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THERMAL FATIGUE STUDY OF FERRO ALLOYS AT DIFFERENT LOADS- A REVIEW

D. SRIKANTH
Assistant professor
St. Mary's Group of Institutions, HYD

ABSTRACT:

A method for calculating the fatigue crack propagation portion of the fatigue life of welds initiating fatigue failure at the toe of the weld is presented. The method can be applied to arbitrarily shaped and loaded members having external fatigue cracks of an assumed initial size. The results indicate that estimates using this procedure can provide reasonable estimates of the fatigue life of mild constructional AISI 304 SS material. In the higher strength quenched and tempered steels, however, the initiation period which is neglected in this analysis may constitute the major portion of the fatigue life. The analytical model allows the relative influence of weld geometry on the crack propagation portion of the fatigue life to be assessed.Thermal stresses can have significant effect on a structure's strength and stability, potentially causing cracks or breaks within certain components. Such failures compromise the overall design of the structure, which can lead to possible weakening and deformation. Due to repetitive thermal load acting on the material could lead to fatigue; the cracks are formed at the critical welded joint locations due to fatigue. So it is necessary to perform fatigue assessment of welded joints and crack propagation analysis through stress intensity factor and to obtain fracture toughness of the material.

Keywords: *fatigue cracks, welded joints, AISI 304 SS material.*

1.0 Introduction:

great number of studies were carried out to evaluate the effect of local stress fields on the static and fatigue strength of mechanical components having a geometry variation modeled the fatigue strength of welded joints which is quantified in terms of the residual stress effect on fatigue strength of welded joints is included in reference curves obtained by elaborating a large amount of experimental data. This simplification is due to the difficulties to quantify the intensity and distribution of residual stress near the weld toe both by experiments and numerical models. A further complication is linked to the dependence of residual stress from welding parameters, geometry, clamping conditions, number of cycles and remotely applied stress. Such complications may be sufficient to discourage the use of expensive and time-consuming experimental techniques based on high intensity synchrotron X-ray and neutron radiation sources; but they are not sufficient to discourage the development of numerical models capable to capture the evolution of the as-welded and load-modified residual stress field near the most likely sites of failure initiation. Even if different numerical models were developed in the past with the aim to calculate the residual stress distribution in welded joints,

Sustainability in ferroalloy production:

Ferroalloys production is an energy-intensive industrial sector with significant CO_2 emissions. In this paper the current situation in ferroalloys processes are discussed from the standpoint of global environmental issues, trends and development. Progress and data of ferroalloys production are frequently compared with steel industry which is a closely related sector and the main user of ferroalloys. Emission factors of processes and electricity production are examined as well as possibilities and future scenarios how to diminish CO2 emissions. As a part of this study a questionnaire was submitted to experts in the field of ferroalloys worldwide to survey opinions on ferroalloys industry today and in the near future.

Thermal Loads to Stress Analysis and Fatigue Behavior:

Technical codes and standards used for the construction, design and operation of nuclear components and systemsprovides the materials data required, detailed stress analysis procedures and a design philosophy which guarantees a reliablebehavior of the structural components and systems throughout the specified lifetime. For cyclic stress evaluation the differentcodes and standards provides fatigue analyses to be performed considering the various loading histories (mechanical andthermal loads) and geometric complexities of the components. In order to fully understand the background of the fatigueanalysis included in the codes and standards as well as of the fatigue design curves used as a limiting criteria (fatigue life usagefactor), it is important to understand the history and the methodologies available for the design engineers are discussed inthe following. The safety margins of this simplified elastic plastic fatigue analysis were studied by using experimentaland numerical results.Most of the fatigue relevant stresses in piping systems are caused by thermal loading. The difference between thedensities of the fluid caused by the temperature gradient from bottom to top of the pipe cross section combined with low flowrates can result in thermal stratification in the horizontal portions of a piping system. The hot and cold fluid levels of thestratified flow conditions are separated by an interface or mixing layer. On the other hand high flow rates can cause a temperaturegradient in pipe longitudinal direction (jump of temperature) and result in a thermal shock loading on the inside pipesurface constant throughout the pipe cross section.

Influence of Surface Finish and Welds:

Design curves in the nuclear codes include a factor of 2 on stress or 20 on cycles relative to the mean of the test datato account for differences between specimen test conditions and real vessels and piping. This includes effects of surface finishand welds. Furthermore there are in the nuclear codes specific requirements concerning the surface finish of components especiallyfor welded regions and for different vessel and piping products and different joints. Stress indices are available foruse of the code equations determining the stress amplitudesthe welded joints are the most critical locations of steel structures due to high stress concentration and due to possible cracking originated from welding process. Large number of cracks detected of varying length on the welded areas of boiler steam drum. In the present work fatigue assessment of welded joints are carried out for the critical locations which were identified from the static and thermal stress analysis. Fatigue in the steam drum is primarily caused by the combined action of pressure and temperature loading. Due to this Thermal loads a significant amount of stresses are induced at welded locations where in particular the crack initiates at the weld toe region. These regions are analysed for structural hot spot stresses. The structural hot spot stress can be determined using reference points by extrapolation to the weld toe under consideration from stresses at reference points.

2.0 Objectives:

- To review the different researches thermal fatigue study of Ferro alloys.
- To understand the behavior of different loads
- To study the behavior on residual stress of welded joint.
- To study the static and structural behavior of welded joints

3.0 LITARATURE REVIEW:

[1] Ma Ueda Y., Murayama H. and Maeda H.(1995)T-joint fillet welds are extensively used in ship engineering and bridge structures. Localized heating from the welding process and subsequent rapid cooling induce tensile residual stress near the toe of the T-joint in fillet welds. Welding produces thermal stresses that cause structural distortions, which influence the buckling strength of the welded structures. This study describes the thermal elastic-plastic analysis using finite element techniques to analyses the thermo mechanical behavior and evaluate the residual stresses and angular distortions of the T-joint in fillet welds. **[2] Michaleris P., Kirk M., Mohr W. and McGaughy T(1997).**weld residual stress analyses are performed for T-joint fillet welds made of similar and dissimilar steels. Three-dimensional uncoupled thermo-mechanical finite element model which can accurately capture residual stresses in a weld piece is developed in order to predict the residual stress states in the fillet-welded T-joint. Results show that the maximum longitudinal residual stresses near the weld toes of the similar steel welds increase with increasing yield stress of the steel welded**[3]Murugan, S., SanjaiRai, Kumar, P.V., (1999),**transverse tensile strength, ductility and impact toughness of the weld joints were affected. The fabricated joints were subjected to radiographic testing so as to make a fair assessment about the quality of the joints. The results obtained show that the low heat input during welding of AISI 304 SS is beneficial in achieving better tensile properties as compared to using high heat input. The impact properties show that impact value increased with increase in welding heat input. It was found that the joints exhibited poorer impact value than the corresponding base material which is evident from the values obtained.**[4] Mochizuki M., Hattori T., Nakakado K.(2000)** Stress intensity factors due to surface crack propagation were analysed by using the influence function method and inherent strain analysis of the residual stress fields caused by welding. The initial residual stress in a plate with a welded butt joint was calculated by using inherent strain analysis, and the redistribution of residual stress and the stress intensity factor due to crack propagation were analysed as changes in the structure's shape.**[5] Maruyama, N., Sugiyama, M.,Yokoi, T.(2000)** In the analysis of crack propagation of welded joints the effect of residual stresses is to be considered when evaluating effective Stress Intensity Factor (SIF) range. To analyze the residual stress field, thermal elastic-plastic analysis was performed considering temperature dependent material properties. The test results of propagation life and crack shape were compared with the data predicted from numerical analysis.**[6] Xiangyang Lu and Tasnim Hassan (2001)** The stress intensity factor in the residual stress fields due to crack propagation obtained by using inherent strain analysis completely agreed with that obtained by using the influence function method. The results of the crack propagation analysis were compared with the experimental results of a fatigue test. It was validated that both the inherent strain analysis and the influence function method were efficient for analyzing stress intensity factors in residual stress fields caused by welding**[7] Hansen J.L and Agerskov H (2002).**The crankshaft housings of large two stroke diesel engines are welded structures subjected to constant amplitude loading and designed for infinite life at full design load. A new design of the so-called frame box has been introduced in the engine using butt welded joints of thick plates, welded from one side only, with no access to the root side. Linear elastic fracture mechanics applied to three-dimensional finite element models has been used to assess this new design from the fatigue viewpoint.**[8] Pavier M. J., Poussard C. (2002)**An investigation of how weld geometry and different type of defects influence fatigue life of the weld has been made on a non-load carrying cruciform joint. The weld geometries were measured and the stress distributions were computed using FEA. Fatigue tests have been performed and the initial defects were analysed. Life predictions with LEFM based on the stress distributions and defects were performed with good agreement with the test results.**[9] Li Yajiang, Wang juan, Chen Maoai (2003)** The stress gradient near the fusion zone is higher than any other location in the surrounding area. This is attributed as one of the significant reasons for the development of cold cracks at the fusion zone in the high strength steel. In order to avoid such welding cracks, the thermal stress in the weld joint has to be minimized by controlling the weld heat input.The experimental results reveal that there is a stress gradient around the fusion zone,this gradient is high near the fusion zone and this is one of the reasons for the formation of cracks in the fusion zone in high strength steels.**[10] Lacarac V. D., Garcia-Granada A. (2004).**the responsibility of engine designers, manufacturers and system suppliers. A real example of several engines of the same type, where fatigue cracks arose in certain areas of their bearing girders, has been presented. The extensive investigation revealed the cause of the damage. The proper design was proved by properly implemented state-of-the-art design methods and by experimental verification of calculations in two ships. Quality and test specifications prescribed by the licensor have been found correct. It is concluded that the damage cause was the impermissible quality of worldwide manufacture and improper production repair welding during manufacture.**[11] Osawa, N., Ueno, D. Shimoike,(2008)** Many steel structures are fabricated by welding steel materials together. When a fracture occurs in a welded steel structure, the origin is often a weld zone. The reason for this is that the weld zone is structurally susceptible to stress concentration and that there is the possibility of various defects. From the standpoint of cutting the lifecycle cost of steel structures, reducing the environmental impact, ensuring the safety of steel structures. **[12] Stacey A., Barthelemy(2008)**In order to evaluate the fatigue lives of marine structures accurately, it is necessary to take into account the load histories induced by sea waves, which may be composed of a random sequence of certain clustered loads with variable stress range. In the proposed crack growth model, the crack opening and closure behavior is simulated by using the modified strip yielding model, and the effective tensile plastic stress intensity range, ΔK_{RP}, is calculated by considering the contact of plastic wake along the crack surfaces.**[13] Suzuki, T., Sugiyama, M., Oikawa, H., Nose, T (2010)** a welding simulation procedure is developed using the FE-software ANSYS in order to predict residual stresses. The procedure was verified with temperature and residual stress measurements found in the literature on multi-pass butt welded plates and T-fillet welds. The predictions show qualitative good agreement with experiments**[14]Suzuki, T., Oota, N., Okawa (2011)** Fatigue crack growth rate properties obtained by testing multi-pass butt-welded joints in the through-the-thickness direction are presented along with a characterization of the mild steel base material. Edge-notched four-point-bending specimens are used to investigate *R*-ratio, specimen geometry and post-weld heat-treatment effects on fatigue crack growth rates. The pervasive influence of residual stresses on welded joint fatigue testing using the fracture mechanics approach is also discussed.**[15] Andres Anca, Alberto Cardona , Jose Risso, (2011**) This work deals with the simulation of fusion welding by the Finite Element Method. The implemented models include a moving heat source, temperature dependence of thermo physical properties, elastic-plasticity, non-steady state heat transfer, and mechanical analysis. Finite element models have been used to analyze the thermal and mechanical phenomena observed in welding processes. Thermal histories and residual stresses have been predicted.**[16] Z. Barsoum and I. Barsoum(2013)** A subroutine was developed in order to incorporate the predicted residual stresses and their relaxation during crack propagation by parametric stress mapping between meshes without and with cracks, respectively. The predicted residual stresses and effective stress intensity factors in the validation example shows good agreement with the results found in the literature. The residual stress redistribution due to crack growth is predicted with reasonable accuracy by the LEFM fatigue crack growth routine and the residual stress mapping routine.**[17] AmayDeoraoMeshram (2014)** a new type of manufacturing process in which the relative motion between the tool & work-piece produces heat in the tool work piece interface makes two metal sheets joined by plastic diffusion by virtue of frictional heat. tool-work material interface by the tool under the action of a vertical load, thereby reducing the material flow stress**[18] NabardHabibi, HomayoonKalantariMoghadam (2016)** the mechanical and thermal properties as a function of temperature as input is considered, and with respect to the electrode voltage and speed, heat flux at boiling temperature until the ambient temperature is calculated and ultimate remaining stress in the body at the end of the process of heat exchange with the environment, are residual stresses In the first stage of thermal analysis to mechanical analysis, is down independently for calculation of temperature distribution versus time and distance from welding line and in the second stage, based on the history of temperature in each node under thermal loading, is down mechanical analysis.**[19] Arun. M , SekharMajumdhar , KependraBhairam (2017)**thermal load acting on steam drum which results in thermal expansion of the steam drum material where this leads to formation of thermal stresses and finally results in cracks on the surface of the material. Thermal stresses are driven by strains created in the structure by a temperature load.The fatigue analysis was pressure load, temperature load caused by the thermal expansion of the steam drum. Static and Thermal stress analysis were performed to identify the critical stress concentration areas to obtain von mises stress and max principal stress.

4.0 Results and discussions

References	Year	Study	Results
Murugan, S., SanjaiRai, Kumar	(1999),	Transverse, tensile strength, ductility and impact toughness of the weld joints were affected. about the quality of joints	The low heat input during welding of AISI 304 SS is beneficial in achieving better tensile properties as compared to using high heat input.
Li Yajiang, Wang juan, Chen Maoai	**(2003)**	the development of cold cracks at the fusion zone in the high strength steel	a stress gradient high near the fusion zone formation of cracks
LacaracV.D., Garcia-Granada A	**2004**	fatigue cracks arose in certain areas of their bearing girders, has been presented	the damage cause was the impermissible quality of worldwide manufacture and improper production repair welding during manufacture
Z. Barsoum and I. Barsoum	**(2013)**	relaxation during crack propagation by parametric stress mapping between meshes without and with cracks	Relaxation during crack propagation reasonable accuracy by the LEFM fatigue crack growth routine and the residual stress mapping routine.
AmayDeoraoMeshram	**(2014)**	The tool work piece interface makes two metal sheets joined by plastic diffusion by virtue of frictional heat.	tool-work material interface by the tool under the action of a vertical load, thereby reducing the material flow stress
Arun. M , SekharMajumdhar , KependraBhairam	**(2017)**	The fatigue analysis was pressure load, temperature load caused by the thermal expansion of the steam drum	The steam -drum material where this leads to formation of thermal stresses and finally results in cracks on the surface of the material.

Discussions:

Welded joints are widely used in the construction of offshore platforms. The large residual stress is generally caused by welding process in welded components Transverse, tensile strength ductility and impact toughness of the weld joints were affected. About the quality of joints The low heat input during welding of AISI 304 SS is beneficial in achieving better tensile properties as compared to using high heat input. Fatigue crack growth rate properties obtained by testing multi-pass butt-welded joints in the through-the-thickness direction are presented along with a characterization of the mild steel base materialDue to repetitive thermal load acting on the material could lead to fatigue the cracks are formed at the critical welded joint locations due to fatigue.

Conclusion:

The fatigue life prediction for the diesel engine welded frame box using the developed the residual stress mapping procedure confirms the fatigue lifeenhancement observed in the fatigue testing of the as-welded specimens compared with the stress relived. This illustrates the significant effect of residual stress on the fatigue life and hence should be included in the fatigue life the crack surface contact it is possible to accurately predict the fatigue lifeof the welded structure, including the influence of the loading sequenceand stress ratio Finally, residual stresses were found out by removing loads on the butt welded plate. Changing of residual stresses and spread of plastic zones according to cooling time were investigated.

Future scope:

- Tools for better fatigue life prediction and equivalent mixed mode crack growth
- models are required.
- Better and more effective detection and characterization methods of weld defects (cold
- laps) in connection with fatigue testing.
- General models for residual stressrelaxation in variable amplitude spectrum loading.
- the development of ever more reliablesolutions to fatigue of steel materials so as to deliver safer, moresecure steel products to our customers.

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