Abstracts of Papers in English

EXERGOECONOMIC OPTIMIZATION OF COMBINED HEAT AND POWER SYSTEM INCORPORATING FLUIDIZED BED GASIFIER

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Key Words: fluidized bed gasification, thermodynamic modeling, combined heat and power system, exergoeconomic optimization.

Abstract

Biomass's utilization provides sufficient energy, which can be used for electricity generation, engine applications and etc. In the gasification process, biomass will be converted into clean and combustible gas in the presence of steam and air. In this paper, a model is presented for the gasification of refused derived fuel (RDF) particles in a bubbling fluidized bed gasifier (BFBG). The model combines the chemical and thermodynamic equilibrium of the global reaction, predicting the final composition of the product gas. Once the composition of the produced gas is obtained, a range of parameters can be derived, such as the exergetic efficiency of the gasifier and the heating value of the product gas, as well as the cold gas efficiency of BFBG. A parametric study of the effect of the gasifying relative fuel/air ratio, gasifying temperature and the moisture content of the RDF on the characteristics of the process and the producer gas composition, is conducted. The model shows good agreement with the experimental results. The model helps to predict the behavior of different biomass types and is a useful tool for optimizing the design and operation of bubbling fluidized bed gasification. Furthermore, thermodynamic analyses (both energy and exergy) have been conducted for a combined system power plant, in which the investigated system consists of a pressurized fluidized bed gasification unit gasifier. In addition, an exergoeconomic evaluation is performed to determine all mass flow rates, exergy flow rates, exergy destruction flow rates, component exergetic efficiencies, exergetic cost flow rates, mass cost flow rates, component product and fuel specific exergetic and mass costs, exergy destruction cost flow rates, component investment cost flow rates, and system total cost. Finally, the exergoeconomic optimization of the mentioned system is performed with the SPECO method.

INCREMENTAL MODELING OF MAGNETO-MECHANICAL BEHAVIOR OF NiMnGa MAGNETIC SHAPE MEMORY ALLOY SINGLE CRYSTALS

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Key Words: magnetic shape memory alloys, superelastic behavior, magnetic-field-induced strain, incremental model.

Abstract

Magnetic shape memory alloys (MSMAs) are a new category of smart materials that have attracted significant interest in recent years for their special properties, such as; large magnetic-field-induced strains up to 10%. Magnetic-field-induced strains in MSMAs are created due to austenite-martensite phase transformation, as well as martensitic variant reorientations. MSMAs have the ability to perform at high frequencies (up to 1kHz), contrary to non-magnetic types, which perform at low frequencies, due to the time involved in heat transfer (up to 5Hz). Major limiting aspects of MSMAs are low blocking stress (about 6-10 MPa) and low output stress (about 10MPa). Considering these features, MSMAs are unique choices in sensor and actuator applications.

In this paper, using the incremental approach, which is a useful method in the analysis of nonlinear behavior of materials, the behavior of Ni-Mn-Ga MSMA single crystal is modeled. This method utilizes a different secant module for different parts of the stress-strain curve, so, it is applicable to a large variety of problems related to MSMAs and appropriate for implementing in the finite element method.

In addition, the stress-strain curve of MSMA is approximated with an analytical relation, whose parameters can be obtained from an experimental stress-strain curve under the effect of a reference field. The incremental model is used in predicting the magnetic-field-induced strain, either under the influence of mechanical stress or in the absence of stress, by means of relating the magnetic field to an equivalent mechanical stress. Furthermore, calculation of the magnetic field equivalent stress is modified to predict the superelastic behavior of MSMA under constant field and variable stress. Results obtained from the incremental model show good correlation with experimental observations.

AN INVESTIGATION OF CONDENSING STEAM FLOW WITHIN A TURBINE CASCADE USING THE BALDWIN-LOMAX TURBULENCE MODEL

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Key Words: condensing flow, cascade, turbulence, baldwin-lomax, nucleation, condensation shock.

Abstract

One of the characteristics of steam flow in turbine cascades is its rapid expansion and deviation from thermodynamic equilibrium. In this state, the supercoolded steam starts nucleating above the Wilson line and returns to the equilibrium condition due to condensation shock and droplet formation. The release of heat caused by rapid condensation reduces the Mach number, increases the pressure in the supersonic region and affects the aerodynamic behavior of the flow. It is agreed, in the literature, that the nucleating and wet stages of steam turbines are less efficient than those running with superheated steam. In this study, a two-dimensional viscous wet-steam flow in a cascade of turbine blading is simulated, using the Baldwin-Lomax turbulence model, and treated by Jameson's fourth order Runge - Kutta time marching scheme, which is modified to allow for two-phase effects. The modified classical nucleation theory is employed for modeling nucleation, and the droplet growth equation is obtained based on the mass and energy balance. The system, as a whole, must obey conservation laws. To apply conservation equations to the two-phase flow they have to be combined with nucleation and droplet growth equations and solved simultaneously. An important difference between the two families of equations is that the droplet growth equation is more naturally expressed in Lagrangian rather than Eulerian form, and droplets are assumed to be carried along streamlines that do not necessarily coincide with the grid lines. For this reason, the two sequences of calculations are carried out separately. The, pressure distribution, condensation shock and size of droplets are predicted and compared with empirical results, which show good agreement. By studying the wet-steam flow as viscous and considering the turbulent effects, the prediction of droplet size, in comparison with the experimental results, is improved, and it has become possible to obtain the skin friction coefficient, the boundary layer thickness and the two-dimensional velocity profiles.

A HIGH-RESOLUTION CENTRAL SCHEME FOR COMPOSITIONAL FLOW SIMULATIONS IN HYDROCARBON RESERVOIRS

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Key Words: two-phase flow, porous media, high-resolution central scheme, finite volume method, compositional model.

Abstract

The compositional model is the most complete model used in hydrocarbon reservoir simulation. The model provides a three-phase, multi-component representation of the fluid flow problem, in which several components, such as; methane, propane and decane, may coexist in three phases (liquid, vapor and aqua). In this model, water only appears in the aqua phase, while the other components can be present in both the liquid and vapor phases. Here, a variation of this model proposed by Trangenstein and Bell is used. The final governing equations include a parabolic pressure equation and a set of hyperbolic convection-dominated equations.

Numerical simulation of the pressure equation is usually a straightforward matter. Solving the component mass conservation equations, however, can be challenging. In recent years, most of the numerical methods used for this purpose have been based on the, so-called, Godunov method, which needs information about the eigen-structure of the governing equations. This makes the numerical algorithms complex and highly time consuming.

In this paper, a high-resolution central scheme, proposed by Kurganov and Tadmor, is extended to solve compositional flow equations. This is a numerical scheme, which is computationally efficient and its accuracy is independent of time step size. The computational algorithm is implemented within the context of the finite volume method. The paper briefly presents the governing equations and elaborates the computational algorithm used here along with full details on the implementation of the high-resolution scheme.

To assess the performance of the proposed numerical algorithm, a number of one-dimensional benchmark problems are solved. Numerical results are compared with available data in the literature.

A HIGH-RESOLUTION NUMERICAL METHOD FOR SOLVING MULTI-PHASE FLOW IN POROUS MEDIA USING BLACKOIL MODEL WITH CAPILLARY PRESSURE

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Key Words: blackoil model; capillary pressure; global pressure; porous media, hydrocarbon reservoirs.

Abstract

Capillary pressure plays an important role in production from hydrocarbon reservoirs, especially when gravity drainage is the dominating mechanism, and in fractured reservoirs. There are several capillary pressure models that are fairly accurate for practical purposes if tuned properly for certain cases. The effect of capillary pressure in the governing equations adds some complexities to the numerical simulation of such flows. This can lead to acute numerical challenges when applied to more detailed flow models, like the blackoil model.

The blackoil model is a three-phase three-component representation of multiphase flows, in which three components (oil, gas and water) coexist in three phases (liquid, vapor and aqua). In this model, water only appears in the aqua phase, while the other two components can be present in both the liquid and vapor phases. These phases, of course, have different pressures when capillary pressure is considered, and defining a proper pressure, based on which is the development of governing equations, is a delicate matter. The final governing equations include an elliptic pressure equation and a set of parabolic convection-dominated equations.

Numerical simulation of the pressure equation is usually a straightforward matter. Solving the component mass conservation equations, however, can be difficult. Most of the numerical methods used for this purpose are Godunov-based methods which need information about the eigen-structure of the equations. This makes the numerical algorithms complex and highly time consuming. This paper presents a high-resolution central scheme for solving blackoil equations with capillary pressure. The vector-based blackoil formulation used in this work was first introduced by Trangenstein and Bell. The numerical scheme used for solving the mass conservation equations is an extension of the work of Kurganov and Tadmor. This provides a numerical scheme that is computationally efficient and its accuracy is independent from the time step size. To assess the performance of the proposed numerical algorithm, a number of one-dimensional benchmark problems are solved. Numerical results are compared with available data in the literature.

AN EMPIRICAL STUDY OF THE EFFECT OF FLATTENING TUBES

ON HEAT TRANSFER COEFFICIENT DURING FORCED CONVECTIVE BOILING OF R-134A INSIDE MICROFINNED TUBES

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Key Words: empirical, heat transfer coefficient, convective boiling, microfin, flattened tubes.

Abstract

In this study, the heat transfer properties of R-134a under convective boiling conditions in horizontal microfinned flattened tubes were investigated. Microfinned copper tubes with outer diameter of 9.52 mm were flattened into oblong shapes with different internal heights of 6.6, 5.5, 3.8 and 2.8 mm. The experimental set-up used in this investigation was a well instrumented vapor compression refrigeration cycle. It consisted of a test evaporator, on which all experiments were carried out. In addition, there was a pre-evaporator to achieve the required vapor qualities. A post-evaporator was used to superheat the fluid before entering the compressor. The refrigerant which flows inside the tube of evaporators is electrically heated by an electrical coil wrapped around it.

The experiments were carried out for mass velocities from 74 to 107 kgm^2s^{-1} and vapor qualities from, approximately, 25% to 95%. The results show that for a given mass velocity and vapor quality, the heat transfer coefficient increases as the tube profile is flattened. Also, the heat transfer coefficient increases with an increase in mass velocity and vapor quality for the flattened tubes, just similar to the round tubes. A new correlation was developed to predict the flow boiling heat transfer coefficient inside the microfinned flattened tubes.

COMBINATION OF FORCE FORMULATION AND METHOD OF CENTERS FOR MINIMUM WEIGHT DESIGN OF TRUSS STRUCTURES

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Key Words: force method, center points, trusses, minimum weight, optimization algorithm.

Abstract

In this article, minimum weight design of trusses under limitations of stresses, size limitations, and the interrelationship between the cross sectional areas, under several loading conditions, has been considered. Normally, a displacement method of analysis is employed by most researchers for the analysis part of the optimization of truss structures. However, using the force method makes the stress constraints for the elements become linear, which facilitates the use of most optimization procedures and improves efficiency. Therefore, in this article, the force method of analysis is employed as the analysis section, in order to utilize these advantages.

The optimization method selected for this research is based on the idea of moving towards the optimum in the feasible part of design space, as defined by the constraints. Whereupon, the method of center points, as defined by the center of inscribed hyper-spheres to the feasible-usable design space, previously developed by researchers for inequality constraints, is adopted. This method is extended, herein, to be capable of taking into account the nonlinear equality constraints arising in the analysis part of the structures also.

The method of inscribed hyper-spheres as a robust procedure for solving engineering optimization problems has important features, which increase its efficiency in comparison to other methods. Firstly, the convergence to the optimum through the feasible design space is important from an engineering point of view. Secondly, its capability of considering only the near active constraints that adequately define the interior surface of the feasible-useable design space, is important, in that it enhances the computational efficiency in practical applications where a large amount of constraints should be satisfied. Thirdly, a uniform margin of safety is observed in the sequence of design points generated in the optimization process, creating a series of near optimum acceptable designs. Fourthly, as the movement towards optimum point is always inside the feasible space and uniformly distant from near active constraints, it shows low sensitivity, with respect to its exact definition.

In the extension of this algorithm for handling nonlinear equality constraints, attempts are made to maintain the main useful features of the method as much as possible. Therefore, in inscribing the hyper-sphere in feasible-usable design space, it is always forced to be tangent to the linearized surface of the nonlinear equalities. As the optimization steps proceed, the radius of the sphere shrinks to zero and its center finds an optimum location on the joint equality constraint surfaces. In this article, cross-sectional areas of elements and forces of redundant members in a truss structure in each loading are chosen as design variables. This selection alleviates the necessity of separate analyses steps in the optimization procedure. Thus, the combination of the method of hypersphere and the forced method of analysis provides higher

computational efficiency and rapid convergence ability. Most of the well known examples that have appeared in the literature so far have been solved by the proposed method. The procedure developed proves to be simple and efficient, as evidenced by the results of several classical problems. Observation of the results shows that rapid decrease of weight is achieved in the early steps and the trend in the reduction of weight is monotonic and relatively uniform.

STRESS RELIEVING OF LOCALLY HARDENED ROTOR STEEL

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Key Words: stress relieving, hardness, heat treatment, greep, FEM.

Abstract

Residual stresses can change parts performance, mechanical properties and also have no desired influence on life time. Some mechanical and thermal effects can be the reason for these stress. A heat treatment process, in order to decrease the surface hardness of locally hardened rotor steel by stress relieving, has been specified. In order to set the main heat treatment parameters, such as time and temperature, two methods were employed using creep principles. In the first method, after equalizing local hardness by internal stress, a coupled explicit thermal-structural finite element analysis implementing creep stress relieving was carried out. This method created a good opportunity to determine the influence of heating rate and constant temperature time on stress relaxation. The second method employed creep equations related directly to hardness.

In the finite element modeling (FEM), residual stresses on rotor steel are simulated by preapplying stresses. The advantage of this method (FEM) is in applying the influence of the presentation of bulk material around the heating section of the model.

Results obtained from both methods were compared with experimental data. Our methods showed stress relieving at 684 to 690°C in 5-6 hours, was efficient which is in good agreement with experimental results. Performing this experiment has some special considerations; the temperature should be increased, and the model must be kept in balanced form and prevented from any corrosion and oxiding, which are shown in the pictures and descriptions in this paper.

Our results showed that the analytical method is very quick and effective, and can be employed in practice. The presented method can be applied to other industrial models to determine final residual stresses and surface hardness after a tempering heat treatment.

FINITE ELEMENT MODEL UPDATING OF A Z-SHAPED PIPING SYSTEM BY MODAL TESTING

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Key Words: piping system, vibrations, experimental modal analysis, finite element method, model updating, particle swarm optimization .

Abstract

In this study, the finite element (FE) model of a Z-shaped piping system is updated using experimental modal data via particle swarm optimization (PSO). PSO is a random search method that imitates social behaviors like fish schooling or birds flocking to solve optimization problems. Members of the swarm inform each other of good positions and adjust their own position and velocity based on these good positions. The best previous position of each member and the position of the best member among all the swarm are recorded and used to find the new velocities (i.e. the rate of the position change) and positions. Because of the random methodology of the PSO, and utilizing a population of solutions rather than a single point, it is more effective in finding the global optimum than the conventional gradient-based algorithms. Besides, the convergence of the PSO does not depend on the initial guess, while the convergence of the gradient-based methods is highly affected by the initial starting point.

This paper deals with the modification of the mass, stiffness and damping matrices of the system, to bring the vibration response of the FE model closer to the experimental one. Having performed modal testing, the first six experimental modes of the system (i.e. natural frequencies, mode shapes and damping ratios) are extracted from the experimental FRF data. Then, considering the modification process as an optimization problem, the weighted sum of the squared error between the measured and computed modal parameters is minimized. Moreover, several physical parameters of the

system with unknown values are considered as design parameters. In the following study, the design parameters are; Young's modulus, density, proportional damping constants, and mass and stiffness of threaded joints. Then, PSO is applied to find the optimum values of the design parameters in the minimization problem. The study showed that the proposed approach is robust, accurate and easy to implement. Utilizing the optimum values of the design parameters, the FE model of the system better represents the vibration behavior of the piping system.

ANALYSIS OF THE ULTRASONIC LONGITUDINAL GUIDED WAVE CHARACTERISTICS IN ELASTIC CYLINDERS

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Key Words: guided waves, longitudinal mode, frequency spectrum, phase velocity, group velocity, wave structure.

Abstract

Guided waves, due to their multimode characteristics, can be employed in NDT&E, if suitable modes are selected. To show how suitable modes are determined, two elastic cylindrical models; a solid aluminum rod and a stainless steel pipe, are investigated, and longitudinal modes, which are axi- symmetric and, hence, find more applications in NDT, are studied in detail. A computer program is developed to extract real roots of the frequency equation and, then, to plot the frequency spectrum and dispersion curves of phase and group velocities and wave structures. These curves show the change in speed of propagation of the various modes if frequency changes. Wave structure curves can be used to identify the proper location of transducers to receive clearer signals. These curves also reveal a clear scope of particle motion on the boundary and inside the body of the cylinders, which could be used in theoretical and experimental result evaluations.

For the solid aluminum rod, the cut-off frequencies of some modes are directly calculated and compared to similar values obtained from other sources. Close agreement indicates an acceptable level of accuracy. At high frequency-low wave length range, the phase velocity of the first mode converges to the velocity of the Rayleigh surface waves in aluminum, while, for the higher modes, this velocity converges to the shear wave velocity. Wave structure curves for some modes at specified frequencies indicate that the axial component of displacement near the surface and at the center of the rod is much higher than the radial component. Therefore, if such modes are to be used in tests, it is recommended to place the receiver at the cross section of the bar. For the stainless steel pipe with infinite length, study of the frequency spectrum, phase and group velocity curves shows similar trends as for the solid rod. From the wave structure curves for the first mode at two different frequencies, it is evident that the axial component of displacement, which is quite sensible on the inner and outer surfaces at lower frequency, vanishes on the outer surface at higher frequency, while the relative magnitude of the radial component remains the same, approximately, either at lower or higher frequencies. This phenomenon is also observed for the third mode, although the radial component on the inner and outer surfaces has higher resolution at higher frequencies than at lower ones. These studies can be employed for power lost optimization in pipes containing liquid (power leak) and for defect detecting in pipe thickness.

A NUMERICAL ALGORITHM TO CONVERT UNSTRUCTURED GRIDS DATA STRUCTURES INTO DIRECTIONAL LAYER ORDERINGS

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Key Words: grid generation - triangular unstructured grids - data structure - layer ordering - directional ordering.

Abstract

Contrary to the structured grid disadvantages, disadvantages the unstructured grid provides sufficient flexibility to generate grid in very complicated geometries and simplifies the grid adaptation, where it is necessary. In spite of termendous efferrs in improving the unstructured grid employment and despite achieving remarkable advancements, this field of research is still open to be explored by new contributors. Basically, most of unstructured grid generators grade its substructures randomly. Therefore, no global directionality can be readily found in a regular unstructured grid data structure. This can cause serious trouble for grid users, such as those in CFD, who need the knowledge of node, face, and cell neighborhood connections. Consequently, because of a quite random neighborhood numberings, the node/face/cell numbers are to be stored explicitly in large vectors and matri-

ces. Evidently, converting this random data arrangement to an organized data structure can enhance the computational efficiency in unstructured grid applications. In this research, a very simple and computationally low cost numerical procedure is developed to construct a layer-by-layer data structure for 2D triangular unstructured grids. The key point in this procedure is that each layer in this pattern has a quasi-structured data structure presenting ordered element number and node number patterns. The objective of this research is to develop a layer-by-layer ordering and renumbering algorithm. which simplifies the above achievements. In this algorithm, the elements and nodes in the unstructured grid are suitably renumbered to produce a new layer-by-layer data structure very similar to those can be found in structured graids. This algorithm benefits from the ordered data of elements and nodes produced in the preceding layer to construct the current neighboring layer and to order its element and node indices properly. The procedure needs to be started from the first ordered node layer (it is usually the inner boundary), and is extended to next neighboring element and node layers until reaching the outer boundary of the domain. In this method, the achieved overall patterns for the constructed node layers are mostly determined by the primitive chosen node layer. where the procedure is started. If we choose the nodes located at the target object as our node layer, the resulting node layers would schematically take a pattern very similar to lines distributed around the target object in an O-type structured grid. However, if the initial node layer contains both the nodes located at the target object and the grid lines connecting the object to its outer boundary, the overall pattern of the constructed node layers will be schematically very similar to a set of grid lines around the target object in a C-type structured grid. Furthermore, if the target object consists of several components, the first node layer must include, not only the nodes located at all body components but also the nodes located at the grid lines i.e. the lives which connect these subbodies to each other. According to our investigation, the current algorithm generates a directional layered data structure very robustly, even in very complex mesh domains. However, in the case of having a complex element connection inside the layers, the method does not guarantee the physical neighborhood condition for some pairs of adjacent elements or nodes in the achieved data structure. These exceptions mostly require negligible additional search inside the constructed layers to find neighboring elements or nodes. Additionally, the current method facilitates the addressing procedure in a data structure, because the search is confined to some neighboring layers instead of the entire grid data. To show the robustness of the method, the new data structure is constructed for an unstructured grid distributed around a submarine. The current evaluations show that the developed algorithm works very successfully, even in domains with complicated geometries and/or complex-unstructured mesh distributions.

NONDESTRUCTIVE EVALUATION OF ADHESIVE JOINTS IN PLATES BY LAMB WAVES

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Key Words: nondestructive evaluation, adhesive joints, lamb waves, plate waves, dispersion curve, mode S_0.

Abstract

In this paper, Lamb waves (also called plate waves) are used for inspection of two plates which are joined by an adhesive bond. The most attractive feature of Lamb waves is that they can travel long distances with little attenuation. However, the dispersive and multi-modal nature of Lamb waves makes their usage in nondestructive testing of materials difficult. Lamb waves can propagate in either symmetric or asymmetric modes designated as S_i and A_i, respectively, with i=0,1,2,... . The most suitable Lamb wave mode for inspection of adhesively bonded plates was found to be the first symmetric mode, S_0. A number of good and defective specimens were prepared from aluminum plates bonded together by epoxy resin adhesive. Using two variable-angle-beam ultrasonic transducers in pitch-catch configuration, the desired plate wave mode was generated in specimens. The incidence angle required for generating a specific mode was obtained by examining the dispersion curves of the plate. Dispersion curves show the dependence of the wave velocity on the frequency for each mode. A number of defective samples were prepared with different defect sizes. The defects were in the form of disbonds implanted in the joint by placing a piece of paper between the adhesive and adherent (see the following figure).
The ultrasonic signals transmitted through the adhesive bond of each sample were analyzed and compared. The results indicate that Lamb waves can efficiently detect anomalies in the bonded joints and provide quantitative measures of defect size.

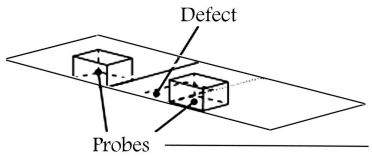

Figure 1: Configuration of the experiments.

HEAT EXCHANGER DESIGN BASED ON CONSTRUCTAL THEORY

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Key Words: shell and tube heat exchanger, optimization, constructal theory, genetic algorithm.

Abstract

Because of the extensive application of heat exchangers in industrial processes, designers take their cost optimization as an important objective. In this paper, a procedure is introduced for economic optimization of the shell and tube heat exchangers by using constructal theory. The constructal law was stated by Adrian Bejan in 1996, as follows: "for a finite system to persist in time, it must evolve in such a way that it provides access to the currents that flow through it" (Bejan, 2000). In this theory, flow configuration is optimized to provide the easiest possible access to the flow current that causes the construction of fractal, dental or tree shaped structures. We rely on the constructal law of maximization of flow access, in order to distribute the volume of tube side fluid flow optimally through the shell side flowing volume, so that heat transfer is maximized. The optimization of flow geometry leads to a tree-shaped structure, in which the ratio between the total tube contact area and the body size is optimized. The optimization is subjected to fixed total heat duty. The optimized configuration and shape of the heat exchanger (diameter, length, baffle spacing and number of tubes) are the result of a genetic algorithm based optimal trade-off between pumping cost investment cost. A Genetic algorithm optimizes the tree-shaped constructal exchanger and gives optimum tube diameter, tube length, baffle spacing, ratio between successive tube diameters and ratio between successive tube lengths, to the branching positions of the tree-flow structure. The effectiveness of the explained method was evaluated by analyzing case studies taken from the literature. Comparison between traditionally designed exchangers and new exchanger designs, based on constructal theory, exhibits that significant cost minimization is possible. Above all, in the case studies, a reduction of total costs up to 52% was observed. The optimization results of the case study verify the ability of this new method to cost optimize S&T heat exchangers.