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PREFACIO

La Red Temática Nacional Aeronáutica (RTNA) organizó el primer Congreso Internacional en Aeronáutica. El evento se llevó a cabo los días 17 y 18 de octubre de 2017 en el Centro Nacional de Tecnologías Aeronáuticas (CENTA) del Centro de Ingeniería y Desarrollo Industrial (CIDESI) en la ciudad de Santiago de Querétaro, México.

México se está consolidando como una región estratégica para la manufactura de componentes aeronáuticos a nivel mundial, con un crecimiento superior al 15% anual durante los últimos tres años. Además, México mantiene una capacidad para atraer inversión extranjera directa, a través de nuevos proyectos con alto impacto de innovación y desarrollo en las diferentes áreas de la industria aeronáutica.

Actualmente, la aeronáutica en México está enfocada principalmente a la manufactura, el mantenimiento, el diseño, la capacitación y los servicios. Los estados de Baja California, Chihuahua, Nuevo León, Querétaro y Sonora, abarcan la mayoría de las empresas aeronáuticas instaladas en el país, empleando a más de 45,000 profesionales. Además, según estimaciones del Programa Estratégico de la Industria Aeronáutica 2010-2020, coordinado por la Secretaría de Economía, se espera que esta industria logre exportaciones por 12,267 millones de dólares para 2021, estimando que México pase a ocupar el puesto número 10 en 2020, y empleando a más de 110 mil personas.

Las proyecciones de crecimiento y consolidación de la industria aeronáutica, obliga a las Instituciones Educativas, Centros de Investigación, Gobierno e Industria a trabajar en conjunto para promover oportunidades en la ejecución de proyectos de investigación de alto impacto, el desarrollo de innovación tecnológica y la instalación de nuevas área científicas especializadas, que en la actualidad no están implantadas en el país, tales como los sistemas de propulsión y simuladores de control de vuelo y aviónica.

El evento consistió en conferencias plenarias por parte de reconocidos especialistas en aeronáutica a nivel internacional, presentaciones orales, mesas redondas, workshops temáticos y una sesión general de posters científicos.

Objetivos

Discutir el marco y necesidades de las compañías aeronáuticas establecidas en México.

Debatir modelos de negocio en la cadena de proveedores aeronáuticos en México.

Establecer trabajo colaborativo de la triple hélice: Industria-Gobierno-Academia.

Conferencistas plenarios

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Caracterización del vórtice de salida de un ala rectangular mediante dinámica de fluidos computacional (CFD)

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ABSTRACT

En la comunidad de la aviación civil y la aeronáutica, los vórtices desarrollados en los extremos de las alas de las aeronaves comerciales representan un riesgo significativo para otras aeronaves durante el vuelo, situación común durante el aterrizaje y el despegue. La Administración Federal de Aviación (FAA) y la Organización de Aviación Civil Internacional (OACI) exigen que las aeronaves que realizan vuelos por Instrumentos (IFR) se mantengan separadas por distancias mínimas que van entre 3-6 millas náuticas. Por otra parte, los vuelos realizados por reglamento de Vuelo Visual (VFR) las maniobras son a discreción del piloto. La rapidez de disipación de los vórtices secundarios cambia significativamente con la curvatura en el espesor de la punta alar, lo que conduce a que las componentes de esfuerzos turbulentos presenten distribución compleja, lo que afecta la disipación del vórtice en una etapa más temprana.

El objetivo general es analizar el efecto de la geometría de la punta de un ala rectangular sobre la estructura y la disipación de los vórtices de salida secundarios y terciarios, mediante la Dinámica de Fluidos Computacional. Los objetivos particulares son la revisión de los modelos de turbulencia apropiados a la aerodinámica de alas de longitud finita y la evaluación cuantitativamente las componentes de la velocidad, vorticidad, presión estática y las propiedades turbulentas referentes al vórtice de salida en un campo cercano. Se concluye que en un ala con punta circular, la inestabilidad de los vórtices secundarios y terciarios no es dominante, permitiendo que las componentes del tensor de esfuerzos de Reynolds muestren simetría espacial en una etapa temprana. En el otro caso, cuando la punta es rectangular, la alta inestabilidad retrasa la propiedad axisimétrica del vórtice dominante. El utilizar un modelo de turbulencia de dos ecuaciones, exhibe mayor decaimiento en el coeficiente de presión estática medible en el centro del vórtice, con respecto a los modelos de turbulencia de una sola ecuación. Sin embargo, ambos modelos no predicen con exactitud la tendencia del coeficiente de presión estática en un campo cercano.

KEYWORDS: vórtices, CFD, turbulencia.

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Desarrollo de un proceso de diseño de superficies de control para vehículos de ala fija

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ABSTRACT

La eficiencia de los dispositivos encargadas de dirigir la dinámica rotacional de una aeronave representa una parte importante para tener un vuelo seguro. Se desarrolló un proceso de diseño de superficies de control con aplicación a vehículos aéreos de ala fija a partir de un modelo dinámico y utilizando el enfoque de dinámica inversa no lineal. El modelo está basado en las ecuaciones que describen las maniobras donde la aeronave se expone a las condiciones más críticas de vuelo. El enfoque de la dinámica inversa se añadió en el proceso de manera que fuera posible definir a la aeronave una trayectoria sobre cada uno de sus desplazamientos rotacionales y a partir de ella determinar el comportamiento del ángulo de flexión de las superficies control necesario para que se cumpliera. Con este análisis se verificó que la geometría propuesta para las superficies de control fuera funcional bajo las condiciones de vuelo presentadas durante la trayectoria completa. El proceso fue aplicado en el diseño de superficies de control para una aeronave propuesta y se analizó su efectividad con simulaciones computacionales. El comportamiento de las superficies de control y los desplazamientos angulares de la aeronave indicaron su eficiencia. El modelo dinámico, sobre el que se basa este trabajo, permite la reducción de la cantidad de pruebas en túnel de viento necesarias para definir las características de una superficie de control. De esta forma, las pruebas en el túnel sólo están enfocadas en el cálculo del parámetro de efectividad, lo que significa que se hace con mayor eficiencia. Este proceso se utiliza actualmente en el Centro de Investigación en Innovación en Ingeniería Aeronáutica como base para el diseño de los elementos de control de nuevos vehículos aéreos.

KEYWORDS: Superficies de Control. Túnel Aerodinámico. Dinámica Inversa No Lineal.

Análisis de la dinámica de vuelo de una aeronave y diseño del sistema de control

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ABSTRACT

Los sistemas de control de vuelo que se emplean en las aeronaves deben satisfacer regulaciones de desempeño y robustez, en particular, las establecidas por la FAA [1]. Las aeronaves al ser sistemas multivariables presentan grandes retos durante el diseño de los sistemas de control. Las técnicas más conocidas para el diseño de sistemas de control multivariable suelen establecer la robustez en términos difíciles de medir in situ. Por otro lado, los sistemas de una entrada y una salida (SISO) suelen ser menos complejos, además la robustez de estos, se establece en términos bien conocidos y aceptados en la práctica: márgenes de fase y ganancia. En este trabajo se muestra el diseño de un control multivariable, mediante el análisis y diseño por canales individuales (ICAD) para realizar la maniobra de viraje coordinado de la aeronave utilitaria Cessna T37. Así mismo se establece la robustez del sistema de control en términos de los márgenes de fase y ganancia [2]. Una de las características de ICAD es la posibilidad de analizar la estructura dinámica del sistema mediante la función de estructura multivariable (MSF). De la misma forma, la magnitud de la MSF es una medida del acoplamiento del sistema en el dominio de la frecuencia. Una característica del giro coordinado es el nulo derrape durante la maniobra. Mediante el estudio de la MSF del modelo dinámico es posible establecer el acoplamiento del sistema y determinar el rango de frecuencia donde el sistema puede estar desacoplado. De esta forma, es posible atenuar el acoplamiento del sistema mediante el diseño de un control de pre-alimentación (feedforward) [3] sin incrementar la sensibilidad estructural del sistema de control, como podría ocurrir mediante el uso de pre/pos compensadores o controladores no centralizados. En el artículo se realiza la simulación digital de la maniobra de la aeronave y se establece la factibilidad de las señales de control. El diseño presentado cumple con los requerimientos establecidos en el FAR 23 Sección 23.157.

KEYWORDS: Sistemas de control multivariable; Análisis y diseño por Canal Individual; Dinámica de vuelo.

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A conceptual design of a sailplane based on a scale model approach

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ABSTRACT

This research work presents a conceptual design of a sailplane based on a scale model approach for specific requirements. This covers the statistical analysis of other standard class sailplanes, a study of the air properties, airfoil selection, and the scale model analysis. In effect this paper includes the aerodynamic characteristics of the wing, the wing geometry design, the minimum gliding angle and minimum drag coefficient calculations and the drag polar computation. The aerodynamic center of the wing and the horizontal stabilizer have been estimated to define a distance between the wing and the horizontal stabilizer among other calculations. In addition this paper contains the design of the horizontal stabilizer in order to accomplish longitudinal stability and a performance analysis of the sailplane including circling velocity and sink rate calculations for best climb performance.

KEYWORDS: Conceptual design, performance analysis, longitudinal stability.

Computational fluid dynamics capabilities for mexican aerospace industry

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ABSTRACT

Nowadays, CFD has become an indispensable tool in the resurgent national aeronautical industry, being an alternative to carry out simulations to aerial vehicles where the necessary experimental infrastructure is not available, especially in the early stages of design.

Objective: To show the scope of the newest CFD's tools for aerodynamic precision simulations for aerial vehicles.

Scope: Simulate and analyze the aerodynamics of Unmanned Aerial Vehicles, a semi-wing and a prototype of Light Sport Aircraft (national redesign and construction) in cruising and near to stall conditions (partially detached fluid).

Methodology: ▪ Analyze the considerations for simulation, as well as the physics of the problem, which implies to have theoretical and practical bases in external aerodynamics. ▪ Apply turbulence model, size of the computational domain, boundary conditions, as well as characteristics of discretization (mesh or lattice). ▪ Propose a discretized independence study, as well as the convergence criteria or stopping to be used. ▪ Analyze the results (forces, moments, contours of state variables, etc.), and propose possible improvements to the current design.

Results: In addition to the numerical ones, more intuitive results are obtained, such as the vorticity field or particle trajectories, which helps to make better decisions when is proposed an aerodynamic optimization to the vehicle.

Conclusions: Numerical results give us reliability and certainty to assist in design, redesign and validation process of aerial vehicle (and its internal components), therefore, is a big area of opportunity in aeronautical engineering. With the continuous development of CFD software we are capable to obtain better results, each time closer to real systems, with high precision and less restrictions on the computation capabilities needed, due to this, we are always working to remain in the vanguard in this field.

KEYWORDS: CFD, aerodynamics, aircraft.

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Aerodynamical experimentation in a wing with spiroid

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ABSTRACT

Spiroids are wingtip devices used for the reduction of induced drag of wings. Nevertheless, not all the spiroid configurations give the desired performance. In the first stage of design, the absolute aerodynamic performance is evaluated through wind-tunnel experiments rather than by numerical simulations. Therefore, it is important to implement an aerodynamic test bench for lift, drag and moment coefficients determination.

This research contribution presents the design of the aerodynamic test bench prototype and some preliminary results of a comparison between a scaled wing with and without spiroid are presented too.

Experiments were conducted in the subsonic, closed circuit, closed test-section of the CIIIA-FIME-UANL. The scaled wing model have a mean aerodynamic chord of 21cm, zero dihedral and twist angles, semi-span of 60cm, aspect ratio of 7.8 and taper ratio of 0.31. The experimental conditions were: free-stream velocity of 30m/s, Mach number of 0.087, and Reynolds number of 5.1 X 10^5. Preliminary results of the aerodynamic lift and drag coefficients are presented in Figure 1.

The data analysis delivers an increment of the lift coefficient and a non-standard behavior of the drag coefficient. This non-standard behavior can be explained as an effect of the low-Reynolds number experimentation. Further experimentation performed with measurement instruments with improved accuracy and sensibility are needed in order to validate this preliminary conclusion. Additional aerodynamic tests conducted in the same facility suggest that a more sophisticated wind tunnel balance is required for standard aerodynamic testing.

KEYWORDS: Wind tunnel testing, Aerodynamic performance, Spiroid.

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Diseño y manufactura de un túnel de viento transónico.

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ABSTRACT

La Universidad Aeronáutica en Querétaro (UNAQ) está enfocada a la generación de conocimiento en el campo de las ciencias aeroespaciales. En México este campo de la ciencia se encuentra en una primer etapa, por lo que, es necesario acercarse o crear infraestructura que permitan alcanzar las metas y objetivos de la UNAQ.

Un túnel de viento transónico es una tecnología que puede simular fenómenos aerodinámicos con velocidades de flujo que hacen importantes los efectos compresibles (efectos que ocurren alrededor del número de Mach de 0.5) y que posibilita el estudio de fenómenos a lo largo de la velocidad del sonido y hasta un máximo de Mach 1.4.

Por lo anterior, se ha preparado un proyecto para la construcción de un túnel de viento transónico, el cual, será el primer de su tipo diseñado y manufacturado en México y que ayudará a generar conocimientos en diferentes líneas de investigación.

El proyecto se encuentra dividido en: el suministro de potencia, cámara de pruebas, instrumentación, tobera convergente-divergente, selección de materiales para cada sección y sistema posicionador.

La propuesta ha enriquecido los conocimientos y definición de procesos que coadyuvan al desarrollo tecnológico nacional y ha dejado de manifiesto que el trabajo en equipo fortalece a las instituciones cuando se tiene escasos recursos económicos.

Actualmente se tienen manufacturados los siguientes elementos: cámara de pruebas, conexión para la cámara-difusor y cámara-tobera, cámara de sedimentación, mesa de sujeción del túnel, así como los elementos de sujeción (bridas) respectivos. De manera simultánea se trabaja en la manufactura de difusor y tobera.

KEYWORDS: túnel de viento, diseño y manufactura, transónico.

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Análisis de la dinámica de periodo corto de una aeronave con movimiento en el centro de gravedad

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ABSTRACT

Uno de los objetivos que se quiere cumplir en el diseño de aeronaves, es que esta pueda mantener un vuelo recto y nivelado. Para esto, es necesario que la derivada del coeficiente de momentos de la aeronave con respecto al ángulo de ataque sea negativa: $\partial Cm/\partial \alpha<0$. Dicha propiedad se denomina estabilidad estática. El principal factor que afecta esta propiedad de una aeronave es la ubicación del centro de gravedad con respecto al centro aerodinámico. A medida que el centro de gravedad se desplaza hacia atrás, el margen de estabilidad estática disminuye y la sensibilidad a las entradas de control y perturbaciones aumenta. En este trabajo se presenta un estudio de la estática y dinámica longitudinal de una aeronave mediante el enfoque del modelo de orden reducido de periodo corto y como el movimiento del centro de gravedad afecta el desempeño de la aeronave en lazo abierto. Este modelo considera principalmente una rotación longitudinal sobre el centro de gravedad acompañada de levantamientos y hundimientos verticales debidos a los efectos aerodinámicos de la velocidad de cabeceo. El modelo de segundo orden obtenido en el cual se tiene las perturbaciones del ángulo de cabeceo y de la velocidad de cabeceo está en función de la posición del centro de gravedad y de la deflexión del elevador. Este modelo resulta ser fundamental para el diseño de sistemas de control en los cuales se busca que las aeronaves cumplan con los criterios de estabilidad en un rango amplio.

KEYWORDS: Dinámica de Vuelo, Estabilidad Dinámica, Centro de Gravedad.

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Implementación de un algoritmo para el diseño conceptual de aeronaves.

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ABSTRACT

En este trabajo se presenta un paquete de diseño por computadora denominado CIIIA-PCAD. Este ha sido desarrollado y programado Matlab © de Mathworks. Los cálculos están dirigidos al Diseño Conceptual y Preliminar de una aeronave de ala fija. El núcleo de los cálculos está basado en los procedimientos generales propuestos por M. H. Sadraey [1]. El objetivo primordial de este programa es el cálculo de los parámetros mínimos requeridos para el diseño conceptual de un vehículo aéreo haciendo uso de una base de datos, la cual es el resultado de un estudio estadístico. Dadas una serie de requerimientos definidos por las especificaciones de la misión a cumplir, los resultados principales obtenidos por el programa son: perfil alar, envergadura, cuerda media, área y distribución de levantamiento, no sólo para el ala principal de la aeronave sino también para las superficies horizontal y vertical del empenaje; así como la distancia óptima del centro aerodinámico del ala al centro aerodinámico del empenaje horizontal, el diámetro de fuselaje y su longitud total. Se presenta un ejemplo de la aplicación del programa tomando en cuenta la propuesta de la SEDENA denominada proyecto Azteca.

KEYWORDS: Diseño conceptual de aeronaves, desarrollo de una línea-base, actuaciones de aeronaves.

Numerical analysis of a mechanism for the morphology in the extrados of an airfoil

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ABSTRACT

The study of the morphology (shape change) in wings leads to the optimization of aerodynamic characteristics in an aircraft, so for the development and implementation of a change in the structure and shape of an airfoil, in this case the extrados, helps to increase the aerodynamic performance of an aircraft at different operating velocities, according to the required mission profile. A previous work on morphology is continued where the "initial" profile is the NACA 4415 and as a new profile "objective" the FUSION. The objective of this work is the dimensioning of the elements of the mechanism used to achieve the required changes. We consulted the different materials used in the aeronautics industry, as well as new materials in this area that could contribute to the good performance of the mechanism without negatively affecting the aerodynamics. These results allow evaluating the performance of a wing with variable extrados with respect to the defined morphology.

KEYWORDS: Numerical analysis, mechanisms, morphing wings.

Análisis dinámico de un torpedo ancla con empuje vectorial

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ABSTRACT

Uno de los principales problemas en la extracción de hidrocarburos en zonas marítimas es poder instalar los sistema que almacenan, exploran y explotan éste recurso, para poder instalarlos existen varios tipos de unidades flotantes: FPSO-Floating Production Storage and Offloading; Semi-Submergible; TLP-Tension Leg Platform , todos tienen como factor común el que deben ser sujetados al lecho marino, para ello un dispositivo que permite el anclaje en el lecho marino es el torpedo de penetración profunda (DPA), un dispositivo que penetra el lecho marino y después de instalarlo tiene una fuerza de sujeción que mediante cadenas permite fijar una unidad flotante, la instalación de un DPA consiste en únicamente dejarlo caer y llegar al lecho marino con una energía cinética suficiente para poder penetrar la superficie, los factores que se consideran para su instalación depende de las condiciones de las olas y de tipo de suelo en el lecho marino.

El presente trabajo se enfoca en el proceso de instalación de un DPA, que a diferencia de los sistemas actuales, se considera una fuerza de propulsión externa que puede modificar la orientación del mismo esto con la finalidad de garantizar una posición adecuada para la penetración en el lecho marino.

Se hace un análisis en CFD para obtener las fuerzas hidrodinámicas que el oleaje pueda generar y para completar las ecuaciones dinámicas que en el presente trabajo de desarrollan. Con los datos obtenidos del análisis CFD se hace una simulación numérica de las ecuaciones dinámicas para ver el comportamiento de las mismas.

Palabras clave: CFD, DPA, dinámica, hidrodinámica, orientación.

Experimental modal analysis of the main rotor blade of the bell 206L helicopter.

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ABSTRACT

Helicopters are typically subjected to heavy vibrations and fatigue loads, which make them more susceptible to aeromechanical instabilities, excessive noise, low flight stability and restricted flight envelopes; this compared to conventional fixed wing aircrafts. The main source of vibration in helicopters is the main rotor, this is due its unstable operating conditions, which leads to flow stagnation areas, interaction between vortex, as well as flow at transonic velocities in the blade tips. The Helicopter Bell 206L is widely used in different applications such as civil transport, surveillance, rescue, among others [1]; that is why it is of great interest to know the dynamic behavior of the main rotor, and thus seek solution to the more common problems in the aircraft. In this research work, the modal analysis for the main rotor of this helicopter is presented, based on its frequency response (FRF) [2], which has been already proven to be a practical tool for the characterization of dynamic behaviors [3][4]. In order to obtain the experimental data, the response of the blade against an external excitation is measured. This is achieved by using the well-known “hammer test” method, having the blade mounted and held in its position in the main rotor. Using a piezoelectric accelerometer, and the necessary components for signal processing, data are captured form a series of excitations performed along the blade at different points by “hammer” impacts; see Figure 1 and Figure 2. Finally, using the Fast Fourier Transform (FFT), the FRFs are calculated for each measurement, this by using specialized software, and form them, the dynamic parameters of the blade are determined; that is, modes of vibration, natural frequencies, and percentage of damping.

KEYWORDS: Modal analysis, helicopter, frequency response function.

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Aerodynamic balance design for force and moment measurement

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ABSTRACT

The key measurement system in a wind tunnel is the multicomponent force and moment measurement instrumentation. More than 70% of the tests in a wind tunnel require some kind of force measurements. Historically the instruments were purely mechanical and their mechanism resembled balances for weighing, hence the uses of the term balance today. Today these balances are often based on transducers or are constructed out of a single piece of metal, on which strain gauges are applied. All balances must have a minimum of one sensing element for every component to be measured. The strain sensor usually is a resistance foil strain gauge, but semiconductor gauges are also used.

KEYWORDS: Instrumentation, aerodynamic balance, gauges.

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CFD-estudio de factibilidad para la implementación de un generador swril en cámaras de combustión

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ABSTRACT

La eficiencia de los proceso de combustión es en gran medida debida al éxito de las condiciones ideales de un buen mezclado, al igual que la preservación de velocidades relativas idóneas de combustión para mantener la estabilidad de un frente de flama y una quema homogénea del combustible en el centro de la cámara, además, la obtención de las temperaturas optimas de diseño y por último, de la reducción de la formación de gases no deseados (NOx y CO). En este trabajo se presenta un estudio 3D de diferentes configuraciones de Swril i) Axial, ii) Radial y iii) Combinado. El análisis de resultados es derivado de simulaciones numéricas hechas con la ayuda de las herramientas computacionales de simulación de flujos ANSYS-FLOTRAN-CFD y ANSYS-CFX en condiciones de diseño bajo un marco teórico. El combustible utilizado para las simulaciones es Jet A1 o queroseno, para el cual se utilizó el generador de librería y especias CFX RIF incluida en el programa ANSYS-CFX. Del estudio se desprende la factibilidad para la implementación de un tipo de configuración de Swril en la cámara combustión del Motor GMMO-1524-A y se presentan las ventajas y desventajas de cada propuesta. El proceso es aplicado de manera iterativa para indicar la eficiencia del motor y así obtener un diseño master de la geometría promedio ideal del sistema de combustión.

KEYWORDS: Swirl, CFD, Combustion, Flujo de fluidos.

Diseño y prueba experimental de anillos de material cerámicos como sistema de enfriamiento en tobera Aerospike para cohete de combustible híbrido de corto alcance.

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ABSTRACT

El alto rendimiento de un motor cohete esta dado en gran medida por la conservación de la integridad de todos sus componentes a lo largo de toda la misión, así mismo sobre el diseño delo combustible y así mismo del diseño de componentes clave, tales como la Tobera. El problema del sobrecalentamiento sobre la superficie de la tobera aerospike es el principal impedimento para su uso en motores cohete de combustible líquido o hibrido ya que el desgaste estructural es alto, impidiendo su uso en misiones de largo alcance y por lo tanto opaca sus principales beneficios, como es el incremento de empuje, disminución de cantidad de combustible empleado y por lo tanto disminución en los costos de lanzamiento. Se sabe que debido a la geometría, el flujo sigue una trayectoria acorde a la superficie de diseño incrementando el empuje y disminuyendo el combustible usado para alcanzar dicha condición, sin embargo, también aumenta la fricción y por consiguiente la temperatura, razón del desgaste estructural y la disminución de su eficiencia. Dicho diseño de geometría se realizó de acuerdo a la teoría de flujo compresible, partiendo de la definición de este tipo de flujos, así como de la teoría del método de las características. Obteniendo dos variaciones de modelos. Consecuentemente el diseño de los anillos se llevó a cabo seleccionando los materiales cuidadosamente, en función de su relación resistencia térmica/peso. Carburo de Silicio, Nitruro de Silicio, Fibra de Carbono y Grafito fueron los materiales seleccionados para la manufactura de los anillos de enfriamiento. Como método de validación se tiene las pruebas experimentales mediante el uso de un banco de pruebas instrumentado con una cámara foto-termográfica, termopares y una celda de carga, así como la ayuda de una cámara de alta velocidad para observar completamente la distribución de los puntos de concentración de temperatura, así como el empuje obtenido. Así mismo el análisis de CFD mediante el generador de mallas ANSA, y el uso del software ANSYS FLUENT.

KEYWORDS: Sistema de Enfriamiento, Cohete de combustible hibrido, Tobera Aerospike, Propulsión

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Identificación experimental del empuje en un motor turborreactor.

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ABSTRACT

Durante el vuelo de las aeronaves diferentes variables no pueden ser medidas directamente, por lo tanto estas deben ser estimadas a partir de la información disponible. Los efectos físicos más importantes en el estado transitorio de los motores han sido establecidos, pero hay una necesidad de modelos sencillos compatibles con las técnicas de control implementadas en la industria aeronáutica. Conocer el empuje generado es fundamental para mejorar el rendimiento de los sistemas de control [1]. El modelado por función de transferencia se ofrece como una alternativa al alto nivel de complejidad y no linealidad en los motores [2]. Diferentes conjuntos de datos fueron medidos mediante pruebas experimentales. Se utilizaron mediciones puntuales de la presión y la temperatura en cada componente del motor mediante termopares tipo K y sensores piezo-resistivos para la medición de empuje se utilizó una celda de carga. Por otra parte, el flujo volumétrico de combustible se midió con un transductor de presión.

El punto de operación para la máxima eficiencia del turborreactor se determinó mediante relaciones termoquímicas, ofreciendo una mayor precisión en contraste con modelos termodinámicos. Delimitar las condiciones de operación en un punto de eficiencia máxima permite incrementar la actuación o desempeño de la aeronave y reducir gastos de operación.

Diferentes funciones de transferencia fueron propuestas y se eligió aquella con el mínimo error medio entre la respuesta del modelo y los datos experimentales. Los coeficientes de la función se definieron mediante un proceso de regresión estadística. El modelo inicial resultó ser una función de transferencia de alto orden. El modelo es filtrado acorde a la frecuencia individual de cada polo y cero tomando en cuenta el rango de funcionamiento del motor. El modelo dinámico se validó con experimentos posteriores. Este modelo representa una linealización del comportamiento del motor para un rango de operación definido (±15% del punto de operación) con un orden reducido y mayor precisión, en comparación con modelos obtenidos por métodos similares [3].

KEYWORDS: Identificación experimental, regresión lineal, modelado de turborreactores.

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Numerical simulation of induced compression corner in a supersonic rocket nozzle.

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ABSTRACT

Within the propulsion system in a rocket, the nozzle plays a key role because is the one who generates the thrust through the expansion of the hot combustion gases by means of increasing the area ratio converting the potential energy to kinetic energy rising the velocity at the exit. The flow could reach high supersonic rates but, when there is a lambda shock wave within the nozzle with flow separation, the flow develops a different behavior that needs to be identified and described. This numerical simulation has the aim to understand the formation of an induced compression corner acting in a 3D under-expanded nozzle configuration. This work leads to a better understanding of the flow separation and an improvement in the theoretical design process.

KEYWORDS: Numerical Simulation, Lambda Shock Wave, Flow Separation.

Aviónica/Avionics

Sistema embebido, basado en componentes comerciales, para adquisición de datos en microaeronaves

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ABSTRACT

En este trabajo se presenta la construcción y prueba de una Sistema Embebido, de bajo costo y realizado con componentes disponibles comercialmente, para ser utilizado, en un futuro, como una herramienta de validación de algoritmos de control en Vehículos Aéreos No Tripulados. Aunque en el mercado actual ya existen Computadoras de Vuelo (CV) de alto rendimiento, estas son de alto costo y cuentan con una arquitectura cerrada, la cual no permite ver ni modificar el código de los algoritmos utilizados; esta falta de flexibilidad impide probar algoritmos especializados en el ámbito de la investigación aeronáutica y de aviónica. Debido a que es la primera aproximación que se tiene a la construcción y prueba de una CV dentro del CIIIA-FIME-UANL, se ha decidido limitar los alcances de este trabajo a un sistema de adquisición de datos de sensores. Los datos obtenidos son los datos inerciales, actitud, rumbo y posicionamiento global a una tasa de 215Hz. El diseño final cuenta con validaciones con un sistema de adquisición de posición absoluta de alta resolución y se tienen pruebas en túnel de viento.

KEYWORDS: Aviónica, Sistemas embebidos, Aerodinámica experimental.

Improvement of wing efficiency for a search and rescue RC aircraft model

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ABSTRACT

Search and rescue (SAR) operations require aircraft configurations with remarkable aerodynamic efficiency to cover broad areas. Since the wing is the main lifting force producer [1], this work proposes to modify the wing configuration of the NexStar RC aircraft model; originally designed with a rectangular wing planform, using a Clark Y airfoil. The objective is to increase the range of this plane subject to NexStar fuselage, elevator and rudder dimensions, and to validate the design experimentally. The aerodynamic profile is selected among the well-studied airfoils, analyzed for example in [2]. The selection criteria were established concerning maximum lift, minimum drag, minimum moment, maximum thickness ratio, maximum L over D ratio, and maximum lift coefficient with a 20% split flap deflected 60°. The reason for the selected criteria was $CLmax$ to allow a high takeoff weight and a low landing speed, without flaps, $CDmin$ for a relatively high cruising speed at a moderate engine power, which will also improve its range. Low Cm to have a good static and dynamic stability, with the provided horizontal stabilizer. High fineness ratio to improve its aerodynamic efficiency, and therefore the total aircraft efficiency. Great $CLmax$ with flap deflected 60°, to allow very low landing speeds, short landing distances and a steep approach in its landing pattern. An acceptable thickness ratio to allow fuel tanks in the center section of the wing, to improve range and loitering during its mission was also considered. To compare all these factors, and considering that one of them is negative, each one will be affected by a weight factor according to its importance. When possible the coefficient values were found for a Reynolds number of 3 × 106 which is generally the lowest shown on the section characteristics of the consulted NACA and NASA reports. The selected wing section is the GAW-1. The new wing planform shall approach the shape of a semi-elliptical wing, with the same wing area as the original rectangular planform; thus the central and external panels were established as central cord equal to 26.7 cm with a span equal to 88 cm. Two trapezoidal external panels with root and tip chords equal to 26.7and 13.3 cm, respectively; and a span equal to 58 cm. Hence, the wing area is 4669.8 $cm2$. The original rectangular wing has an area of 4660 $cm2$. The difference of 0.2% is negligible. The new wing is being constructed. The RC aircraft will flight using its original wing and the modified wing. During the flight, a telemetry system will store the plane sensors information which includes an Attitude and Heading Reference System and a Global Positioning Unit and the pilot control inputs [3]. The experiments are designed to determine stall speed, take-off run, the maximum rate of climb and the required power curve [4]. This work is a first effort to validate an aerodynamic design experimentally.

KEYWORDS: Flight mechanics, Integrated Design and Validation, Flight Physics.

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Master-Slave for location after a contingency

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ABSTRACT

Master-Slave UAV (M-S UAV) for location after a contingency is a system for searching people after natural or provoked contingency. M-S UAV systems have two elements: Slave is an out-of-road heavy use robot and Master is an UAV. Both of them will work without attending for human controls, by means of Artificial Intelligence (AI) for navigation, internet for communication of low cost hardware. M-S UAV will be designed in four stages, this paper works the first stage: prototype and energy system.

Goals: Master-Slave system is a prototype to help in natural disasters in order to decrease search time, support in rescue missions. It will be programmed without human control navigation, sustainable and easy to work with.

Scope: Master-Slave system project will be developed in four stages, 1st Slave prototype and the primary energy system, 2nd Data adquisition and secondary energy system, 3rd solution for autonomous flight of the UAV, and 4th the final prototype, pretending to use it for location after a contingency.

Methodology: The methodology for all four stages are project concept, development, theoretical analysis, prototype production and final validation.

Results and Conclusions: In the first stage, it was manufactured and checked the robot (slave) and the design of the primary energy system got 5 V and 0.2 A. This design was not for used in the off road vehicle. This system need time to conclude the 2nd, 3rd, 4th stages.

KEYWORDS: Master-Slave, UAV, disasters.

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Sistema de adquisición de datos para un túnel de viento.

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RESUMEN

Las pruebas de túnel de viento se pueden dividir en dos grandes grupos: pruebas estáticas y pruebas dinámicas. En las pruebas estáticas se miden fuerzas y momentos generados por el flujo de aire sobre el objeto sólido que se prueba (perfil alar, ala, aeronave de ala fija, aeronave de ala rotatoria, etc.); esta información es relevante para caracterizar aerodinámicamente al objeto. En las pruebas dinámicas se miden posiciones angulares y/o lineales para tratar de caracterizar el movimiento del objeto. En el caso lineal, estas caracterizaciones arrojan el margen estático de estabilidad y las derivadas aerodinámicas, respectivamente. Tanto para la experimentación estática como para la dinámica, es necesario contar con bancos de prueba que permitan la correcta recolección de los datos. El diseño, construcción y prueba de estos bancos es un problema de ingeniería complicado debido a que, en general, debe diseñarse un nuevo banco de prueba para cada tipo de experimento que se desee realizar [1]. Aunque a nivel internacional ha habido grandes programas en aerodinámica experimental, en México este tipo de investigación no ha tenido gran desarrollo. Los investigadores y estudiantes del Cuerpo Académico de Aerodinámica y Aviónica, del CIIIA-FIME-UANL, están convencidos de que es necesario desarrollar plataformas para la investigación en aerodinámica experimental y presentan, en este trabajo, la sección de electrónica y programación de uno de los bancos de prueba que actualmente se desarrollan. La metodología utilizada, para la estación en tierra, se ciñe a la propuesta estándar hecha por National Instruments a través de un “Ejecutivo de Prueba” con el que se puede automatizar diferentes pruebas dinámicas dentro del túnel de viento. Para la estación de a bordo se utiliza un sistema estándar tipo Pixhawk pero con modificaciones importantes para adecuarse a experimentos dentro del túnel de viento.

KEYWORDS: Aerodinámica Experimental, Interfaz Gráfica de Usuario, Identificación de Aeronaves.

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Superaleaciones/Superalloys

The role of temperature in the service-induced degradation of gtd-111-ds superalloy: experimental and simulation approaches

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GTD-111 is a widely used Ni-based superalloy to manufacture the first stage bucket of Industrial Gas Turbines (IGT) due to its excellent high temperature properties. It is well known that superalloys degraded when they are exposed to high temperature and stress during service. The main microstructural changes include coarsening and coalescence of gamma-prime phase, intergranular decomposition of the primary carbides (MC) to secondary carbides (M23C6), and topological close-packed (TCP) phases formation. These changes have a strong detrimental effect on the thermomechanical performance of the turbine component.

The aim of this study is to understand the effect of temperature on the service-induced degradation of a GTD111-DS first stage bucket of a GE7FA IGT. In order to identify the critical temperature zones in the blade, a combined finite element and computational fluid dynamics modelling-numerical analysis were calculated. These results were correlated with microstructural and chemical characterization of different cross section along the bucket.

KEYWORDS: GTD-111-DS, Ni Based Superalloy, Industrial Gas Turbines.

Effect of the process parameters on the microstructure and mechanical properties of IN718 manufactured by DMLS

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Abstract

Inconel 718 is a widely used Ni based alloy for aeronautic applications, due to its high mechanical properties and oxidation resistance at high temperatures. At present, the Additive Manufacturing (AM) allows to improve the design of aeronautic components in different ways. AM decreases or completely avoid the machining time, depends on the required roughness. However, nowadays AM has challenges to overcome. Seeking to fulfill the mechanical requirements, it iCs necessary to understand the effect of the heat on the product and to control the process. This study is focused in the investigation of the Process-Structure-Properties relationships. First, cylinders of 10 mm of height were fabricated by Direct Metal Laser Sintering (DMLS) with stripes pattern scan. IN718 powder of 38 µm size average was used in the process. Structural, chemical and mechanical evaluations were performed on specimens, with the aim to investigate the effect of properties and the volumetric energy density on the microstructure, porosity and thermos-mechanical properties. The microstructural characterizations were obtained by Scanning Electron Microscopy (SEM) and Electron Backscattering Diffraction (EBSD); the chemical analysis was obtained by Wavelength Dispersive Spectroscopy (WDS) and inductively coupled plasma mass spectrometry (ICP-MS), and the mechanical evaluation includes tensile strength and hardness. In some experiments was kept constant the volumetric energy density varying different parameters as such as power laser, scan speed and hatch distance. The analysis was made as deposited, prior any heat treatment, to evaluate the effect of the thermal gradients generated during the AM process.

KEYWORDS: Inconel 718, DMLS, Additive Manufacturing.

Development of a tensile and fatigue test fixture for DMLS Inconel-718 samples: a theoretical and experimental approach

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ABSTRACT

The development of new components in aerospace industry requires the research of new materials and processing methods. Inconel 718, a nickel-based super alloy, has been widely used in jet aircraft due to its outstanding properties [1]. Direct Metal Laser Sintering (DMLS) is one of the cutting-edge technologies used nowadays in fabricating high-value parts, reducing machining time and achieving complex geometries that cannot be obtained with conventional machining. This method employs a high-power laser beam to sinter metallic powder following a CAD design, resulting in 3D printed parts [2]. To implement this process in manufacturing environments, it is necessary to understand the mechanical properties that DMLS sintered parts have in comparison to other manufacturing processes. Tensile testing is the most common destructive testing technique carried out in materials to determine their mechanical properties. Tensile properties are measured during development of new materials and processes to predict their behavior under forms of loading other than uniaxial tension. The strength of the material is often the primary concern, whether it is to determine the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. Also of interest is the material's ductility, which is a measure of how much it can be deformed before it fractures [3]. Axial force fatigue test is used to determine the effect of alternating stresses on the performance of materials and their life expectancy [4]. Carrying out tensile and fatigue tests on additive manufactured samples help to design and understand the effect of the printing parameters on the actual performance of the material, as well as to determine the optimal configuration for specific purposes. To carry out these tests, a fixture was developed to hold the DMLS sintered Inconel 718 samples in the testing machine, which was fitted with a controlled environment ceramic chamber. Design was done in SolidWorks 2017, and performance simulations, including stress distribution and life expectancy, were performed in ANSYS 16. The resulting design is currently being fabricated.

KEYWORDS: Fixture, Inconel 718, DMLS.

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Oxidation kinetics behavior of Inconel 718 superalloy manufactured by direct metal laser sintering (DMLS)

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ABSTRACT

Inconel 718 (IN-718) is the most used nickel based superalloy, due to excellent creep properties, oxidation and hot-corrosion resistance at high temperatures. However, machining with conventional methods is difficult as a result of its high hardness and low-thermal conductivity. An alternative can be use additive manufacturing (AM) technologies. Direct Metal Laser Sintering (DMLS) is an AM process that can be used to fabricate or repair IN-718 parts with complex geometries. This work presents the oxidation behavior of IN-718 specimens fabricated by DMLS under different oxidizing and corroding environments (e.g., dry-air, H2O/Ar and Ar). The study was carried out under isothermal conditions in the temperatures at 800, 1000 and 1200°C. The aim of this work is to understand the effect of the DMLS processing parameters (i.e., layer thickness, hatching space, laser power and scan speed) and postprocessing parameters (i.e., standard treatment and HIPing) on oxidation kinetics of DMLS-IN718 coupons. The results were compared with wrought IN-718 alloy. The effect of the oxygen partial pressure on their oxidation kinetics was studied by XRD and SEM.

KEYWORDS: Additive Manufacturing, Inconel 718, Oxidation.

Structural characteristics of B2-NiAl AND -NiAlCr doped with y intermetallic powder synthesized by SHS in mechanical milling

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ABSTRACT

The B2-NiAl based alloys have been widely used for aeronautical applications due to their excellent mechanical properties and oxidation and corrosion resistance. Mechanical alloying using high energy ball milling is frequently used to synthesize the B2-NiAl intermetallic. A self-propagating process can be ignited when a highly exothermic powder mixture is activated in a ball milling after a certain activation time [1], which leads to the formation of B2-NiAl intermetallic. During the last decades, significant efforts have been made to improve the properties, processing and design methodology of NiAl systems [2], including the addition of some reactive elements such as Y, Zr or Hf. Since NiAl exhibits an ordered structure, addition of those reactive elements may present certain site preferences occupying predominantly Al sites in the supercell alloy for the stoichiometric composition. In the case of Cr, it occupies both Ni and Al sites [3,4]. In this work, the influence of Y doping on the structural characteristics leading to the formation of NiAl and NiAlCr solid solutions is presented. Additionally, the effect of milling time on the particle size and morphology of the obtained alloy compared to raw materials is also described.

KEYWORDS: NiAl, mechanical alloying, reactive elements

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Estudio de propiedades termodinámicas y estabilidad de red en superaleaciones base Níquel aplicando la metodología CALPHAD: caso de estudio IN718.

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ABSTRACT

Las superaleaciones base níquel se han desarrollado históricamente debido a la necesidad de encontrar materiales que soporten cada vez temperaturas más altas. En la industria aeronáutica, el incremento en las temperaturas de entrada de los motores de reacción ha sido una de las razones para tal desarrollo1. IN718 es una de las superaleaciones base níquel más utilizadas debido a su alta resistencia a la fluencia, fatiga térmica y corrosión en un amplio rango de temperatura, constituyendo aproximadamente el 34% del peso del componente en el acabado para un motor típico de turbina de gas3. La microestructura deseada de IN718 es una matriz γ homogénea y reforzada por una fina dispersión de precipitados ordenados de γ' (Ni3Al) y γ''(Ni3Nb)2. En condiciones estándares de operación de las turbinas se precipitan fases que causan baja resistencia a la rotura y ductilidad, tales como fases Topológicamente Empacadas Compactas (TCP), tipo laves y delta. Durante condiciones de no equilibrio el Nb tiende a segregar a las regiones interdendríticas, favoreciendo la precipitación de la fase Laves y NbC. Por lo tanto, es perjudicial en la formación de las fases endurecedoras γ´´4. Para las condiciones de procesamiento y servicio de IN718 es necesario controlar y comprender la estabilidad de la microestructura porque en ella se basa el enfoque que se desee dar al sistema y obtener así los resultados deseados. Por lo cual, el objetivo de este trabajo es incrementar el entendimiento termodinámico de la microestructura, así como establecer el papel de los tratamientos térmicos y elementos aleantes sobre las propiedades de la superaleación IN718. Para ello, se emplea el programa termodinámico ThermoCalc con la base de datos para aleaciones base níquel TCNI8. Se realizó el cálculo teórico de los diagramas de equilibrio de la superaleación aplicando modelos de análisis multicomponentes y el método de minimización de la energía libre de Gibbs. El análisis se desarrolla en base a sistemas binarios ideales, y pseudobinarios, en base a la matriz (Ni, Cr) y los elementos formadores de fases precipitantes (Nb, Ti, Al). Se calcularon diagramas de equilibrio de sistemas binarios y ternarios, entalpías de formación de fases, curvas de energía libre de Gibbs en función de la temperatura y composición, fracción volumétrica de fases, preferencia de sitio y diagrama de Schiel que permite entender el proceso de solidificación del sistema.

KEYWORDS: ThermoCalc, IN718, Microestructura.

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Simulación Termodinámica y Microestructural de la Aleación base Titanio Ti-6Al-4V Sometida a un Tratamiento Térmico Controlado Mediante la Metodología CALPHAD.

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ABSTRACT

Las aleaciones base titanio se emplean en diversas aplicaciones aeroespaciales, petroquímicas y biomédicas debido a sus excelentes propiedades mecánicas, anticorrosivas y su relativa baja densidad [1]. La aleación Ti6Al-4V destaca por su densidad única, extraordinaria relación resistencia-peso y alta resistencia a la fatiga y a la corrosión. Se aplica en componentes de cohetes de despegue vertical, tanques de combustible, estructuras de fuselaje (sector aeroespacial), para servicios de alta resistencia a la corrosión en intercambiadores de calor, plantas de procesamiento químico o generación de energía y para aplicaciones de alto rendimiento como equipos de perforación y sumergibles (industria petroquímica), en dispositivos protésicos para implantes óseos y articulares, válvulas cardíacas e implantes dentales (industria biomédica) [1-2]. En titanio puro existen dos modificaciones alotrópicas: α a baja temperatura, y β siendo de estructura cúbica centrada en el cuerpo y estable a alta temperatura. El sistema Ti-6Al-4V pertenece a la familia de aleaciones α-β con 6% en peso de Aluminio que estabilizala fase α y 4% en peso de Vanadio que estabiliza la fase β [2, 3]. Las propiedades mecánicas dependen en gran manera de la microestrura y del historial térmico que experimente durante su procesamiento y condiciones de operación. El propósito de este trabajo es simular, analizar y comprender la evolución microestructural de Ti-6Al-4V mediante el uso de la herramienta computacional Thermo-Calc, la cual se basa en la metodología de cálculo de diagramas de fase (CALPHAD). El trabajo se desarrolló empleando las bases de datos termodinámicas TTTI3 y TTTIAL bajo el método de optimización de minimización global. Se determinó la relación entre los elementos aleantes con los límites de solubilidad y estabilidad de red en diagramas de fase binarios, pseudo-binarios y ternarios, así como las curvas de Gibbs y actividad química en función de la temperatura y composición. Conjuntamente se calculó el diagrama de Schiel con la finalidad de obtener la solidificación de no equilibrio. Los resultados obtenidos por simulación se compararon con las observaciones experimentales publicadas [4]. Se observó la influencia de la composición nominal de V y Al sobre e l equilibrio de las fases α y β. Se estudió la transformación de fase en la región β + α en función de la temperatura desde 300°C hasta 1200 °C y se identificó la temperatura de β - transus alrededor de 979 °C.

KEYWORDS: Ti-6Al-4V, Microestructura, ThermoCalc.

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Manufacturing of Metal Matrix Nano-Composites (MMNC) enhanced by ceramic additives

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ABSTRACT

The Metal Matrix Composites (MMC) offers a unique mechanical balance of physical and chemical properties. However, the currently development of Nano-Composites (MMNC) could be a new alternative with significantly enhanced properties. In recent years, the Additive Manufacturing (AM) laser-based enables rapid fabrication of bulk parts with complex shapes directly from powder, based on a layer-by-layer incremental manufacturing [1-4]. Due to the well-controlled laser energy and building layer-by-layer the thermal consequences on substrates are less important than those obtained with conventional welding technologies leading into a great potential for repair/recover dimensions of turbine blades, molds, dies, etc. The Selective Laser Melting (SLM) has been used for evaluating the thermo-physic properties of metal molten due to the addition of ceramic nanoparticles in the preparation of MMNC by wet mechanical mixing/stirring [5-7]. Findings showed that depth of metal molten increases without respective increment of heat affected zone, compared with SLM using powders without ceramic nanoparticles. In this research different powder preparation and parameters are in progress for production of MMNC. The aim is to evaluate the different available technologies of powder processing to enhance the AM laser-based by using MMNC as raw material in SLM and Laser Cladding (LC) processes. Mixtures of Ni-5 vol.% Al2O3-nanoparticles were processed by high-energy ball milling for producing MMNC. Particle sizes were 15-90 µm and 50 nm of Ni and Al2O3, respectively. The milling process was conducted in a Simoloyer CM01 starting with mixing at 250rpm/5min followed of cycling operation at low-high velocities (400rpm/1min-1200rpm/4min) and total milling time of 30, 45 and 60 and 90 minutes. Optical (OM) and scanning electron microscopy (SEM) shows improvement of ceramic nanoparticles dispersion by increasing milling time. A second powder-processing step by using the mechanofusion process improves particle size sphericity and flowability required in SLM-LC processes.

KEYWORDS:

Metal Matrix Nanocomposites, High-energy ball milling, Selective Laser Melting, Laser Cladding.

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Theoretical approach of thermodynamic properties of maraging C300 steel.

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ABSTRACT

Maraging steels are iron-based alloys of the martensitic steels family with excellent weldability and outstanding mechanical properties conferred by intermetallic phases precipitation. These alloys contain Co, Mo and Ti responsible for the strengthening phases precipitation as well as a high Ni content (15 and 25 %wt) which makes them attractive for missile manufacturing, deep immersion submarine cases, forging dies and pressure casting dies applications, space vehicles and extrusion press pistons. In binary Fe-Ni alloy, such as maraging steel, initial martenstic transformation temperature (M_s) and initial austenitic transformation temperature (A_s) decrease with increasing Ni content and Co, Mo and Ti addition. Maraging microstructure consists of γ-austenite and α-martensite, which changes depending on Ni content and Ni-based (Ni_3Ti, Ni_3Mo) and Fe-based (Fe_2Mo, FeTi) intermetallics. This work exhibits a detailed description of the computational software (CALPHAD) application for studying the effect of the alloying elements on the thermodynamics properties and martensitic transformation of the NiFe system considering the incorporation of elements present in maraging C300 steel (Fe-Ni-Mo-Co-Ti-Al). The effect of alloying elements addition on the maraging steel crystalline net stability is also studied by an approximation to the real system based on the binary and pseudo-binary systems. Finally, microstructural changes and intermetallic precipitation are correlated to martensitic and austenitic retained fractions considering equilibrium diagrams, Gibbs free energy, formation enthalpy and chemical activity as a function of state variables such as pressure, temperature and chemical composition.

KEYWORDS: Maraging, Martensite, TermoCalc.

High temperature behavior of gamma titanium aluminides for turbine blades: creep and oxidation studies

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ABSTRACT

The components of turbines used in aerospace applications must withstand extreme operation conditions and from these, the operation temperature is if not, the most important variable existent in these components. The blades used in specific region of turbines for aerospace and energy generation applications are exposed to a variety of phenomena either of mechanical and chemical nature that increase the rate of degradation of the material used. Nowadays gamma titanium aluminides have been proposed as the material of choice for the fabrication of turbines blades used in the low temperature regions of turbines used in aerospace and energy applications. These alloys are not exempt of degradation processes and their behavior under this conditions must be studied. In this work, results the high temperature oxidation and creep behavior of a model gamma titanium aluminide alloys are presented. The oxidation in dry air follows a behavior that could be described by the parabolic rate law. In contrast, exposure of the alloy to the same oxidation temperature in a water vapour-containing atmosphere changes the oxidation behavior of the alloy in a totally different manner. In addition, the alloy was coated with thin films of complex nitrides deposited by HIPIMS and the creep behavior was studied. It was found that the creep resistance of the coated alloys depended mostly, on the formation of oxides on the surface of these systems. .

KEYWORDS: gamma titanium aluminides, oxidation, coatings

Wear behaviour of high temperature alloys for aeronautics purposes

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ABSTRACT

In recent years, nickel and titanium based superalloys such as γ-TiAl are used for aeronautics, power generation and automotive applications given their good corrosion properties and microstructural stability. What has been less characterised is the wear resistance of these systems at high temperature; therefore, an understanding of the wear behaviour is required aiming to predict the material damage and durability for specific applications working conditions. In this investigation, the high temperature sliding wear resistance of γ-TiAl is assessed using a pin-on-roll configuration in a multipurpose tribometer. The effect of atmosphere on oxide generation and its impact on the evolution of tribilogical variables like wear rate and friction are also studied.

KEYWORDS: Wear, gamma-TiAl, dynamic conditions.

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Recubrimientos/Coatings

Effect of corrosive environment on corrosion behavior of multilayer PVD coatings

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ABSTRACT

Using physical vapor deposition (PVD) technique multilayer AlCrN/TiSi, AlCrN/Ti + CrSi and AlCrN/AlCr + Cr coating were deposited on Inconel 718. The open circuit testing, potentiodynamic polarization and Electrochemical Impedance Spectroscopy (EIS) have been employed to study the corrosion performance of the multilayers coatings. The results of the open circuit potential indicated that there was no pattern of the behavior corrosive of the coatings in H2O, NaCl and H2SO4. The corrosion rates of the different systems are in the range of 1E-3 mm/year. Some coatings showed tendency to the pseudopasivation in the different electrolytes with a positive hysteresis indicative of localized corrosion. Both by the Nyquist and Bode diagrams it was possible to identify the time constants. The Nyquist diagrams reveal excellent electrochemical behavior at AlCrN/AlCr + Cr in H2O and NaCl. For H2SO4 the most stable coating was for AlCrN/TiSi. PVD coatings present the highest corrosion rate in H2SO4, and both AlCrN/TiSi and AlCrN/AlCr + Cr present corrosion localized. KEYWORDS: Corrosion, PVD, superalloy 718, multi-layer coatings.

KEYWORDS: Corrosion, PVD, superalloy 718, multi-layer coatings.

Microstructural and mechanical characterization of cold sprayed Inconel 718 coatings

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ABSTRACT

Cold Spray (CS) is a solid-state material deposition technique, where spray particles are deposited via impact at supersonic velocity conditions and bonded to a substrate as a result of the associated severe plastic deformation. Nowadays CS is used for coating deposition, repairing as well as for Additive Manufacturing. CS has the main advantages that avoid the effects associated with high-temperature spraying such as internal oxidation and thermally-induced stresses. Different metallic materials have been sprayed by CS with excellent results in terms of low residual stress, low oxides content and mechanical properties similar to bulk properties. However, spraying high strength materials such as the nickel-based superalloys, e.g. Inconel 718 represents a big challenge due to the high critical velocity required to reach enough plastic deformation to assure good bonding and thus high quality of the deposits. Inconel 718 is the most widely used nickel-based superalloy for high temperature due to its excellent mechanical, thermal and corrosion resistance and thus widely studied by additive manufacturing processing. In this contribution, Inconel 718 powder was cold sprayed on IN718 substrates to study the first stages of coarse deposits (approx. 1200 µm) seeking for an additive manufacturing concept. The window of CS process parameter sets in order to define critical conditions for bonding was analyzed with the KSS software (Kinetic Spray Solutions). An analysis of physical, microstructure and mechanical properties of the “as-sprayed” coatings is presented. For instance, single particle adherence was investigated by performing a modified cavitation test (ASTM-standard G32-10).The flexural strength of the coarse coating was studied by performing bond strength test (EN 582). The tensile strength was determined by in plane tensile test using micro-flat tensile specimen technique. Residual stress of the deposits were measured using an Ex-situ coating property sensor (Reliacoat). The electrical conductivity were determined in accordance with the ASTMstandard E1004.

KEYWORDS: Nickel-based superalloys, Cold Spray, Additive Manufacturing

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Tungsten disulphide composite coatings for potential applications as solid lubricants in the aeronautical industry

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Magnetron Sputtering WS2-X thin films (where X: Ti or Cr) were deposited from X= 0 to 40 at.% in order to investigate its effect on the structural, mechanical, chemical, electrochemical and tribological 40 at. %properties. X-ray diffraction patterns showed an incremental WS2 amorphization from X= 20-30 at.% as a result of the structure supersaturation with Ti and Cr. A profilometric analysis showed an average thickness of 1.5 µm with intrinsic residual stress induced by the Ti a Cr additions. The effect of different loads on the mechanical properties of the films were studied using instrumented nanoindentation. The indentation hardness, reduced elastic modulus and plastic deformation were evaluated and compared. The Korsunsky model was used to characterize the hardness performance of the coating system. The generation of radial and circumferential cracks was observed in the WS2-Ti composite, which were associated to cohesive and adhesive failures. This procedure allowed the estimation of the adhesion critical load and to determinate the fracture toughness behavior in the thin films. The above was compared with results of the scratch test. Raman spectroscopy showed the presence of WO3. The tribological evaluation was carried out by Pin-on-disk test showing very similar coefficients of friction independent of the WS2-X systems exhibiting a maximum decrease about X= 10 at.%. The electrochemical resistance of the WS2-X systems were evaluated using Tafel slope analysis and Electrochemical Impedance Spectroscopy. As a general conclusion it can be establish that the WS2-X for X=10 showed the best mechanical and corrosion resistance performance independent of alloying element (Ti or Cr).

Keywords: Tungsten disulphide, solid lubricants, mechanical properties, tribology, electrochemistry

The effect of controlled thermal exposures on the tribo-oxidation behavior of C-Ti1-XAlXN coatings used in high speed machining in the aerospace industry.

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ABSTRACT

The need to increase the efficiency of production processes in the aerospace industry has led to the wide use of the high-speed machining processes for the manufacture of different structural components made of special steels. Additionally, the use of this kind of machining has stimulated many efforts to improve the performance of machining tools exposed to continuous increasing high temperatures and sliding motion. To this end, for the last 30 years machining tools have been improved with a variety of coatings such as TiC, CrN and TiN. The modern research trend has been aimed at improving the performance of these coatings by designing new architectures or adding dopants such as Al, Si, etc. As a consequence, the use of hard c-Ti(1-x)AlxN coatings is becoming widespread. These coatings have maximum service temperatures from 900 to 1100°C, but for some applications, e.g. high speed machining, the tool temperature can reach temperatures above 1100°C, forcing the need to further improve the coating performance. In recent years, some authors have proposed the beneficial effects of stable oxides produced on the surface of these systems at high temperatures. However, few studies have been realized to understand the tribo-oxidative performance of c-Ti(1-x)AlxN coatings, and how such oxides could act as protective layers. In this work we report studies of the effect of controlled thermal treatments on the tribo-oxidative behavior of c-Ti(1-x)AlxN coatings. M2 steel disks were coated with c-Ti(1-x)AlxN by the cathodic arc PVD method. The coatings were characterized before and after the controlled thermal exposures in order to investigate their oxidation behavior, as well as, their microstructural (SEM, XRD) and compositional evolution (EDS) upon time. The thermal exposures were performed at 700°, 900° and 1100°C for 5, 30, 60, 150 and 300 min in air. Finally, the tribological behavior of the coated steels was studied using a pin on disk tribometer applying 5 N during 2000 cycles with a speed of 1500 rpm and a counterbody of WC. The wear tracks were analyzed by profilometry, SEM and EDX. We report the details & discussion of the results on the effect of different thermal treatments on the tribological performance of the c-Ti(1-x)AlxN hard coatings.

KEYWORDS: High speed machining tools, hard coatings, tribo-oxidation behavior.

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Effects of the hardened layer onto AISI M2 STEEL by plasma assisted nitriding for aeronautical applications

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ABSTRACT

Several large alloyed components such as air valves, camshaft and aircraft pistons, rods, spacers, diaphragms, shafts, bolts, nuts and bolts, screws, etc., and many precision components are nitrided. The plasma assisted nitriding has recently been one of the thermo-chemical treatments used mainly in the aeronautics industry, as it improves surface hardness, wear resistance with anti-creep properties as well as corrosion resistance and fatigue are improved, having high impact on the decrease in pollutants and costs for their production. The nitrogen solubility is temperature and time dependent, for instance at 450ºC, Fe-based alloys will absorb up to 5.5-6.0% of N. Beyond this point, different nitrides precipitation are expected as a function of the alloy composition. The plasma nitriding is particularly attractive because of its high efficiency and low temperature. Low-temperature processes can generate a precipitated-free hardened layer as a result of interstitial diffusion of nitrogen atoms to the point to reach a supersaturation causing a significant expansion of the austenitic and martensitic lattice parameters.The nitriding of the AISI M2 steel by a plasma-assisted nitriding process under a controlled nitrogen atmosphere was carried out at 400 ° C. The effects of the nitriding conditions on the microstructure, crystalline phases, chemical composition and micro hardness of the obtained specimens were evaluated by Scanning Electron Microscopy (SEM), XRD Analysis and Elemental Composition by Energy Dispersive Spectroscopy (EDS). The corrosion behavior was studied by Electrochemical Impedance Spectroscopy (EIS).The hardness and modulus E profiles of the nitride surfaces were evaluated by Nano-indentation.

KEYWORDS: Plasma Assisted Nitriding, hardened layer, Nano-indentation.

Effect of superalloy substrates on NiCoCrAlYTa bond coats deposited by HVOF for thermal barrier coating applications.

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ABSTRACT

NiCoCrAlY-type coatings have been one of the most used for aeronautical applications because they exhibit a good balance between their oxidation resistance and ductility [1–3]. During thermal exposure, the coating suffers interdiffusion phenomena caused by the aluminum depletion to form a superficial thermally grown oxide layer and by the diffusion of reactive elements, which are present in the superalloy, through the coating [4,5]. This contribution is conducted through the optimization of high velocity oxy-fuel (HVOF) thermal spray processing parameters for the fabrication of NiCoCrAlYTa coatings. Based on design of experiments (DoE), analysis of variance, and construction of process maps, the effect of stand-off distance (SOD), powder feed rate (PFR), and fuel-oxygen ratio (F/O) on the final coating characteristics (thickness, deposit efficiency, internal oxidation and porosity) is here studied. After optimization of process parameters, the NiCoCrAlYTa coatings are deposited onto Inconel 100, CMSX-4 and M247-LC-SX superalloy substrates, which present differences in their microstructural properties as well as their chemical composition. Subsequently, the coating-superalloy systems have been heat treated during 4 h at 1080 ºC in vacuum in order to activate the diffusion of elements from the superalloys substrates through the coating. Finally, a 7YSZ EB-PVD top coat is deposited to evaluate the oxidation behavior of those systems under thermal-cyclic and isothermal exposure. The results are showed in the present contribution.

KEYWORDS: HVOF NiCoCrAlY coatings, Thermal Barrier Coating systems, element interdiffusion.

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Corrosion resistance of coatings WC-Co-VC manufactured by HVOF thermal spray

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ABSTRACT

WC-17Co coatings are used to protect components against wear, high temperature and corrosion. The objective was study the mechanisms and corrosion resistance of bimodal coatings WC-17Co-VC applied by high velocity oxygen fuel (HVOF) spraying at different concentrations of VC. Bimodal mixtures were obtained from micro and nanostructured powders and then deposited on AISI 304 steel using a HVOF gun and a robotized arm. The electrochemical characterization was performed by linear polarization resistance test and potentiodynamic polarization curves. It was determined that the anodic branches present a tendency to passivation; However, it's more pronounced in sodium chloride. The addition of nanostructured WC-17Co particles improved its corrosion resistance in H2O and NaCl according to RPL and PPC tests. WC-17Co-VC coatings by thermal spraying HVOF present a higher corrosion rate in acidic media.

KEYWORDS: Electrochemical characterization; passivation; thermal spray HVOF; WC-17Co; WC-17CoVC

An AlLi alloy prepared by powder metallurgy using an alternative sintering route

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ABSTRACT

Aluminum-lithium (Al-Li) alloys are lightweight and high performance materials that have been used in applications where low density is a crucial point in the selection of structural elements, as is the case of modern aerospace industry. In the 1970s, induced by the oil crisis, Al producers began a major development of AlLi alloys looked for lighter aluminum alloys with high rigidity for components manufacture that could be handled and assembled using standard techniques. In fact, Li is the only metal that improves the elasticity modulus and lowers the density when it is alloyed with Al (with the exception of beryllium, whose use is associated with disturbing health problems).

The present work deals with the study of binary Al-Li system prepared by mechanical milling and sintered following two routes: A conventional one (CS) based on cold compaction and posterior pressure-less sintering for extended periods of time (hours), and an alternative one (IS), that deals with induction heating and uniaxial compacting (simultaneously) which reach high densification rates in minutes. The first step was the AlLi alloy preparation using a high-energy ball mill for 2 hours. The mechanically milled powders were subsequently sintered using the above mentioned routes: with CS the samples were compacted under 900 MPa pressure and sintered at 550°C with a heating rate of 10°C/min for 4 hours and by IS where the samples were compacted and sintered (450MPa - 450°C) at the same time for 3 minutes, following an impressive heating slope of 158°C/min.

Morphological and structural studies of mechanically milled powders were performed using a JEOL-JSM 7201F SEM/EDS microscope and a Pan Analytical X´pert PRO X-ray diffractometer, respectively. On the other hand, the mechanical properties of sintered samples were performed by hardness and compression tests at room temperature, the second one was carried out in an Instron Universal tester and yield strength was calculated from strain-stress curves. An increased mechanical response of the specimens was evident using our alternative method based on induction sintering, keeping an important grain refinement of the Al matrix.

KEYWORDS: AlLi alloy, mechanical alloying, induction sintering.

Development of Cu electrodes by low pressure cold spray for piezoelectric based devices

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ABSTRACT

Piezoelectric devices such as transducers have been of special interest in aeronautics, particularly due to its potential use as energy harvesters in airframes. Bismuth base piezoelectric materials are strong candidates to replace lead base piezoelectric transducers. The electrical charge generated by these materials is typically collected through electrodes connected to their surfaces or interfaces (e.g. for uni, bi or tri-morphs), which in general correspond to noble metals. However, in recent years the use of copper-base electrodes, has been encouraged mainly for cost reasons. For this reason, it is necessary to study the Cu-Al junction, which corresponds to the contact between the device and the fuselage. Due to the physical metallurgy of the Al-Cu junction, conventional welding methods involve the formation of brittle intermetallic compounds, leading to negative effects on mechanical strength, electrical and thermal conductivity. Cold spray technology is an alternative method to reach and improve the Cu-Al junction owing to is useful for depositing materials sensitive to oxygen and temperature. In this work, we studied the first stages of deposition of copper on stain steel by cold spray as a first approach to understand the Cu-Al junction.

KEYWORDS: copper electrodes, low pressure cold spray.

Development of light metallic materials reinforced with carbon nanotubes by the sandwich technique

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ABSTRACT

Metal matrix composites (MMCs) have been used in several applications where high specific resistance and temperature are required for some uses in the aerospace and aeronautic industries. In general, these composites are manufactured using as reinforcing material particles or some fibers like glass, ceramic and carbon fibers. However, among other issues, the matrix-reinforcement interface and the reinforcement dispersion degree are still open questions. Recently a new manufacturing process for the production of MMCs reinforced with carbon nanotubes, known as sandwich technique has been proposed [1, 2]. This technique produces materials comprised of a metallic matrix and banded structured-layers of multiwalled carbon nanotubes (MWCNTs). The present study has been aimed on the reinforcement of magnesium sheets with MWCNTs by the sandwich technique. The composite materials produced exhibited good diffusion between magnesium layers and MWCNTs. The MWCNTs were observed well dispersed, aligned and embedded into the magnesium matrix. The composites showed an increase in their tensile mechanical properties, which was due to the good dispersion and alignment of MWCNTs that allowed a good load transfer from the matrix to them. The mechanical properties on the interface between the magnesium layers, measured by nanoindentation, were highly increased by the presence of the MWCNTs. Thus, the sandwich technique allows the production of MMCs with mechanical properties improved in both the bulk and small-scale.

KEYWORDS: Metal matrix composites, carbon nanotubes, sandwich technique.

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Fabrication of (Bi0.5Na0.5)TiO3 based ceramic powders for thermal-sprayed piezoelectric coatings as potential energy harvesters in aeronautics

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ABSTRACT

Piezoelectric energy harvesting is a green and sustainable option of generating electric power. It consist of transforming mechanical energy from ambient sources into electric energy through the piezoelectric direct effect. For example, the mechanical vibrations of aircrafts in flight can be harnessed to generate electric energy and supply low power applications, using piezoelectric materials on its structure. The most studied and commercially used piezoelectric ceramics are based on PZT due to their high performance for a number of applications in electro-mechanical systems. However, the high toxicity of lead compounds has motivated the necessity to study lead-free ferroelectric systems. Bismuth sodium titanate (Bi0.5Na0.5)TiO3 (BNT) based ferroelectrics are excellent candidates to substitute some of the PZT based compositions for certain applications. With the purpose of projecting BNT based ferroelectrics for energy harvesting applications at large scale, thermal spray technologies are promising options for efficiently deposit functional ferroelectric ceramic coatings over large surfaces. The fabrication of suitable feeding powders for thermal spray methods is an important subject because their microstructural characteristics influence the final properties of the coatings. It is desirable to have a specified morphology and size distribution of the powders in order to have better control of the coatings characteristics. In this work BNT ceramic powders were fabricated by a route of solid state reaction and high energy milling. BNT powder agglomerates were produced using spray drying technique, and the influence of process parameters was determined from a design of experiments (DoE). In addition, ceramic bulk samples were obtained by conventional sintering, using the same agglomerated powders. Their structural, microstructural and ferroelectric properties were characterized to later stablish a comparison with those of the coatings.

KEYWORDS: Energy harvesting, Thermal spray, Lead-free ferroelectrics

Bismuth based smart ceramics (Bi-smart ceramics) for energy harvesting applications in aeronautics

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ABSTRACT

Ferroelectric ceramics are of great interest for scientific and technological applications, as capacitors, ferroelectric memories, transducers, MEMS, and energy harvesters among others. Particularly piezoelectric energy harvesters (PEH) have received increased attention in the last years due to its capacity of converting mechanical stresses into electric energy, and being integrated in electromechanical systems. Lead-free ferroelectrics (Bi0.5Na0.5)TiO3 (BNT), (Bi0.5K0.5)TiO3 (BKT) and BaTiO3 (BT) form binary and ternary solid solutions like BNT-BT, BNT-BKT and BNT-BKT-BT, which are attractive because the compositions located within the MPB region of these systems exhibit improved piezoelectric and ferroelectric properties. Bi-Smart ceramics is a project funded by the Conacyt Program Frontiers of Science and deals with the deposition of Bibased ceramic thick films, Cu electrodes and layered heterostructures (ceramic/metal) using thermal spray technologies, evaluating the viability for piezoelectric energy harvesting applications in aircrafts. In this project different research lines are integrated starting with the synthesis of Bismuth oxides (Bi2O3) from Bi-metal as raw material, which is of great importance for the production of BNT based ferroelectric ceramics. Compositions in the phase transition region of BNT-BKT-BT (morphotropic zone) with promising electromechanical properties were determined in studies of by design of experiments (DoE), using Mixture design in which is possible to control and define the compositions of the system with required electromechanical properties. Other important topic is the study of the structural disorder of the perovskite structure of BNT-based ceramics which plays an important role in the definition of its macroscopic properties. The control of the processing parameters is reported as a solution to obtain homogeneity along the ferroelectric ceramics. The BNT-BKT-BT ternary system can be evaluated through a modulus mapping using nanoindentation and microRaman, correlating the mechanical and electromechanical properties including elastic/ferroelastic, elastoplastic and fracture behavior. Concerning the fabrication of the proposed energy harvesting structures, it is important to address the process of electrical charge generated by piezoelectric materials, which is collected through electrodes connected to their surfaces or interfaces. It has been proposed the deposit of Cu on Al substrates. Due to the physical metallurgy of the Al-Cu junction, cold spray technology is a suitable method due to its capacity for depositing materials sensitive to oxygen and temperature. The stages of the piezoelectric coatings process include the production of suited BNT-based ceramic powders for thermal spray process. The particle diagnosis, analysis of first stages of deposit and the determination of the deposit processing parameters by DoE.

KEYWORDS: Energy harvesting, Thermal spray, Lead-free ferroelectrics

α- Alumina ceramic support

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ABSTRACT

In this work we present a structural characterization of alumina supports prepared by sol– gel process using formate aluminum (Al(O2CH)3). The influence of the aging conditions, has been studied by NMR. Thermal decomposition of formate aluminum has been studied by X-ray diffraction and IR spectroscopies. Coordination and site distortion of Al polyhedra have been estimated by 27Al NMR spectroscopy. Thermal transformation of aluminum formate sol-gel to α-Al2O3 is reported. XRD and IR spectroscopy confirmed the presence of the precursor at 25 °C, and showed the precursor hydroxide at 200 °C. After calcinations, amorphous Al2O3 and η-Al2O3 were present at 400 °C and 800 °C, respectively. Coordination numbers and chemical interactions were determined by MAS nuclear magnetic resonance on different elements. 27Al MAS NMR study showed that solgels contain 6-coordinated aluminum ions. Four, five and six-coordinated aluminum species were present after calcinations at 400 °C. The transformation into α-Al2O3 was observed at 1050 °C. 1H MAS NMR was used to characterize aging conditions. The material was characterized morphologically by SEM microscopy. SEM images of sintered α-Al2O3 and BET surface analysis revealed a porous ceramic support with a microstructure of intertwined microwires with a nanoporosity of 3.37 nm and a surface area of 5.48 m2 /g being ideal parameters for application as catalyst support monolith of low surface area for applications in emission control.

KEYWORDS: Alumina, Ceramic support, Sol-Gel.

Challenges of building block approach on Light Sport Aircrafts

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ABSTRACT

On the frame to develop small aircraft technology in Mexico, Horizontec S. A. de C. V. in a joint venture with CENTA propose the design, manufacturing and test-in-fly Light Sport Aircrafts (LSA). Horizontec has designed and built the Falcon 1, a two-seat light-weight experimental aircraft based on wood/glass fiber materials. The Halcon 2 project aims with design and manufacturing of a LSA on carbon fiber reinforced materials. The goal is the application to certify the aircraft together with the Mexican Aeronautics Authority (DGAC) in accordance with the mandatory circular for Mexican light and experimental aircrafts CO AV-27/12 and the ASTM Standards F2245 [1]. Like any aircraft structure, Halcon 2 project is designed and manufactured under the "Building-Block Approach, known as the Pyramid of Tests [2]. For Level 1, coupon level, a series of test for each material used on the LSA must be done. An extensive materials characterization has been done, in order to obtain the elastic constants for all composite materials. For Level 2, elements level, performance of sandwich structures has been required, as most key elements of the fuselage and wings will use this configuration. For level 3 and 4, components and subsystems level, the design of molds, assemblies and test frames are now been developed, with the goal to perform 1-to-1 scale mechanical tests. For Level 5, aircraft level, only drop test has been defined for the assembled aircraft. The main challenge is to manufacture all main components of the aircraft by Vacuum Assisted Resin Infusion (VARI) [3]. In parallel, design and calculation of the aircraft has been carried out via Computational Fluid Mechanics (CFD) and Finite Element Analysis (FEA). The CFD approach has been useful to determine the aerodynamic performance of the aircraft and to estimate the flight envelopes. Furthermore, FEA approach has been employed for calculate the stresses and strains of the structure, plus, to test different materials and layup sequences in the main components.

KEYWORDS: Light Sport Aircraft, composites, vacuum assisted resin infusion.

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Analysis and validation of the aerodynamics design of a light sport aircraft

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ABSTRACT

The goal of this research is to determine the aerodynamics performance of a light sport aircraft design proposed by Horizontec S.A. de C.V. The flow analysis and the aerodynamic curves were calculated by computational fluid dynamics simulations at stall design velocity at different angles of attack (α), since the ASTMF2245 standard requires the analysis at such conditions in order to verify the well behaviour of the aircraft. Steady state simulations were carried out using a RANS turbulence model implemented with wall functions to capture the boundary layer effects with a coarse grid. The simulations were performed in OpenFoam toolbox. For the case of the flow through the aircraft at stall conditions (VS=23m/s, α=16°), due to the large angle of attack, we expect the separation of the flow at certain zones of the boundary layer formed at the surface of the aircraft, then, the SST k-ω turbulence model that is able to take into account such separation was implemented. Tetrahedral meshes with acceptable metrics were constructed for the isolated wing and the complete aircraft simulations. Appropriate refinement was applied on the zones close the wing and aircraft to compute accurately the flow. In order to capture the boundary layer effects, a sub mesh conformed by cells aligned to the surface of the aircraft was build. The value of y+ was fixed to 50 computed with the freestream velocity to keep the approximation at the logarithmic region of the boundary layer. The aerodynamic analysis was divided in two parts, in the first one, the isolated wing was studied in order to find the aerodynamic performance of the designed wing. In the second part, the numerical simulations of the complete aircraft were performed to obtain its global aerodynamic features. In both cases, the simulations were done for the cruise and stall velocity for different angles of attack to generate the polar curves of the isolated wing and the complete aircraft. The CFD simulations were in agreement with analytical and vortex lattice results giving certainty to the analytical results obtained in the earlier design stages.

KEYWORDS: aerodynamics, stall conditions, boundary layer.

Impact behaviour and damage propagation of composite stiffened wing panels.

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ABSTRACT

This research analyses the damage tolerance of composite hat stiffened panels when subjected to low-velocity impact (LVI). Choosing the dimensions obtained in a previous publication developed by the Composites Research Unit of the University of Bath as base geometry for the analysis.

In order to guarantee the accuracy of the stiffened panel impact simulation, a flat plate impact model was built based on ASTM D7136. This model was based on the test and impact simulation on a flat plate presented in two previous articles. The output records of the model built for this research were compared to the results obtained by other authors, to assess the accuracy of the methodology to be utilised later on.

The hat stiffened panel model was built developing 7 different models in order to compare three groups of study. The first group analyses the impact behaviour and damage with four impact energies in the centre of the upper flange. The second analysis group compares three different impact locations on the stiffener, with the same energy for each case. This allows determining the most critical impact location on a hat stiffened panel. The third analysis compares the impact behaviour and damage propagation of two stiffened panels with different web angles to assess the influence that this design variable can have on the damage tolerance of the stiffener.

A good initial approach of the damage was obtained for different cases explained through the three studies. Considering the absorbed energy by the damage in the stiffened panel, the worst impact location is the edge impact on the upper flange. It was also found that the web angle does not have a relevant influence in LVI. As a result, a good overview of the hat stiffened impact behaviour is given to be used as reference for future designs.

KEYWORDS: Composites, Damage Tolerance, Low-Velocity Impact Simulation.

Morphing airfoil designed by kinematic synthesis of rigid body mechanism.

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ABSTRACT

Upper camber shape-change of a wing decreases the velocity on an agricultural aircraft, which is required to operate in small field; previous aerodynamic work showed that this must be realized from an initial airfoil (NACA 4415) to a final airfoil (FUSION) [1]. The main problem is to determine the way to realize the geometric change; which could be made through the use of rigid-body mechanisms, compliant mechanisms and smart materials. In this research, the approach applied to the morphing airfoil design is based on kinematic synthesis of rigid body mechanisms [2][3], which permit the mechanism adaptability by a set of established morphing profiles with different arc lengths. In order to achieve the shape-change required, a chain of links connected by revolute and prismatic joints are used. The design of each link is generated through the segmentation of the two target profiles, where an acceptable error and a variable length segment were specified for each target airfoil. Synthesis has been realized to carry out a single degree of freedom (DOF), this means to select and assemble different types of links and building blocks. Several mechanisms with different geometric errors are analyzed by CFD (Computational Fluid Dynamics) to get aerodynamic parameters (Cl and Cd). These results permit to evaluate the aerodynamic performance of airfoils obtained by the use of synthesis of mechanisms respect to the initial and final airfoils.

Using the synthesis previously descripted are obtained six different Shape-change Mechanism (SCM) that were assembled by building blocks approach as shown in fig 1. The mechanism configuration depends of acceptable error used in segmentation procedure, when this measure decrease the number of rigid links and structural complexity increase. By the other way aerodynamic characteristics obtained by CFD show that do not have direct relation to the geometric error.

KEYWORDS: Morphing airfoil, building blocks, mechanism.

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Residual strength for glass-epoxy laminates subjected to low-energy impacts.

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ABSTRACT

The present work deals with the mechanical behaviour of glass fibre reinforced plastics (GFRP) after been subjected to a low energy impact (less than 50 J). The aim is to obtain the Residual Strength Diagram (RSD) which relates the ultimate strength of the composite as a function of the impact energy. Two laminate configurations are considered: heavy plain-weave and light plain-weave. The thermoset employed is EPOLAM 2015 epoxy system by Axson®. Both laminate configurations have $[0/90]_5$ layup and they were fabricated by vacuum bagging, to assure 50% of fibre volume fraction. Impact test were performed using a fixed weight drop-test machine. For heavy plain-weave, impact energy values were set at 20 J, 30 J y 40 J; meanwhile for light plain-weave, impact energy values were fixed at 2.5 J, 5 J y 10 J. Both range values were chosen to induce Barely Visible Impact Damage (BVID). Tensile tests were done to calculate the ultimate post-impact strength for the laminates. For both laminate configurations, ultimate strength is reduced 40% compared to non-impacted coupons. Post-mortem fractographic analysis revealed that the ruling failure mechanisms were woven distortions and delaminations.

KEYWORDS: Low-energy impact, residual strength, BVID.

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Determination of residual strength in riveted carbon/epoxy composite materials.

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ABSTRACT

This work is of vital importance because of degradation and failure in aircraft structures frequently start at joints, and the fastening elements commonly used in the aeronautics industry are rivets. The present research aims to investigate the residual strength of riveted carbon/epoxy woven laminates. Coupons have eleven balanced woven bidirectional layers manufactured by Resin Transfer Molding (RTM). Mechanical characterization of carbon/epoxy material has been done following ASTM D3039. Two composite laminates were joined using simple riveted joint using 5/32” cherry locked rivet. The maximum tensile strength of the riveted joint was calculated following the ASTM D5961 standard. The maximum joint tensile strength is the baseline property for further mechanical evaluation of the composite riveted joints. Evaluation of the residual lifetime under tensile-tensile fatigue under several stress ratio will be performed, in order to estimate the accumulated damage on the composite joined parts.

Table 1. Composite Mechanical Properties 3K-70-P/EPOLAM 2015

Tensile strength: 578 MPa

Elastic Modulus: 46.33 GPa

Poisson´s ratio: 0.08

KEYWORDS: Riveted composites, damage mechanics, residual strength.

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Development of geopolymers in composites materials for the aeronautical sector

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ABSTRACT

Inorganic polymers, more commonly known it as Geopolymers, are aluminosilicates materials activated in an alkaline environment which has excellent physical and chemical properties. Principally due their thermal characteristics, geopolymers are consider like a fireproof materials and are used it in wide range of applications where is necessary withstand elevated temperatures for high period of time [1].

The process named as geopolymerisation are the synthesis between alkaline medium solutions with silicates, for this work we use fly-ash as a source of silicates due their elevated content of aluminum, silicon, and oxygen [2]. The current work presents the study of development geopolymers in composites materials especifically carbon fiber reinforced plastic (CFRP). The objective is improve on thermal properties of composites materials for will be use in environments exposed to high temperatures. The geopolymer composite matrix were prepared mixed an epoxy resin with fly-ash in one alkaline solution of sodium hydroxide. A fractional factorial design of experiments were used to evaluate the most significant factors that influence the fireproof capability of the material.

KEYWORDS: Composites, Geopolymers, Fireproof materials.

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High fatigue cycle behavior in carbon fiber-epoxy L shape joints.

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ABSTRACT

This work exposed the fundamental reasons for the research on the mechanical, chemical and hybrid (mechanical + chemical) L-shaped butt joints made of Carbon Fiber Reinforced Epoxy Polymer (CFREP) subjected to fatigue for structural assemblies. In general terms, the enlisted steps describe the procedures followed during this research, so a contrast can be made between the regulatory requirements and the manufacturing practices in the field. Although some research has been made bonded L shape joints in metals [1] and bolted joints in carbon fiber composites [2] subject to quasi static loads, persist an absence of technical information on angular joints for aeronautical structural assemblies, which by their nature are subjected to cyclic loads as an alternative for the union of structural assemblies to simple overlap. The group has studied the last one in high cycle fatigue, finding cohesive failures when they are adhesive, failure by sinking of the rivet in hybrid unions or by shearing of the same in the mechanical joints, but this information is missing in L shape joints. This forces to oversize this type of unions or inhibits the use of them, with the consequent operational cost in the first case due to weight increment, and limiting the field of application in the second. A comparison between FEM analysis with quasi-static loads and experimental results reported by [2] to explain the failures modes present in the samples, prior to the fatigue experiment, finding the coincidence of high stress zones in the FEM analysis with the first ply failure in the experiments, then, is expected to explain the failures modes in fatigue test. Quasi-isotropic L shape samples made of 8 plies of plain wave carbon fiber and Axon Epolam 5015/5015 epoxy resin system have been made by wet-preg and vacuum process, and have been used to manufacture bolted, adhesive and hybrid joints in order to make high cycle fatigue test. Finally, it is expected that this research helps to fill in a gap on the knowledge of the behavior of L-shaped butt joints made of CFREP, leaving evidence of the possibilities that such union has for aeronautical structural assemblies.

KEYWORDS: Fatigue, CFRP, L-shaped

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Caracterización, análisis e innovación de laminados de fibra de carbono aplicado en partes semi-estructurales de motores a reacción.

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ABSTRACT

Se analizará la viabilidad de sustituir materiales metálicos (aleaciones) y materiales cerámicos por materiales compuestos de matriz polimérica dentro de la sección fría del aerorreactor. El trabajo que se está realizando toma en consideración el alcance de nuevos materiales con una excelente relación resistencia peso y que a su vez son capaces de resistir altas temperaturas. Estos materiales (Fibras y resinas) permitirán reducir de manera considerable el peso de componentes metálicos y cerámicos que se emplean en la actualidad en los aerorreactores. La tecnología actual y el acceso económico a materiales más sofisticados permiten considerar la manufactura de materiales compuestos avanzados, innovando en el desempeño de los aeroreactores. Se manufacturaron por diversas técnicas (RTM, Infusión y Autoclave) laminados reforzados con diferentes tipos de fibra de carbono y resinas, para posteriormente hacer una caracterización térmica-mecánica de manera exhaustiva a los laminados, sometiéndolos a pruebas mecánicas a temperatura ambiente y después a una temperatura elevada. Además, se realizaron ensayos de impacto de baja velocidad, para comprobar la resistencia al impacto de estos laminados, ya que su implementación dentro de los aerorreactores, hace que los materiales que se usan estén expuestos a colisiones de partículas extrañas durante la ingesta de aire en el funcionamiento del aerorreactor. Seleccionando de esta manera el proceso de manufactura, el tipo de fibra y la resina más óptimas para manufacturar los laminados de fibra de carbono, que serán implementados como una innovación al sustituir partes metálicas semi-estructurales en los motores a reacción.

KEYWORDS: Laminados, fibra de carbono, RTM, motor a reacción.

Synergetic effect of multiwalled carbon nanotubes and graphene oxide on interlaminar fracture toughness of carbon fiber/epoxy composite laminates

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ABSTRACT

This work reports an effective strategy to improve the mode I and mode II interlaminar fracture toughness (G_{IC} and G_{IIC}) of unidirectional carbon fiber/epoxy composite laminates using a hybrid combination of multiwalled carbon nanotubes (MWCNTs) and graphene oxide (GO). Double cantilever beam (DCB) and end notched flexure (ENF) tests were conducted to evaluate G_{IC} and G_{IIC} of the composite laminates fabricated with sprayed MWCNTs, GO and MWCNTs/GO hybrid. Experimental results showed the positive effect on the G_{IC} and G_{IIC} by 16% and 14% improvements on composite laminates with 0.25% wt. MWCNTs/GO hybrid content compared to the neat laminate. These results were explained in terms of the damage mechanisms observed at the fracture surfaces of tested specimens by scanning electron microscopy. A synergetic effect between MWCNTs and GO resulted in improved interlaminar fracture toughness of prepreg based laminates typically used in aeronautical and aerospace industries.

KEYWORDS: Multiwalled carbon nanotubes, Graphene oxide, Composite laminates, Interlaminar fracture toughness.

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Strain rate sensitivity of compressive mechanical properties of PPS fiber-reinforced composites.

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ABSTRACT

Thermoplastic fiber-reinforced (TFR) composites have been introduced to structural aerospace components due to several advantages over thermoset composites, such as ability to be re-molded and/or re-worked, storable at ambient temperatures, low void content, ability to be fusion welded and recyclability. During service, these structures may be subjected to dynamic loads like impact of foreign objects, projectile impacts or shock waves induced by blast loading, which produce large deformation in the material in fractions of milliseconds, but the structural behavior and failure mechanisms in these types of composites at that kind of high strain rates are not fully understood yet. Taking this into account, the present work presents an experimental study on the mechanical behavior of polyphenylene sulfide (PPS) based composite laminates, reinforced with carbon and glass fibers (PPSCFC and PPSGFC), under compressive load at different strain rates. Dynamic and quasi-static tests have been carried out using a Split Hopkinson Pressure Bar (SHPB) apparatus and an electromechanical universal testing machine, respectively, over the same specimen geometry and batch. High speed imaging system was used to monitor the failure process during the test and fractography analysis was performed. Results showed that the strength and ultimate strain of the PPSGFC are strain rate dependent. An increase of 27% of the strength and 36% of the ultimate strain rate were obtained when quasi-static and dynamic results were compared while the Young Modulus remained almost constant (22.14 GPa approx.). PPSCFC's strength average value was 531.6 MPa with a coefficient of variation of 2.7% which indicates the strength remained constant at all the strain rates. Ultimate strain presented a small increase which is probably due to the localized strain induced by the dynamic test method and is reflected in modulus decrease. Mixed shear and delamination failure mode was observed for all specimens in both materials which leads to think that damage mechanisms is not strain rate dependent. Highest strain rates specimens presented fragmentation in several parts and SEM fracture surfaces observation revealed two types of surfaces, one melted and the other one non-melted. Non-melted surface exhibited typical fractographic aspects, while melted one was featureless and smooth.

KEYWORDS: High strain rate, Split Hopkinson Pressure Bar, Thermoplastic fiber-reinforced composites.

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Determination of the mold configuration to manufacture UAV' helix with high fiber content thermoplastic composite.

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ABSTRACT

Injection point determination in a plastic injection mold for propellers for unmanned aerial vehicles (UAV) using high volume fiber thermoplastic matrix composites is presented. By means of the finite element structural simulation, the intensity and direction of the main stresses in the propeller when this one undergoes a determined condition of flexion is obtained, locating critical zones as for its structural demand. Since the flow of a molten plastic into a cavity defines the orientation of chains and fibers, the information of the structural study was compared with the simulations results of the injection process in terms of the directionality of the fibers of the injected material and the presence of mixing and welding lines depending on the location of the injection point, giving the structural criteria of the propeller for the design of the cavity of a plastic injection mold [1, 2]. Based on the results, a decision matrix was developed to determine the best injection point option for the mold cavity design, with emphasis on the stress distribution with respect to the fibers orientation and welding lines, establishing the appropriate entry position to obtain a piece with acceptable structural and surface quality in the shortest possible time. It is concluded that the alignment of the fibers during the injection process is very important for the appropriate structural rigidity of the system.

KEYWORDS: Computer Aided Engineering, Composite materials, Plastic injection molds.

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Surface modification of aramid fibers by air plasma, silane and zinc oxide nanoparticles for advanced composites

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ABSTRACT

Aramid fibers are structural fibers extensively used for armor protection and as polymer reinforcement due to their high strength, toughness and damage tolerance [1]. However, these fibers are highly susceptible to UV degradation and exhibit poor adhesion with most polymer matrices [1, 2]. A strategy recently explored to overcome such drawbacks involves coating the fibers with ZnO nanoparticles. Even though this strategy has shown adhesion improvements between the ZnO-coated fibers and the polymer matrix [3], further enhancements through surface modification prior to ZnO synthesis has not been investigated. Given this motivation, in this work aramid fibers are treated by air plasma and/or surface-modified with a silane-coupling agent prior to ZnO synthesis in order to improve their chemical interaction. The synthesis of ZnO onto the fibers was conducted by two sequential growing process; ultrasound and subsequently microwave heating using methanol as suspending medium. The morphology of the ZnO-modified fibers was characterized by scanning electron microscopy and crystal properties was characterized by X-ray diffraction. Results of this work evidence that surface modification of aramid fibers by using air plasma and/or a silane coupling agent plays a dominant role on the homogeneous coverage of the fiber with ZnO with respect to the pristine fibers. The ZnO-modified fibers developed in this work are excellent candidates to manufacture advanced polymer composites with enhanced UV protection and mechanical properties.

KEYWORDS: Aramid fibers, surface treatment, ZnO synthesis.

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Explorando los beneficios del aerogel como aislamiento térmico para tuberías de motores aeronáuticos.

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ABSTRACT

Una de las mayores dificultades en el diseño aeronáutico en motores es el aislamiento térmico en tuberías, que se ven afectadas por las altas temperaturas a las que son expuestas mientras el motor se encuentra en funcionamiento o incluso cuando se apaga y no hay circulación de fluidos (aire, aceite, combustible). Esta problemática se ha resuelto con la adición de componentes que incrementan el peso y costo de operación.

En este trabajo se propone aprovechar las cualidades de los materiales denominados Aerogel [1], que tiene una conductividad térmica muy baja y única. Esta tecnología se emplea para las barreras térmicas en procesos a alta temperatura para diferentes industrias.

Con esta tecnología se abre la avenida de la oportunidad de evitar calentamientos excesivos en componentes esenciales del motor que permitan ciclos de vida mayores.

Se presentan los resultados de análisis analíticos de diferentes materiales “Aerogel” y los mecanismos de adhesión más prometedores para que la tubería y motor no sufra modificaciones. Los resultados se basan en estudios por Microscopía de Barrido con Electrones (SEM), Difracción de Rayos X (XRD), Análisis Termogravimétrico (TGA) y Calorimetría Diferencial de Barrido (DSC), así mismo se hace una validación por métodos de simulación. La comparación de los resultados obtenidos permitirá hacer una selección basada en el criterio costo-beneficio apropiada para resolver problemas industriales en este aspecto.

KEYWORDS: Aislante térmico, aerogel, tubería aeronáutica.

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Thermal characterization of particle reinforced polymers for cubesat structures

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Abstract

The present work lies in the framework of designing polymeric fibre reinforced materials to be used in nanosatellite structures (CubeSat). The CubeSat are exposed to high radiation levels (because of the sun irradiance), and so, the accurate determination of the thermal properties are a key issue for the materials design used in such applications. This work reports the thermal performance of a biphasic epoxy resin system (EPOLAM 2500) incorporating two types of ceramic nanoparticles: zinc oxide and alumina, chosen as potential fillers to improve the thermal properties of the epoxy system. Three concentrations of each ceramic were studied to evaluate the effect of the particle concentration on thermal properties of the thermosetting plastic. Thermogravimetric Analysis, Differential Scanning Calorimetry and Fourier-transform infrared spectroscopy were performed to determine degradation and cured kinetics. The influence of the different concentrations of the nano-filler in the effective thermal diffusivity, effusivity, and conductivity thermal response of the epoxy system were determined by means of the photoacoustic technique and infrared photothermal radiometry.

Keywords: CubeSat, epoxy, thermal behaviour, ceramic particles.

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Mechanical and structural characterization of TiO_2 nanoparticles incorporated in a thermostable resin.

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ABSTRACT

In recent years, it has conducted considerable research to improve the performance of the resins using as composite nanoparticles [1]. The rigid inorganic particles can also withstand tensile stresses and harden and further strengthen the resin matrix if they have an excellent binding effect on the matrix [2]. Titanium dioxide (TiO_2) is a ceramic material that can be synthesized by various methods. TiO2 may be loaded compared to aluminum, it has high resistance to fatigue and corrosion, it is insoluble in water but soluble in concentrated sulfuric acid and strong bases [3]. In this work, nanoparticles of TiO2 (NPs) have been synthesized through the sol-gel method and their incorporation into a polyester resin using ultrasonic dispersion techniques for their possible applications in optical filters, coatings, chemical sensors, catalysts and sterilization materials. The TiO2 NPs were synthesized from a precursor solution of titanium isopropoxide and isopropyl alcohol and furthermore the pH was monitored in the solution with 1M NaOH to obtain the stable colloidal solution with a pH range of 7-11, as well as a calcination process at 600, 700, 800 and 900 °C with a heating rate of 5 °C/min. The characterization of the thermal morphology and properties of the TiO2 NPs were performed by XRD difraction, Fourier infrared spectroscopy (FTIR), and Raman spectroscopy, thermogravimetric analysis (TGA) to evaluate the effect of pH and the calcination of the temperature of the physical properties of the samples. Also, mechanical and thermal studies were carried out on the polyester resin samples with incorporation of 0.05% TiO2 NPs. These resins are characterized flexural test and TGA to fix the effect of the integration of TiO2 NPs on the mechanical and thermal properties of the polyester resins. Acording to the XRD difraction patterns, the TiO2 particles present anatase and rutile cristal structure. When the particules where incorporated into the polyester resin, curing time dicreased, delaing the onset temperature of decomposition from 326 °C to 350 °C and the temperature of complete decomposition from 460 °C to 727 °C. Also the results obtained from the mechanical tests indicates that the incorporation of synthesized particles increases the elasticity of the composite.

KEYWORDS: TiO_2, polyester resin, mechanical and thermal properties.

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Modification of the mechanical properties of a polyester resin by incorporation of Zinc oxide nanoparticles.

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ABSTRACT

Zinc oxide (ZnO) is an effective inorganic absorber of UVA and UVB radiation. ZnO is abundant, inexpensive, broad spectrum resistant to UV rays, chemically stable and very transparent in visible light. Due to increasing use of composite structures in transport industry, it is necessary to improve the mechanical properties of composite materials and some other possible applications such as resistant to UV rays analyze the multifunctional behavior of the composites. This work describes the synthesis of zinc oxide nanoparticles (obtained by the sol-gel method) and its evaluation in a polyester resin [1,2]. ZnO was synthesized from a solution of NaOH precursor, allowed to age for 24 h for further gelling at 100 °C. Subsequently, calcination was performed at 600, 700, 800, 900 and 1000 °C. For the incorporation of the ZnO in the polymer matrix it was necessary to use an ultrasonic bath to promote the dispersion in the specimen and avoid points of agglomeration. The ZnO / polyester compound was characterized by FT-IR, and X-ray powder diffraction, where the wurtzite phase was identified. The resin is characterized by the flexural test and TGA for the analysis of the effect of ZnO on the resin. The X-ray diffraction patters indicated the formation of wurtzite structure in all the samples, with a crystal size between 18.2 nm and 26 nm. The Young's modulus in ZnO flexural tests incorporated in a polyester resin, increased according to the increase of the heat treatment, yielding a maximum modulus of 2929 MPa.

KEYWORDS: Zinc oxide, polyester, nanoparticles, UV.

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Synthesis and characterization of a polyester composite reinforced with alumina nanoparticles.

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ABSTRACT

Composite materials comprise a new class of materials where nanometric structures are dispersed within a matrix. The present research project focuses on the improvement of the thermo-mechanical properties of a thermoplastic resin by the incorporation of nanoparticles of alumina. Alumina nanoparticles were prepared by the aqueous sol-gel technique using a citrate polymeric precursor derived from aluminum nitrate and citric acid solution. The thermal decomposition of the precursor and subsequent formation of g-Al_2O_3 was characterized by X-ray diffractometer (XRD) and Fourier Transform Infrared Spectra (FTIR). G-alumina powder was obtained after heat treatment at 900 ° C with an average crystal size of 140 nm. The solution mixing technique was used to make nanocomposites of unsaturated polyester (UPR) and nanoalumina. The nanoparticles were suspended in isopropyl alcohol by ultrasound and subsequently the polyester resin was added. The thermomechanical characterization was performed by Thermogravimetric Analysis (TGA) and Standard Test Method for Flexural Properties of Polymer Matrix Composite. It was observed that the thermal properties of the polyester increase with the incorporation of 0.50% by weight of nanoparticles of alumina. Furthermore, it was observed that nanometer sized particles lead to significantly enhancement of the fracture with a reinforcement of 0.05% by weight.

KEYWORDS: Nanocomposite, alumina, polymer.

Synthesis of reduced graphene oxide to measure the effect of its incorporation in the mechanical properties of a composite (natural fiber/epoxy).

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ABSTRACT

Graphene has been studied considerably for its electrical and mechanical installations, it is currently in use of materials such as reinforcement (nanoparticles); as well as on the surface of the carbon fiber, increasing the contact area of the fiber, among other properties. Also graphene has been used in cotton fibers for electronic applications and protection of ultraviolet rays [1]. The present project consists in measuring the effect of the incorporation of reduced graphene oxide into the mechanical properties of a composite, which will be made with natural fibers and an epoxy matrix. To reach this goal, graphene will be added to the fiber to provide it stronger mechanical properties, since graphene is a material that has exceptional properties, and this, could help the natural fiber to increase its strength and elastic modulus. The synthesis of graphene was performed by following the modified Hummer's method was performed; in addition, the graphene oxide was expanded in a tube furnace with a temperature rate of 5 °C/min to 230 °C, under nitrogen atmosphere [2], where suitable results are obtained for the application to the fibers, through the characterization by UV- vis, and X-ray diffraction. It has been characterized by UV-vis where the analysis showed a maximum absorption peak of 232 nm approximately of GO which was ascribed to the p-p* transitions of the aromatic C–C bonds and a weak shoulder appeared at 300 nm due to n–p transitions of C=O bonds [3]. Later on, the treatment of natural fibers will be carried out to have a better adhesion to the reduced graphene oxide, as well as a better interface with the epoxy resin.

KEYWORDS: Reduced graphene oxide, natural fiber composite, mechanical properties.

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Synthesis of barium titanate nanoparticles and their incorporation into an epoxy resin

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ABSTRACT

The polymer-barium titanate composites are of incipient interest in the polymer industries because the characteristics of the final composite can be modified when the constituent fractions are varied. The epoxy resin is a suitable matrix because is relatively easy to form a composite structure by incorporation of a high dielectric constant ceramic, such as barium titanate.

This work describes the properties of a polymer matrix composite (epoxy resin) with different weight concentrations (0.05, 0.1, 0.25 and 0.5 %wt) of barium titanate as reinforcement. The ceramic material was obtained by sol-gel synthesis using barium acetate and titanium isopropoxide as precursors, acetic acid and, ethylene glycol as chelating agents. Samples were dried at 120 °C during 2h and calcined at 900 °C for 3 h.

The crystalline structure of the barium titanate powders was characterized by X-ray diffractometry (XRD) and Raman spectroscopy. The morphology was observed by Scanning Electron Microscopy (SEM). The DRX and Raman measurements indicated the formation of cubic barium titanate structure. According to the SEM observations, sample consists of agglomerated round particles with average of 130 nm.

The properties of the composite (epoxy-titanate barium resin) were studied, as a function of the ceramic weight percent, by infrared spectroscopy (FTIR), differential thermal analysis (TGA) and 3 point bending tests. The FTIR spectra showed the characteristics bands derived from the epoxy resin. The thermograms showed a slight decrease in weight between 150 °C and 200 °C, indicating loss of moisture. Above 275 °C, a second mass loss is attributed to the thermal decomposition of the resin itself, but there is a decrease in the thermal stability of the composites containing barium titanate particles, as reinforcement, in comparison to the pure resin. At higher concentrations, reinforcements favor the diffusion of the volatile compounds in the decomposition process of the resin. Also within systems with reinforcement of barium titanate there is a small increase in thermal stability from 450 ° C to 750 ° C which can be attributed to the increase in volume caused by the same incorporation of the material and may be acting as a barrier in the complete calcination of the epoxy matrix.

The e-point bending tests showed the effect of the nanoparticles on the rigidity and strength of the composites. The relationship between the flexural modulus and the BaTiO3 content indicates that the addition of BaTiO3 results in a modulus increase up to 0.05% by weight (from 3275.4 to 3801.6 Mpa). Above 0.1% to 0.5% by weight of BaTiO3, the flexural modulus decreases reaching a lower fracture point.

KEYWORDS: Epoxy resin, barium titanate, composite material.

Caracterización de nanotubos de carbono en disolución para aplicaciones aeroespaciales.

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ABSTRACT

Nanomateriales han sido utilizados recientemente en diversas industrias debido a sus cualidades únicas. En el sector aeroespacial, es evidente la incorporación de nanomateriales para mejorar los componentes o innovar nuevos elementos que cubran las necesidades actuales. Aunque la inclusión ha ido lenta. Los materiales compuestos y la tecnología de recubrimientos han sido de las beneficiadas inmediatamente con la incorporación de nanomateriales. Sin embargo, la promesa para generar componentes con mayor valor agregado aún está por llegar. Una de las limitaciones de la incorporación de los nanomateriales en el sector aeroespacial es que los nanomateriales tienen una tendencia a la agregación, eso evita componentes con propiedades homogéneas. En este trabajo se presentan resultados que permitan lograr nanomateriales dispersión y homogéneos en diversas matrices que coadyuvan a la manufactura isotrópica compleja.

KEYWORDS: nanotubos de carbono, disolución homogénea, dispersión.

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Propiedades mecánicas en estructuras celulares tipo giroide fabricadas por manufactura aditiva

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ABSTRACT

La manufactura aditiva (AM) describe procesos para fabricar componentes directamente a partir de representaciones CAD. Los componentes AM no se limitan por restricciones de diseño; pueden ser de formas libres y bastante complejas, proporcionando la oportunidad para la ligereza y una mayor funcionalidad. Las estructuras sólidas celulares (CS) están siendo ampliamente utilizadas en la industria aeronáutica, automotriz, naval y en intercambiadores de calor debido a sus altas relaciones resistencia/densidad y superficie/volumen; que les permiten absorber grandes cantidades de energía de deformación de una manera predecible y poseer alta eficiencia de intercambio de calor. En términos de propiedades mecánicas, las CS pueden ser realmente subóptimos en comparación con los enfoques de optimización topológica (TO), pero pueden ofrecer un rendimiento superior en casos que presentan incertidumbre en las condiciones de carga. La característica de las CS que ha recibido más atención hasta la fecha es la densidad relativa, o fracción de volumen, ya que las relaciones entre la fracción volumétrica y las propiedades habituales de interés, tales como el módulo y la resistencia, están bien establecidas y se han verificado para otro tipo de estructuras estrechamente relacionadas; por ejemplo espumas. Otras variables de diseño de CS incluyen el tamaño y la geometría de la celda unitaria (diamante, kagome, etc.) [1]. Otra familia de geometrías CS que tienen un gran potencial para AM son las superficies mínimas triplemente periódicas (TPMS). De estas TPMS se destacan el Giroide Simple (SG) [2,3] y el Giroide Doble (DG), este último se identificó recientemente por tener alta rigidez y baja tensión en comparación con otros tipos de CS, lo que es particularmente adecuado para su uso en componentes ligeros. Además, se ha observado que el DG, a diferencia de otros tipos de red, posee rigidez axisimétrica, convirtiéndola en un buen candidato para aplicaciones en las que la naturaleza exacta y la dirección de las cargas no son totalmente conocidas o están sujetas a grandes incertidumbres [1]. En el presente trabajo se muestran resultados preliminares sobre el diseño (tamaño de celda y espesor de pared), fabricación y pruebas de estructuras ligeras SG y DG. Se muestra la relación que existe entre el parámetro t de las ecuaciones de ambos giroides y la densidad resultante de las muestras (fracción volumétrica entre el 15 y 30%), así como la influencia del tamaño de celda en pruebas de compresión (6 – 8 mm). Las muestras fueron fabricadas por el método (Direct Metal Laser Sintering) DMLS en acero inoxidable 17-4.

KEYWORDS: Estructuras ligeras, Giroide, Compresión.

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Propiedades mecánicas en estructuras celulares anisotropías tipo diamante fabricadas por manufactura aditiva

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ABSTRACT

Las estructuras celulares (CS) han sido consideradas como los materiales más eficientes en peso, debido a que poseen una resistencia específica y rigidez relativamente alta y sus aplicaciones en aeronáutica han sido difundidas ampliamente. En comparación con los materiales tradicionales, tienen mayor capacidad de carga y mayor eficiencia de peso [1]. Se puede lograr un ahorro en peso mediante la sustitución de componentes tradicionales por CS o por cambio de materiales y aleaciones. Otra ventaja de las CS radica en su constitución geométrica periódica, que deja espacio abierto en la estructura a favor del diseño multifuncional. Por ejemplo, a través del relleno del espacio intracelular con espuma absorbente de microondas. Las estructuras celulares también presentan excelentes comportamientos anti-impacto, con alta eficiencia de absorción de energía mecánica. Ha habido muchos estudios sobre las propiedades mecánicas de las CS, como isogrid, Kagome, diamante y triángulo mixto. Una característica importante sobre las propiedades mecánicas de las CS es su anisotropía. Como las estructuras están constituidas por diferentes orientaciones de las hileras, sus materiales no se distribuyen uniformemente en el espacio, dando como resultado las propiedades anisotrópicas. Tanto la rigidez y la resistencia anisotropía de los materiales de las CS han sido estudiadas por varios investigadores. La estructura tipo diamante tiene una anisotropía más fuerte que la de isogrid, Kagome y estructuras triangulares mixtas. La estructura de diamante tiene mayor rigidez y resistencia específicas que otros materiales, así como anisotropía mecánica más fuerte [2]. En este trabajo se emplea variantes de la CS tipo diamante como modelo, para discutir los efectos de la anchura de los puntales sobre la anisotropía de la resistencia a la compresión, así como de la densidad. Las muestras fueron fabricadas en acero inoxidable 17-4 mediante la tecnología Direct Metal laser Sintering (DMLS) La anisotropía de las estructuras puede ser reducida o mejorada ajustando el ancho de los puntales en diferentes orientaciones, así como a través de variantes en el diseño de las mismas.

KEYWORDS: Estructuras ligeras, anisotropía, diamante.

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A nanostructural study and analysis of the photonic crystals of the butterfly wings as biomimetic aerodynamic.

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ABSTRACT

Colors exhibited by butterfly wings are usually contributed by two sources: pigments and periodical submicrometer structures, which are also referred to as “chemical” and “physical” colors, respectively [1,2]. The photonic crystals are dielectric media with a periodic distribution of their refractive indexes. In photonic crystals well defined ranges of frequencies exist, in which light cannot propagate through the structure [3]. In this work, results from Light Microscopy, Confocal Microscopy, HRSEM, Raman and X-Ray Diffraction techniques are shown. These information permitted interpreted and evaluated micro and nano characteristics of butterfly wings and suggested optical and mechanical properties that can be used on biomimetic studies at automotive and aerospace applications [4]. Results offer a promising scenario for advanced materials (lightweight and high strength) and photonic applications in different fields from the generation of energy to the encryption.

KEYWORDS: nanostructure, photonic crystals, colors generation.

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Experimentos virtuales para materiales compuestos.

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ABSTRACT

Los materiales compuestos manufacturados a partir de polímeros reforzados con fibras (MCPRF) han demostrado un excelente balance entre rigidez, tolerancia a la fatiga, resistencia a la fractura y baja densidad en comparación con metales estructurales. Este balance ha iniciado una revolución en el paradigma para el diseño, desarrollo, construcción y certificación de estructuras aéreas, marítimas y terrestres de última generación con relaciones positivas de costo de operación-beneficio. Sin embargo, los mecanismos de inicio y propagación de daño que comprometen la integridad mecánica de MCPRF son muy difíciles de predecir. Estos mecanismos actúan de forma simultánea y altamente no-lineal a través de un amplio rango de escalas estructurales. Por supuesto, la certificación de la confiablidad y durabilidad de MCPRF se ve forzada a apoyarse en esquemas empíricos extremadamente caros y lentos. Por ejemplo, la certificación de la estructura de una aeronave considerada de gran tamaño requiere de aproximadamente 104 pruebas a nivel probetas solamente. En los últimos años, la evaluación del desempeño de MCPRF basada en especímenes virtuales ha emergido como una poderosa estrategia para profundizar en el entendimiento de los mecanismos multi-escala que controlan el inicio y propagación de daño. De esta forma se busca reducir significativamente el tiempo y el esfuerzo experimental para predecir la confiabilidad y durabilidad de MCPRF. La presente plática describe el consenso de la comunidad científica acerca de las prospectivas y la factibilidad asociados con la formulación de especímenes virtuales que representen con una alta fidelidad las múltiples escalas presentes en la estructura de MCPRF. Los retos y dificultades en la formulación de especímenes virtuales también se discuten brevemente.

KEYWORDS: Materiales compuestos, experimentos virtuales, micromecánica.

Ultrasonic fatigue testing issues in aeronautics industry

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ABSTRACT

Fatigue testing on materials or components is a common activity in several research laboratories for aeronautics. An issue very discussed is the pertinence and validity of accelerated methods to complete very high number of cycles in a single test, meaning the high cycle regime or gigacycle regime. For instance, a servo-hydraulic fatigue testing machine working at frequencies of 1 to 100 Hz will reach 10^9 cycles in 115 days to 31 years. However, an ultrasonic fatigue testing machine working at frequencies of 15 to 20 kHz will complete one milliard of cycles in around 14 to 18 hours. The components in aeronautics are subjected to very high number of cycles during their lifetime. Taking as example an helicopter turbine rotor working 3,000 hours at average speed around 30,000 rpm is expected to reach 5.4×10^9 cycles during its lifetime and it should be important to know the fatigue strength up to this regime for all materials involved in such mechanism. Ultrasonic fatigue devices exploit the elastic wave theory to apply small displacements on an isotropic body at high frequencies. An axial vibration at one end of a round or flat specimen subjects the piece to stresses in the middle section where a node of zero displacement and maximum strain occur. Stresses applied in the elastic regime of materials can be applied to form S-N curves with number of cycles above 10^8 cycles. This premise of isotropy in an issue if composite, bi-modal, hybrid or adhesive joined components need to be tested. This work is around the world of possibilities in industrial applications for ultrasonic fatigue testing and the available configurations for fatigue endurance and crack growth analysis in the real high cycle regime. Some evidences of no effect of the testing frequency in various materials are presented and discussed.

KEYWORDS: Gigacycle fatigue, high cycle loading, ultrasonic fatigue.

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Estrategia analítica para la caracterización y verificaciones de las uniones entre elemento de amortiguamiento y estructura móvil.

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ABSTRACT

Dentro de la vida en servicio de un motor aeronáutico se definen y categorizan fases de mantenimiento, la primera se realiza cuando el motor se encuentra instalado en el ala de la aeronave, la segunda se enfoca en desinstalar el motor y manipularlo dentro o fuera de los hangares especializados de mantenimiento y la tercera o especifica radica en limpiar, inspeccionar y reparar los componentes que conforman el motor de manera individual. En la segunda fase de mantenimiento, la manipulación del motor se hace mediante equipo especializado de trasporte (fixture) ya que no siempre se cuenta con talleres y hangares especializados en esta fase, de tal modo que es necesario diseñar y fabricar vehículos capaces de soportar, manipular y trasladar el motor.

Los vehículos de trasporte de motores aeronáuticos poseen la capacidad, en la mayoría de ellos, de transitar por terrenos irregulares y hostiles (para cuestiones militares) por ello los vehículos son dotados de dispositivos amortiguados capaces de mantener la integridad del motor durante el traslado. Los soportes que sirven de interface entre los dispositivos amortiguadores y la estructura principal del vehículo deben tener la integridad suficiente para soportar las cargas mecánicas y vibraciones que actúan durante el transporte y de esta manera preservar las cualidades del motor. Por lo anterior, estos elementos son vitales y su diseño requiere de estudios y análisis específicos que permitan un diseño garantizado para su fin. En este proyecto se presenta la estrategia analítica para caracterizar y mejorar los dispositivos de aislamiento de vibraciones y mecánicos de los equipos de manipulación y traslado de motores, en esta parte nos enfocaremos al estudio de la zona de unión entre el móvil y el elemento de amortiguamiento, por lo que, verificar que la soldadura cumple con las especificaciones será un primer reto debido a la complejidad para obtener la muestra y posteriormente la secuencia analítica que se ha seguido para obtener resultados confiables. El estudio se enfoca en microscopia de luz, microscopia de barrido con electrones y difracción de rayos X.

KEYWORDS: Microscopia, Soldadura, Integridad.

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Generación de mapas para la mitigación de riesgo en aviación por presencia de ceniza volcánica: caso de estudio en el volcán Popocatépetl

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ABSTRACT

Un volcán en activo deposita en la atmósfera miles de toneladas de gases y ceniza volcánica en cada evento eruptivo. Debido a la elevación del cráter estas erupciones pueden alcanzar las zonas del espacio aéreo utilizado para las operaciones de navegación de las aeronaves. Este material volcánico es transportado por los vientos dominantes pudiendo ser transportado cientos de kilómetros de la fuente representando un peligro a la aviación. Durante los años 1953 a 2009, se reportaron 129 encuentros de aeronaves con ceniza volcánica (Guffanti et al., 2010) y durante los años 2010 a 2014 se reportaron otros 113 encuentros (Christmann et al., 2015). Esto demuestra el inminente riesgo que presenta la aviación debido al fuerte incremento del tráfico aéreo que se ha venido dando en las últimas décadas. El presente trabajo muestra una metodología para la generación de mapas de mitigación de riesgo en las operaciones aeronáuticas por presencia de ceniza volcánica. Está basada en dos herramientas: Un estudio de vientos a niveles superiores y un análisis de imágenes satelitales. Como caso de estudio se tomó el volcán Popocatépetl (19.02ºN, 98.62ºO, 5425 msnmm) el cual se encuentra a ~70 km al Sureste de la ciudad de México y ~30 km al Oeste de la ciudad de Puebla. En un área de 200MN alrededor del volcán se ubican 36 instalaciones aeroportuarias de diferentes categorías (Internacionales, Nacionales, Municipales y Militares). En lo que respecta al espacio aéreo se identificaron 58 aerovías con alta probabilidad de ser afectadas en el caso de una erupción del Popocatépetl. Se desarrolló un estudio de vientos en la altura permitiendo identificar dos patrones predominantes. El primero con dirección predominante entre NNE y SE y con velocidades en un rango entre 10 m/s a 30 m/s. El segundo periodo muestra una dirección predominante entre S y NO con un rango de velocidades de 2 m/s a 20 m/s el cual se presenta durante los meses julio a septiembre. Los meses de julio y octubre se consideran como periodos de transición. Por otro lado, se utilizaron imágenes MODIS para identificar el área de dispersión de estas nubes de ceniza y comprobar la dirección propuesta de desplazamiento dependiendo de la época del año. Con esta información se propone un mapa que muestra las zonas con alta probabilidad de ser afectada por presencia de ceniza tomando como referencia la época del año en la que se lleva a cabo la erupción.

KEYWORDS: Mitigación de riesgo, aviación, ceniza volcánica

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Rotary friction welding (RFW) by lathe for aeronautics materials

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ABSTRACT

Rotary friction welding (RFW) is the most common form of friction welding. In general, it is a solid state process as it does not cause melting of the parent material during the welding process. Conventionally in this welding process, the faying ends of the material rods are square turned. In this study, alternate designs of faying surfaces such as providing taper (external and internal) and conventional square cut (as-cut and as-polished) surfaces are compared. The aim was to study how the faying surface conditions affect the welding strength. Rotary friction welding of 6061 Al alloys (aluminum-magnesium-silicon) was studied. Welding was performed on an adapted lathe machine. The rotary friction welding applied was a like-direct drive friction welding. The rods were friction welded at a rotational speed of 2400 rpm with a forge pressure of 4.1 MPa. The joints were evaluated for hardness and tensile strength and it is found that the square cut system has the best strength. Optical microscopy technique was carried out to observe the microstructure at the interface. Strong grain refinement due to severe plastic deformation was seen at the interface. Finally, possible reasons for the better strength of square cut system were discussed.

KEYWORDS: Rotary Friction Welding, Al 6061, speed rate

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