Preheat Temperature Effect on welding Repair Process on Truck Frame by using FCAW technique

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**Abstract.** The open cut mining methodology in the coal industry is involving many of fleet equipment, where one of them which play an essential role is hauling truck. This paper presents the experiment results to identify the effect of different preheating temperatures by using flux core arc welding (FCAW on frame material of 100 tons of truck working at a coal mining operation. The approach methodology used to experiment was to apply three different preheating temperature of welding process on a crack occurred on the truck frame. Without preheating was used as first option, 90oC of preheating was used as second option and 120oC as the third approach. They were applied to 12 materials which had common failures on frame structure then monitored’[1]

There are several industry attractive aspects of flux cored arc welding (FCAW) process that need further investigation. This paper presents an effect FCAW technique to repair 100T Mining truck, in process repair frame. FCAW is a welding process that uses a heat source that comes from electrical energy that is converted into a heat source in an electric arc. Author illustrates this method using FMEA for simulated temperature effect time improvement successfully. Also, the welding parameters that can provide better microstructure, mechanical properties and minimum residual stresses in thick walled weldments need to be established to validate the application of FCAW process. This paper investigates two different welding sequences and studies their effects on the microstructure, the hardness and the size of the heat-affected zones (HAZs). The results show that there were no significant differences in the microstructure, hardness and the size of HAZ between the two proposed sequences. However, significant improvement in the microstructure and a reduction in the hardness and the size of HAZ were achieved after depositing the second welding bead irrespective of the depositing sequence.

**Keywords** - Welding, FCAW, Crack, Preheating, Coal, Mining,.

1. Introduction

The majority of truck and shovel operations in the Indonesia coal industry, use Caterpillar 777D trucks. These trucks are at various stages of their service life and many of them have experienced fatigue cracking at several locations after a relatively short duration of time in service (in some instances as low as 20,000 hours). The life of a truck is generally limited by the life of its chassis; hence a key aspect in planning repairs or replacement of a truck is the prediction of the remaining service life of the truck’s chassis and body. At the same time, it is necessary to develop a comprehensive risk management strategy for operating the trucks safely until replacement. Fatigue cracks of truck chassis and bodies have been observed at various stages of their service life. [2]

The OEMs have indicated that most of the cracking is due to severe operational conditions specifically the condition of the haul roads. However, the design loading conditions or the design criteria for these trucks are not available from the OEM. Also, there is no standard for design of these large mining trucks currently available in the public domain. Previous studies have indicated that the haul road conditions can have a significant effect on the fatigue life of some components, especially areas/components of the chassis and body.[3] During the initial stages of the study, the industry monitors decided that the study should be conducted on the CAT 777D truck which is the most common truck in the mining fleet. The Kideco mine site was nominated where testing was to be conducted. This project involved the detailed study of the Caterpillar 777D chassis under normal mine operations.

In a welding world, Flux-Cored Arc Welding (FCAW) process commonly used in different industries to join the metals and alloys. It has a few numbers of benefits such as high deposition rates, more tolerant of rust and mill scale than GMAW, simpler and more adaptable than SAW, less operator skill required than GMAW, high productivity than SMAW and goo surface appearance[4]

The investigation focused on the Welding process. In welding, there are several types of heat treatment before or after the material is welded. Materials, especially carbon steel, will experience structural changes and grain due to the effect of the cooling speed. The heat treatment in question is preheat and PWHT (Post Welt Heat Treatment). preheat is part of the heat process treatment before welding which aims to reduce humidity from the welding area and to decrease the temperature gradient thus minimize problems such as distortion and excess residual stress. [5]

The investigation consists of:

• Detailed review of previous failure history on the CAT 777D chassis in Kideco Jaya Agung Mine.

• Extensive measuring and testing program.

The results used to identify the best preheat temperature are related to the distortions that occur during a given heat exposure variation that affects life chassis.

1. Methodologies

Methodologies on the research will be described as follow:

*2.1 Data Collection Method*

The data required as input data for calculation is a record of overall maintenance activities which must include official maintenance categories of SAP used by the company. This data will be used to compare the conditions before and after the implementation of the Maintenance management improvement program.

*2.2 Validation and Verification*

The aim is to create a model that represents conditions close to the characteristics of the actual system as a substitute for the actual system for the purpose of system testing, system behavior analysis, and system performance prediction.

*2.3 Implementation & Post Implementation Analysis*

Implementation and post implementation of FMEA analysis is designed to:

a. Identify and fully understand potential failure modes and their causes, and the effects of failure on the system or end users, for a given product or process.

b. Assess the risk associated with the identified failure modes, effects, and causes, and prioritize issues for corrective action.

c. Identify and carry out corrective actions to address the most serious concerns. FMEA can be viewed as a proactive procedure for evaluating a process by identifying where and how it might fail and assessing the relative impact of different failures.

Despite FMEA’s primary objective is improving the system design, it can be applied in any stage of a project to mitigate potential future risks produced by failure modes. FMEA is conducted by a cross-functional team of subject matter experts that analyzes the system to identify weaknesses and propose correcting actions that prevent a negative impact on the system’s performance. At this point, it is important to note that FMEA’s objective is not to predict failures. Its aim is to identify existing and potential failures through a subjective and systematic assessment to classify those failures according to a risk measure.

• Frequency of Occurrence : that represents the number of times the failure mode occurs.

• Detectability Assign an Occurrence Assign a Detectability Assign a Severity Reevaluate the RPN number after the actions are completed.

**Table 1.** Baseline Truck Maintenance Intervals

|  |  |  |  |
| --- | --- | --- | --- |
| **Inspection and Maintenance** | **Miles** | **Time** | **Intervals** |
| Visual Inspection | 3,000 to 5,000 | Monthly | NA |
| Wheel gauging, adjusting, checking and replenishing lubricants | 12,000 to 15,000 | Three to four months | NA |
| Predictive testing | NA | As determined by RTS |  |

1. Discussion

Results of the experimental on analyzing Pre-weld heating on the crack frame failure are as follow:

**Table 1**. Pre-Weld Heating Sample

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample** | **Temperature ( °C )** | **Time ( minute )** | **Distortion (mm )** |
| 1 | Without Preheat | 30 | 1.32 |
| 1 | 90 | 30 | 1.83 |
| 1 | 120 | 30 | 1.40 |
| 2 | Without Preheat | 60 | 1.45 |
| 2 | 90 | 60 | 2.06 |
| 2 | 120 | 60 | 1.51 |
| 3 | Without Preheat | 90 | 1.49 |
| 3 | 90 | 120 | 2.10 |
| 3 | 120 | 120 | 1.65 |
| 4 | Without Preheat | 300 | 1.60 |
| 4 | 90 | 300 | 2.30 |
| 4 | 120 | 300 | 1.85 |
|  |  |  |  |

**Table 2**. Preheat for various metals

|  |  |
| --- | --- |
| **Types of Steel** | **Preheat** |
| Low carbon-Carbon Steel | Room temperature or up to 200°F ( 93°C ) |
| Medium-Carbon Steel | 400-500°F ( 205-260°C ) |
| High-Carbon Steel | 500-600°F ( 260-315°C ) |
| Low-Alloy Nickle Steel-Less than1/4(6.4 mm) thick-More than ¼ (6.4 mm ) thick | Room temperature500°F ( 260°C ) |
| Low-Alloy Nickle Chrome steel-Carbon content below 20%-Carbon content 20% to 35%-Carbon content above 35% | 200-300°F ( 93-150°C )600-800°F ( 315-425°C )900-1100°F ( 480-595°C ) |
| Low -alloy Manganese steel | 400-600°F ( 205-315°C ) |
| Low -alloy Chrome steel | Up to 750°F ( 400°C ) |
| Low-alloy Molybdenum SteelCarbon content below 150%Carbon content above 15% | Room temperature400-650°F ( 205-345°C ) |
| Low alloy High Tensile Steel | 150-300°F (66-150°C ) |
| Austenitic stainless steel | Room temperature |
| Ferritic stainless steel | 300-350°F ( 150-260°C ) |
| Martensitic stainless steel | 400-600°F ( 205-315°C ) |

1. Conclusion
* Preheating 90°C has the greatest impact value on the weld metal at 2.30 mm because it has a micro ferrite acicular structure which has better toughness than the microstructure in the treatment without preheating and preheating 120°C.
* The toughness without preheating is better than the preheating treatment at 90°C and 120°C. However, it has a tendency to crack the weld metal, therefore preheating with a temperature of 90°C is the optimal temperature for welding truck Frame 777D.
* The Effect of Preheating Temperature on Welding Truck Frame Repair Using FCAW Technique. Inadequate preheating results in different types of cracking, insufficient fusion, and penetration. Carbon equivalent is used as a tool for approximating proper preheats. Besides CE, optimum preheating temperature also depends on section thickness, restraint, ambient temperature, filler metal hydrogen content, and previous cracking problems.
* There are three most important set of Establish New Method of Welding Procedure on Maintenance/Repair 777D 100 Tons’ Truck: preparation for welding, repair welding, postweld operation.
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