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# REINFORCED COMPOSITES AUTOMOTIVE LEAF SPRING: OPTIMUM DESIGN AND PERFORMANCE

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The application of composite materials to industrial components offers the possibility of weight savings and increased performance. This paper addresses a special application that of a leaf spring for a heavy truck axle suspension system using an optimum design approach. The classical beam theory as well as a large deformation theory for the analysis of straight and curved beams is presented. Results indicate that for the range of loads and leaf springs in the automotive industry, classical beam theory provides a conservative estimate for the deflection and represents a good first approach in the design of leaf springs.

An optimum design using nonlinear programming is used in this paper with the objective function being the weight function. Many constraints such as the maximum allowable stress, limit of deflection, and the desired spring constant are considered. Two criterion are adopted, the constant stress and the constant area. Three different materials are used, namely E-Glass/Epoxy, Kevlar/Epoxy and Graphite/Epoxy. Analytical results indicate that leaf springs made of Kevlar/Epoxy have the lightest weight, however, the E-Glass/Epoxy springs are the most economical, this latter factor may be specially important to the automotive industry. Fabrication also represents a very important aspect in this area. A basic question to be asked is that of which manufacturing technique is most suitable for composite leaf springs? Several possible related issues are discussed including mechanical properties, product shape, equipments and cost.

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# ANALYSIS OF SEPARATION CONDITIONS FOR SHRINK FITTING SYSTEM USED FOR SLEEVE OF CERAMICS CONVEYING ROLLERS

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Steel conveying rollers used in hot rolling mills must be exchanged frequently at great cost because hot conveyed strips induce wear and deterioration on the surface of roller in short periods. In this study, new roller structure is considered which has a ceramics sleeve connected with two steel shafts at both ends by shrink fitting. Here, although the ceramics sleeve can be used for many years, the steel shaft sometimes has to be changed for reconstruction under corrosive action induced by water cooling system. Since the thermal expansion coefficient of steel is about five times larger than that of ceramics, it is necessary to investigate how to separate the shrink fitting system by heating outside of sleeve and cooling inside of the shaft. In this study, the finite element method is applied to analyze the separation mechanism by varying the geometrical and thermal conditions for the structure. Finally the most appropriate dimension and thermal conditions have been found, which may be useful for designing of new rollers. The following conclusions have been found for the new rollers.

(1) Heating outside of the sleeve and cooling inside of the shaft by water are found to be necessary for separation. Also, it is found that the separation time becomes shorter if the atmosphere temperature goes up more quickly or the shrink fitting ratio becomes smaller.

(2) The separation time becomes shorter if the outside diameter of the sleeve becomes larger.

(3) The separation time becomes shorter if the heat conductivity of ceramics sleeve becomes smaller.

(4) The separation time becomes shorter because of larger effect of water cooling when thickness of the shaft becomes smaller.

(5) In this study, for the effect of fitted length on separation time, there exists a most suitable length with which the separation time is shortest.

**Keywords:** *Thermal Deformation, Tool, Machine Element, Ceramics, Finite Element Method*

# TRANSIENT DISPLACEMENT AND STRESS FIELDS IN AN ELECTROSTRICTIVE HOLLOW CYLINDER UNDER THE ELECTRICAL SHOCK

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It is very important and valuable to investigate response histories and distributions of transient stresses, displacement of asymmetric electrostrictive structures subjected to the electrical shock. Analytical studies for electro-elastic behaviors of electrostrictive hollow cylinder coated with the electrode on the inner and outer surfaces, are presented in this paper. Exact solutions for transient displacement and stress fields in the hollow cylinder are determined by using Laplace and Hankel transform techniques. The numerical results are also presented and graphically shown. It is found that for a thick walled hollow cylinder, the transient displacement and stress field would be significantly large in magnitude when electrical loading is applied.

It is possible for engineers to design electrostrictive cylindrical device that can achieve some special functions. In addition, the technique for solving the asymmetric problem in the paper is applicable to the cylindrical problem of other materials.

**Keywords:** *Electrostriction, Hollow Cylinder, Electrical shock, Stress field*

# LONG RANGE INTERACTION OF RIGID SPHERES CONTACTING WITH ELASTOMER

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Nanoparticles can self-assembled into interesting patterns through various interaction forces in external fields such as electric field and magnetic field. The long range interaction between two nano-scale rigid spheres in the elastic field of the elastomeric substrate is studied through a continuum mechanical model. The direct interaction body forces between the spheres and the semi-infinite substrate are obtained by integrating the Lennard-Jones potential of atoms and have been equivalent to the distributed forces on the surface of the substrate in view of the property of incompressibility of the substrate. The equilibrium equations of the system is obtained and solved with theory method and numerical method. First order approximation analysis indicates that the far vertical displacement field of one sphere adsorbed on the substrate decays as $(r/R)^{-3}$ and the indirect long range interaction of the two spheres through the deformed substrate decays as $(r/R)^{-5}$. Through the Ginsburg-Landau kinetic numerical relaxation method the accurate equilibrium state of the system is obtained. The total energy of the system decreases with increasing the spacing of the tow spheres which in accordance with the theory analysis. In numerical simulation, we also find the equilibrium position in height direction of the sphere over substrate is changing with separating the two spheres. The effects of the radius of the sphere, the interaction between the sphere and the substrate, and the rigidity of the substrate are studied for the long range interaction between two spheres. The results predict the elastic field can be used to direct the nanoparticles' self-assembly behaviors.