINATED COMPOSITE USING CARBON NANOFIBERS

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Abstract

Due to the natural inconsistency of the mechanical and thermal properties of fiber and matrix, residual stresses are introduced during the curing process of fibrous polymer composites. Considering a high Young's modulus and the negative coefficient of thermal expansion (CTE) of carbon nanofibers (CNFs), the addition of CNFs into the matrix makes its properties closer to reinforcement, and this reduces residual stress in laminated polymer composites. In this research, a novel method to decrease the deformed shape of cross ply un-symmetric laminated composites, by adding vapour grown carbon nanofiber, is proposed. To this end, first, using thermo mechanical analysis (TMA) and tensile test methods, the coefficient of thermal expansion and the Young's modulus of vapour grown carbon nanofiber reinforced epoxy are measured. The characterizations showed a significant decrease in the coefficient of thermal expansion and a slight increase in the Young's modulus of the matrix. Then, using the sonication technique, as well as the hand layup method, vapour grown carbon

Effective cooling techniques are greatly needed for cooling any sort of high-energy device. Common heat transfer fluids, such as water, ethylene glycol and engine oil, have limited heat transfer capabilities due to their low heat transfer properties, and numerous researchers have been investigating better ways to enhance the thermal performance of heat transfer fluids. Nanofluids are suspensions of nanoparticles in base fluids; a new challenge for thermal sciences provided by nanotechnology. The tested fluids are prepared by dispersing the Al and Cu or metal base fluids into the water at three different concentrations; 500, 1000 and 2000 ppm.

Thermal conductivities of these fluids are measured experimentally by a thermal property analyzer, i.e., KD2 Pro, using a KS-1 sensor needle, as this needle is preferred for low viscosity fluids. Experimental results show that the thermal conductivity of nanofluids is higher than base fluid and the thermal conductivity of Cu/Water nanofluid is more than Al/Water nanofluid. This is because Cu-metal thermal conductivity is more than Al-metal thermal conductivity. In addition, a comparison is made between the experimental results of thermal conductivity and the results calculated using the models presented for their prediction.

This study presents the heat transfer coefficient and friction factor of Al-water and Cu-water nanofluids flowing in a spiral coil in the laminar flow regime with constant wall temperature. The experiments were undertaken at different concentrations and under various operational conditions. The effects of different parameters, such as Gz number, wall temperature and nanofluid particle concentration, on the heat transfer coefficient and pressure drop of the flow were studied. The thermal conductivities of these fluids are measured experimentally and results show that the thermal conductivity of Cu-Water nanofluid is about 18% higher than Al-Water nanofluid in 2000 ppm. Nusselt number oscillations can be seen for different nanofluids, which are caused by the secondary flow.

Key Words: Spiral coil, nanofluid, nusselt number, pressure drop, thermal conductivity.

NUMERICAL SIMULATION OF GAS-LIQUID TWO-PHASE FLOW IN LONG HORIZONTAL CHANNEL AND SLUG FREQUENCY EVALUATION USING TFM

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Abstract
As gas and liquid flow simultaneously in a duct or pipe, different flow regimes will be generated. One of these regimes is called the slug flow, which is a common occurrence in gas-liquid two-phase flow in ducts. In recent decades, research into slug flow has increased because of gas and liquid transport, especially for applications with undersea reservoir operations with long pipelines. Information about the flow regime is necessary for thermal and hydraulic calculations. As pioneers declared, one of the most important considerations in the development of slug flow models is to predict slug frequency that has not been solved completely. This subject is a major issue that remains unsolved for two-phase flow in pipes or ducts.

Many studies have reported results that are restricted to their experimental conditions, because different parameters can influence slug frequency. The numerical modeling of slug flow is important for simulation and prediction of physical behavior in gas-liquid transfer pipelines design, process equipment and, also, slug catchers.

In this paper, air-water two-phase flow is simulated using the Pressure Free Model (PFM). The conservation equations are solved numerically by a class of high order shock capturing methods. To verify the various numerical methods in the developed code (Lax- Friedrichs, Ritchmyer, FORCE and FLIC), the water faucet problem is used. Comparison of the results with analytical solution of the benchmark cases shows good agreement. As the results of the developed codes verified, the FLIC method is selected to simulate the stratified air-water flow in a long horizontal channel. The results show good agreement in comparison with experimental data, which was conducted in the Multiphase Flow Laboratory of TMU. In this research, for the first time, it was found that the PFM under a well-posed condition could predict and evaluate two-phase flow behavior in long horizontal channels, in addition to slug frequency calculation and capturing the hydraulic jump, which forms before slug initiation.

Key Words: Numerical modeling, PFM, water faucet problem, hydraulic ump, slug frequency.

and parametric fit, with 3-parameter Weibull distribution, using maximum likelihood estimation (MLE) and a graphical approach, is conducted. In addition, the blade is assumed to be subjected to different modes of failure, and the cumulative mode-specific functions are derived for each failure mode using a Nelson-Aalen estimator. An important result from parametric analysis is that blade reliability has a 3-parameter Weibull distribution, and, so, the blades exhibit an increasing failure rate. Finally, considering the mode-specific hazard functions, failure mode 1, i.e., excessive vibration, is observed to be a major contributor to blade failure.

Key Words: Reliability, helicopter blade 205, statistical analysis, multiple failure modes, 3-parameter weibull distribution.

SURFACE ROUGHNESS AND MAXIMUM UNDEFORMED CHIP THICKNESS MODELING IN SURFACE GRINDING

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Abstract
Grinding is a surface finishing process, and surface roughness is one of the most important factors in evaluating the performance of the finished component. The development of a comprehensive model that can predict surface roughness over a wide range of operating conditions is still a key issue for the grinding process. In this paper, a new predictive surface roughness model for the surface grinding process is developed, based on maximum undeformed chip thickness modeling. By considering the random nature of grit distribution and grit geometry and, thus, variations in the depth of grain penetration, the concept of a probability density function (PDF) has been utilized. Gamma PDF has been determined to be the best function, by comparing the main distribution functions in a histogram graph of chip thickness, and, based on this PDF, maximum undeformed chip thickness modeling has been carried out. The representation of chip thickness in the proposed model is a function of grinding parameters, the wheel microstructure and process kinematic conditions. The developed model for surface roughness prediction is based on the geometrical analysis of the grooves left on the surface due to the grit-workpiece interaction, and has been resulted using maximum undeformed chip thickness modeling. The surface roughness model has been validated by the experimental results of the surface grinding of a thermally sprayed WC-10Co-4Cr coating. Reasonable agreement has been observed between predictions from the proposed model and the experimentally measured surface roughness. This is also supported by the values of the average percentage of error between predicted and experimental results. The average value of relative error between predicted and measured values of surface roughness was 8.53%. According to these results, it can be concluded that the proposed surface roughness model is an effective prediction technique.

Key Words: Grinding, surface roughness, chip thickness, probability density function.

EXPERIMENTAL STUDY ON FORCE CONVECTION OF A NANOFLUID IN A SPIRAL TUBE

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Abstract
Fluid heating and cooling are important in many industries such as power, manufacturing, transportation, and electronics.

with a prototype implementation and successful test results. The robot was approximately 60kg in weight and may move in ground cables with a maximum speed of 20m/min.

Key Words: Inspection robot, high-voltage power lines, simulation, mechanical design.

MODELING AND SIMULATION OF A LATENT HEAT THERMAL ENERGY STORAGE SYSTEM (LHTES) CONTAINING PHASE CHANGE MATERIALS

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Abstract
The growing need for energy, considering limited energy resources, pollution and global warming, have forced people to be more sensitive about the rate of energy consumption. Despite this fact, because of rising living standards, there is an increasing demand for cooling systems in buildings around the world. This increasing demand has led to a peak in electrical power consumption during hot summer days. Finding a solution for this peak is a new challenge for scientists. A leading option is to save available energy for use when it is needed. Saving the coldness of the night air for air conditioning during the hot summer days of tropical regions, instead of using common cooling devices, could be a proper opportunity to save energy. This idea is not only a good option for solving the electrical power imbalance between supply and demand, but also shifts the cooling energy use to off-peak periods and avoids peak demand charges. Phase Change Materials (PCM), because of their unique specifications, such as their capability of melting and freezing at a selected temperature, and their promising ability to reduce the dimensions of storage systems compared with usual storage systems (because they use the latent heat of the storage medium for thermal energy storage), can be used for this purpose. Initially, deriving a mathematical model for describing a heat exchanger packed with phase change Materials is essential. For this propose, a Latent Heat Thermal Energy Storage system (LHTES), containing flat slabs of Phase Change Material (PEG 600), has been investigated numerically and experimentally. For the numerical investigation, a one-dimensional model considering axial conduction and using effective heat capacity has been proposed to describe the built LHTES. The results of the model and experiments were compared, and good agreements were achieved.

Key Words: Phase change material, PCM, thermal energy storage, numerical model, LHTES, free cooling, polyethylene glycol 600.

STATISTICAL DATA ANALYSIS AND MODELING OF HELICOPTER BLADE RELIABILITY CONSIDERING MULTIPLE FAILURE MODES

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Abstract
Following the development of the aerospace industry, the concept of reliability has attracted much attention in the field of mechanical engineering. However, limited failure data and statistical analyses of helicopter component reliability exist in technical literature. For filling this gap, a nonparametric analysis is conducted on the performance of the 338 blades of Iranian helicopter 205, which was in service between 1974 and 2012. These blades have 41 different failure modes. In this paper, using statistical analysis, the reliability of the helicopter blade 205, which has multiple failure modes, is obtained. The Kaplan-Meier estimator is used for calculating the nonparametric reliability functions. Confidence intervals for the nonparametric reliability results are derived,

Key Words: Cylindrical panel, ratcheting, uniaxial cyclic loading, combined cyclic loading, plastic energy, stainless steel 304L.

NUMERICAL AND EXPERIMENTAL INVESTIGATION OF THE MOTION OF A DEFORMABLE SOLID BODY AND ITS IMPACT ON A RIGID SUBSTRATE

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Abstract
In this study, a numerical model for simulation of the interaction between a deformable solid body and an incompressible fluid is developed. The solid object is assumed to be a hyperelastic material which has many applications in biological systems. The developed model uses an Eulerian approach for both fluids and solids and the volume of fluid method, to obtain the position of the solid object. For treating the solid object, a deformation tensor is employed, which is computed by means of a transport equation at each time step. Based on the obtained value of deformation and, also, the constitutive equation of the solid object, elastic stresses can be calculated. This term, which has a nonzero value only in the solid zone, is added to the fluid governing equations .The elastic stresses have discontinuities across the fluid/solid interface. Therefore, the dynamic boundary condition is not completely satisfied. For improving this boundary condition, the viscosity in the solid object is increased, which reduces the effects of the elastic stresses in the fluid/ solid interface; resulting in a stable simulation.
For validating the numerical results, a simple experiment is performed, in which the movement of a spherical deformable solid object in air and its impact on a rigid substrate are studied. In this experiment, a CCD camera is employed to capture images from the movement of the solid object. Next, an image processing technique is used to obtain the required data. The same case is also simulated using the developed numerical program, and the obtained results are compared with those of the experiments. The numerical results are in good agreement with those of the experiments performed in this study.

Key Words: Fluid-structure interaction, hyperelastic material, volume of fluid, numerical simulation, image processing.

SIMULATION AND EXPERIMENTAL VALIDATION OF A NEW CABLE INSPECTION ROBOT FOR HIGH VOLTAGE LINES

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Abstract
In this article, detailed design of a novel power line inspection robot was studied. This robot may be used to move on ground cables for special purposes such as the inspection and fault detection of electric power lines. Designed active and passive mechanisms in the proposed robot enable it to move over various obstacles on ground cables, such as clamps, warning balls and mast tips. Indeed, this robot is the first designed robot with the capability of moving over all ground cable obstacles. The active mechanisms contained seven rubber-coated rollers (i.e. four vertical rollers and three horizontal rollers), as well as three mechanisms, in order to make the horizontal rollers move vertically. The passive mechanisms included a set of spring-dampers installed in each joint of the robot arms. Simulation results in ADAMS software reveal a desirable stability of performance when moving on ground cables with a maximum slope of 30-degrees. Also, the robot showed a suitable performance when passing over the warning balls (with a maximum diameter of 700mm), rectangular mast tips (170*170 mm) and mast tips with a 30-degree twist in the horizontal plane. The feasibility of these maneuvers was proven

Abstracts of Papers in English

AN EXPERIMENTAL STUDY ON THE RATCHETING BEHAVIOR OF STAINLESS STEEL 304L CYLINDRICAL PANELS UNDER CYCLIC, AXIAL AND COMBINED LOADINGS

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Abstract
In this paper, the ratcheting behavior of stainless steel 304L cylindrical panels under cyclic combined and axial loading is studied. Experimental tests were performed by a servo-hydraulic INSTRON 8802 machine for several samples. The panels were fixed in normal and oblique directions under 20 degrees and subjected to cyclic loads. The effect of the length and angle of the cylindrical panels on ratcheting behavior and plastic energy was investigated. Based on the experimental results, it was found that bending moment played a crucial role in the dissipation and increase of plastic deformations. The ratcheting displacement for a cylindrical panel under combined loading is larger than for one under uniaxial loading, because the bending moment cooperates with the axial load to increase ratcheting displacement for cylindrical panels under combined loading. Also, for several cycles at the beginning of loading, the ratcheting displacement rate of the panel under combined loading was higher than that of the one under uniaxial loading. Finally, the ratcheting displacement rate of both types of loading became equal. The results showed that when the length of samples increased, ratcheting displacement and plastic energy increased, and sample life decreased.