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Simulation And Analysis Of A Welding Process Using A Thermo Mechanical Dimensional Model

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Abstract

The present draft thesis consists in the numerical simulation of a welding process, for this purpose a model is developed thermo-mechanical 3 Dimensional with prescription of temperature based on the hypothesis of detaching the welding process in three large fields (temperature field of efforts and deformations and microstructural status field) and the mutual influence that exists between them. Are carried out two studies, first a transitional thermal study in order to obtain the thermal history, the same that then will serve as external load (input) for the nonlinear mechanical study, in order to achieve the main objective which is to know the history of efforts throughout the process and the magnitude of the residual efforts.

1. Introduction

At present the weld is one of the most widely used processes for manufacturing and repair of various equipment and structures in the whole field of engineering, it is therefore of great interest to increase the quality and prevent failures during the manufacture or in service. To this end we develop procedures, which are based on the performance of experiments, being the WPS (specification of welding procedure) the final result. The evaluation of the WPS ensures that is qualified the quality of a weld. The rating of this WPS is based on the integrity of the board, the absence of defects, the resulting microstructure, the mechanical tests and nondestructive testing.

It is not often use computational methods in the development of the WPS. It is expected that the numerical simulations serve to complement the experimental procedures for obtaining a more complete WPS, considering aspects such as residual efforts, deformations, etc., which can then be compared with other WPS developed experimentally.

Using the numerical simulation, in particular the finite element method, you can evaluate the different parameters and conditions without the need to make a large number oftrials, something that for industrial applications is very important. It is also useful in the design of manufacturing processes, as well as the component manufactured in themselves, including when it is in service.

In the soldering process different physical phenomena occur as a result of the interaction of the fields of temperatures (thermodynamics), efforts and deformations (mechanical) and microstructural state (metallurgy). The temperature field is a function of many welding parameters such as: power of arc, welding speed, welding sequence and environmental conditions. The formation of residual efforts and distortions in the weld depends on many interrelated factors such as: thermal field, material properties, and conditions of edge type of welding and soldering conditions.

The residual efforts and distortions that arise after the welding process are a consequence of: plastic deformations, deformations due to creep, etc. In the present study assumes that there are only plastic deformations after the welding process because it is not expected to happen creep, due to rapid cooling.

The general objective is to contribute to enhancing the quality of the welded connections, through the incorporation of the numerical simulations on the WPS (Specification of Welding Procedure). The objectives of this study are to obtain the thermal history of the welded joint throughout the process and even during the stage of cooling. But mainly it is seeking to obtain the magnitude and distribution of residual efforts once cooled the welded joint and the variation of efforts throughout the process; to which the simulation is done through an analysis thermo-mechanical not linear and non-stationary.

In the first chapter presents the theoretical foundations that serve as the basis for the present study.

The second chapter seeks to present the state of the technology in numerical simulation of welding processes, with the purpose of locating the present study in the current context of the technology.

2. THE METHOD OF FINITE ELEMENTS

The finite element method has become a powerful tool in the numerical solution of a wide range of engineering problems. Applications range from the analysis by deformation and effort of automobiles, aircraft, buildings and structures of bridges to the analysis of the heat flow fields, fluids, magnetic, leaks and other problems of flow. With advances in computer technology and the CAD systems, can be modeled complex problems with relative ease. In a computer can be tested several alternate settings before the construction of the first prototype. All this suggests that we modernize using these developments to understand the basic theory, modeling techniques and the computational aspects of the method of finite elements. This method of analysis, a complex region that defines a continuum is discretization in simple geometric shapes called finite elements. The properties of the material and the regions rulers, are considered on those elements and expressed in terms of unknown values at the edges of the element. A process of assembly, when considered duly loads and restrictions, gives rise to a set of equations. The solution of these equations gives us the approximate behavior of continuous.

- **General Foundations:**The more general concept of all the finite element method receives the name of approximation. The approach of the problem is that it wants to approximate a function f in a region P limited by a contour L also complies, certain boundary conditions.

  On a volume of arbitrary control like the one in we try to find an approximation of a function f anyone in this volume control in such a way that take, in addition, some certain values in its outline L. In this case the function f to approximate is, the temperature. As can be seen, the method is completely general since f is a function either.

- **The Welding Process:** The welding process is defined as the process by which establishes continuity, between metal parts or non-metallic, produced by a heating of materials at a certain temperature with or without the application of pressure or by the application of pressure only, with or without the use of material of contribution.

3. STATE OF TECHNOLOGY IN NUMERICAL SIMULATION OF WELDING PROCESSES

The history of the numerical simulations by means of the finite element method to predict the thermal and mechanical behavior that generates the process of Fusion Welded dates back to the 1970s. Lindgren [15] said that two of the most important conferences that have been related to this topic are "Mathematical Modeling of Weld Phenomena" [16], and "Trends in Welding Research" [17]. The first series of conferences was dedicated to the numerical simulation associated with the comparison of results with their respective pilot testing. The second series of sessions, focused only on the simulation thermo-mechanics of the welding process, have a greater scope at this point. Radaj [14] gives an overview of different processes and phenomena that need to be considered. The Manual Volume 1 thermal stresses "I" [18] deepens in the mathematical models that govern this physical phenomenon [13].

The simulation of the welding process emerges as a need to better understand the phenomenon and analyze what are the factors that have more relevance in the process. One of the main advantages of the simulation is the low cost that has compared to the experimentation to achieve optimization of processes. The latter is another of the reasons why there has been more emphasis on the development of improved processes of simulation. It is important to highlight that the investigations of simulation of welding are bound to various aspects involved in the phenomenon. Among them was the investigation of the puddle weld that involves the study of the fields of speeds and temperatures of the material merged. It also studies the process of transfer, that is, the arrival of the material of contribution from the electrode to the base material by effect of the generation of heat. These studies allow a better understanding of the penetration of the puddle of welding and the subsequent distribution of the chemical composition. In addition to these fields of research of the welding process, also there are others that are avian mainly to the prediction of the residual efforts and corrosion [20].

4. SIMULATION NUMERIC THE PROCESS OF WELDING

Simulate a physical phenomenon can be divided into three stages,pre-process, process and post-process.

The pre-process, stage in which establishes the model, builds the geometry of the problem, establish conditions for border or outline sets burdens, defines the material and its properties. On the model will establish the mesh, which consists in discretize the model on the basis of points or nodes, these nodes are connected to form the finite elements, which then formed the volume of material.

The process, stage in which you perform all calculations and thus was obtained the solution of the problem. The post-processing stage, which allows you to view the results of the problem in the form of color ranges or numerical lists.

In the present study the program is used SolidWorks, which in its version 2009 SP2.1 brings with him the tool for integrated numerical simulation SolidWorks Simulation (formerly called Cosmos Works). With the SolidWorks can only be constructed the geometrical model (i.e. is part of the pre-process), the rest of operations are performed with the help of the SolidWorks Simulation (part of the pre-process, process and post-process).

Although the program SolidWorks is not a program exclusively for numerical simulation of welding processes, allows us to through your tool SolidWorks simulation studies of frequency, static, of buckling, thermal and fatigue, non-linear, etc. in addition to linking these studies. The welding process is treated as a problem thermo-mechanical, for this purpose it is necessary to perform a study or thermal model (studies the distribution of temperature and the flow of heat due to driving, convection and radiation) and a study or non-linear model. In the nonlinear analysis assumes that the relations between the loads and the response induced is not linear.

Conclusions

The main conclusions of the work can be summarized in the following points:

- The technique or method of prescription of temperature is satisfactory and especially efficient to obtain the thermal history and residual efforts, in addition to the history of efforts throughout the process; highlights the efficiency of the present study as above were carried out similar studies using more sophisticated techniques to obtain the same results.

- Checked the hypothesis raised by Karlsson [4], the influence exerted by the temperature field on the field of efforts and deformation is significant. The variation of the efforts throughout the process and the magnitude of the residual efforts obtained, owing to the higher temperature gradients and dilations that occur during the process, as demonstrated. On the other hand, checks that the influence exerted by the field of efforts and deformations on the field of temperatures is not significant. This is due to the temperature increase, due to the variation of efforts and deformations, is irrelevant in comparison to gradients of temperature reached during the process.
- The simulation of the welding process is carried out by dividing the problem in two studies. First a transitional thermal study, which gets the thermal history, that comes to be the input or external load for the nonlinear mechanical study. Based on the knowledge of the thermal cycles at any point of the welded joint during welding process and even during cooling can be determine what variation of efforts throughout the process and the resulting waste efforts.
- The transitional thermal study is a critical step in the simulation of the welding process, due to the fact that the result of this study will serve as input to the nonlinear mechanical study, also comes to be more complex and more influence on the results, since it depends on a greater number of parameters such as temperature, geometry, thermal properties variables as a function of temperature and conditions of thermal edge, in contrast to the nonlinear mechanical study depends on a smaller number of parameters such as: mechanical properties variables with the temperature and conditions of mechanical edge.
- To obtain results that are close to the reality it is essential to make an adequate modeling of the material, i.e. there must be information about the dependence of the thermal and mechanical properties of the base material and filler material in function of the temperature.
- Other important aspects to obtain satisfactory results in the simulation come to be: the refinement of the finite element mesh in the area corresponding to weld bead (area

which prescribes the temperature) and adjacent areas close to this, as well as use a small passage of time, especially in the transitional thermal study, for greater accuracy in the results.

- The fact of using the technique of prescription of temperature in place of the technique of source of heat generation (more complex model) used by Carrión [13], translates into a saving in the computational cost. For residual efforts the technique of prescription of temperature is satisfactory, i.e. there is no need to use a more complex model, in addition the technique of source of heat generation should be employed in case required to study the puddle of welding or heating phase of the process in a comprehensive manner.
- Based on the knowledge of the magnitude and distribution of the efforts can make a better control of these. The residual efforts can cause weakness in the area affected by the heat. However empirical methods have been developed (basically because of ignorance of the magnitude and distribution of the residual efforts) to mitigate and control them.
- From the thermal history obtained it is possible to determine the cooling rate of any point, this speed has a significant effect on the metallurgical structure and the mechanical properties of the ZAC and is considered by Fosca [5] as the second most important aspect of the thermal cycle thermal cycle, the first aspect comes to be the width of the ZAC.

Recommendations

The main recommendations of the work can be summarized in the following points:

- It is possible to extend the methodology used in the present study to more complex geometries, since it has been demonstrated the effectiveness for the thermal history and the history of efforts and deformations in the soldered joint.

- Include in future studies the effect of the Status field microstructural, according to the hypothesis of Karlsson [4] The Status field microstructural exerts a significant influence on the field of efforts and deformations, in this way could be resolved many weld ability problems that occur in practice.

- To give greater emphasis to the modeling of material, something that is generally inaccurate, as has been expressed by several researchers, to reason that the information in regard to dependent thermal and mechanical properties of the temperature is low, this deficiency is one of the main causes of error in the simulations.

- In case you want to study aspects such as the heating process or the puddle weld, it is recommended that you use a source of heat generation in function of time.

- You should compare the results obtained, both in the field of temperatures as those obtained in the field of efforts and deformations with experimental results own, unfortunately we do not have the technology to measure thermal cycles or to measure efforts and deformations, however it is possible to compare the results obtained with the results of the literature, in addition to compare with experimental measurements also of the bibliography consulted.

References:-

[1] T. Chandrupatla. Introduction to the study of Finite Element in engineering. Second Edition. 1999.

[2] G. Hernandez Riesco. General introduction to the technology of Welding - General Aspects. Course of Training of Engineers European/International of welding. 2005.

[3] L. Karlsson. Thermal Stresses in welding. In: thermal stresses, Vol. 1 (Ed.: R. B. Hetnarski), pp. 299-389. Amsterdam: North-Holland 1986.

[4] C. Fosca. Introduction to the metallurgy of the Welding. Seventh Edition. Pontifical Catholic University of Peru, 2007.

[5] G. Alpsten. I VarmvalsadeEgenspänigarStålprofiler. Institutional förBrobyggnad, Royal TeknisaHögskolan, Sweden. 1967.

[6] AWS. Welding Handbook. Volume 1, Fundamentals of welding. American Welding Society. Seventh Edition. 1976.

[7] K. Masubuchi. Thermal stresses and Metal Movement during Weld Structural Materials, Especially High Strengths Steels. Proceedings International Conference in welded construction anthier Effects, Vol 1, pp 1-10. 1977.

[8] M. Clarin. High Strength Steel. Local Buckling and residual stress.
Licentiate thesis. 2004.

[9] D. Radaj. Heat Effects of welding. Temperature Field, Residual Stresses, Distortion. Publisher Springer Verlag. 1992.

[10] A. Garcia Portoles. Metallurgy of welded connections. Modeling. Polytechnic University of Madrid.

[11] N.N. Rykalin. Berechnung der WärmevorgängebeimSchweißen: VEB Verlag Technique 1957.

[12] V. Carrion. Welding ánicoTérmico-Mecanalysis using the Finite Element Method. Thesis to opt for the title of mechanical engineer. 2005.

[13] D. Radaj. Residual welding stresses and distortion. Calculation and measurement. Editorial DVS Verlag. 2003.

[14] L-E. Lindgren. Numerical modeling of welding. Comput. Methods. Appl. Mech. Engrg. 2006.

[15] M. And H.K.D.H. MuruganathBadeshia. Mathematical modeling of Weld phenomena 6. Edited by H. Cerjak and H.K.D.H. Badhesia. London, England, Maney Publishers.

[16] S. A. David, T. Debroy, J.C. Lippold and H.B. Smart. Trends in Welding Research: Proceedings of the 6th International Conference. Novelty, Ohio, USA, ASM International.

[17] R. B. Hetnarsky. Thermal stresses (Mechanics and mathematical methods: a series of handbooks). Noth-Holland.

[18] C. Mendez Herrera. Residual Stress analysis and prediction of instability in welded panels. University of Seville. 2007

[19] K. Masubuchi. Analysis of Welded structures. Pergamon Press, 1980.

[20] V. J. Papazoglou and K. Masubuchi. Numerical Analysis of Thermal Stresses During Welding Including Phase Transformation Effects. *ASME* J. Pressure Vessel Technology, vol. 104, August, pp. 198-203, 1982.

[21] P. Marcal. Weld Problems, Structural Mechanics Programs. Charlottesville, University Press, pp. 191-206, 1974.

[22]

[23] J. Goldak, B. Patel, M. Bibby and J. Moore. Computational Weld Mechanics, AGARD Workshop-Structures and Materials 61st meeting Panel. 1985.

[24]

[25] H. D. Hibbitt and P. V. Marcal. To Numerical Thermo-Mechanical Model for the welding and subsequent loading of a fabricated Structure, Computers & Structures. vol. 3, pp. 1145-1174, 1973.

[26]

[27] L-E. Lindgren. Finite Element Modeling and Simulation of Welding Part 1: Increased complexity. Journal of Thermal Stresses Vol. 24, pp 141-192. 2001.

[28]

[29] L-E. Lindgren. Computational Welding Mechanics. Thermo mechanical and microstructural simulations. Woodhead Publishing Limited, 2007.