Failure Analysis of Tracked Vehicle Transmission and Recurrence Prevention

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1. Introduction

In general, since the transmission of a tracked vehicle performs not only the shifting function but also the steering and braking functions, it is known that the structure and function of the transmission for a tracked vehicle is more complex and diverse than that of the transmission for a general wheeled vehicle [1,2]. During the annual maintenance of tracked vehicles operated by the ROK Army, a large amount of unidentified metallic foreign substances were observed in the oil filter when exchanging the transmission oil and oil filter, as shown in Fig. 1. Therefore, in the present study, failure analysis was carried out to investigate the root cause for failure during the field operation of the transmission of a tracked vehicle operated by the ROK Army and to prepare a countermeasure to prevent reoccurrence.

2. Failure Analysis of the Transmission

After the transportation of the transmission from the field military base to the ROK Army Consolidated Maintenance Depot, it was found that the hub assembly (Steel) for the C1 clutch in the range pack of the transmission was destroyed by carrying out the phased disassembly and inspection. Therefore, secondary damages to the surrounding parts, such as the retainers (Aluminum) and friction discs (Copper), were expected because the parts made of steel are generally harder than those of aluminum or copper. The damaged parts were observed in the range pack of the transmission, as shown in Fig. 2.

The hub assembly for the C1 clutch is fabricated into an assembly in which the hub and oil deflector are welded together. The destroyed hub assembly

Fig. 1 Unidentified metallic foreign substances observed during annual maintenance

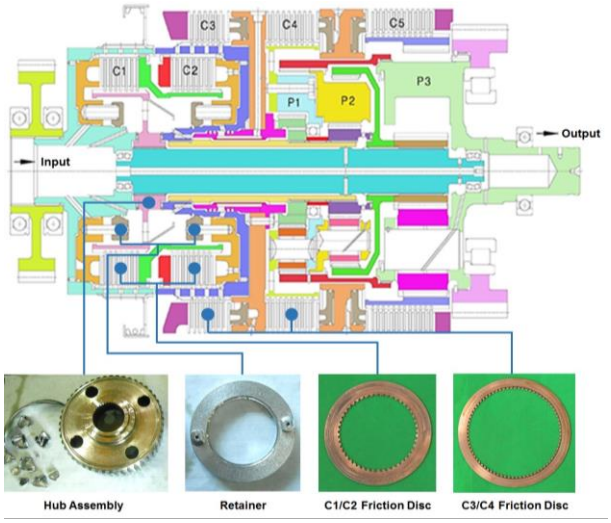

Fig. 2 Locations of damaged parts found in the range pack of the transmission by phased disassembly and inspection

was completely separated into the hub and oil deflector, and the oil deflector was also broken into several pieces, as shown in Fig 3. The primary and secondary damaged parts were analyzed in order to investigate the root cause of failure, and a large amount of metallic foreign substances collected in the oil filter was also analyzed.

First, chemical composition analysis, hardness measurement, and a non-destructive test were conducted to check the conformity of the damaged parts with the requirements in the military drawings.

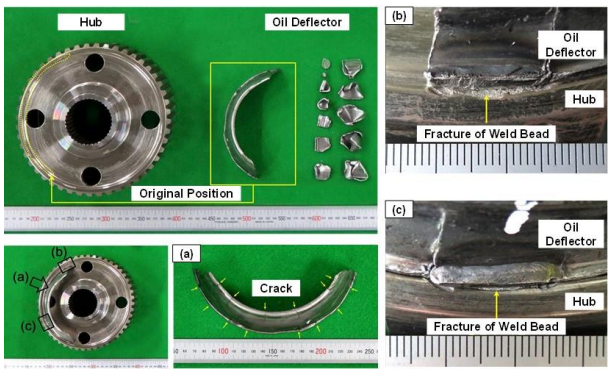

Fig. 3 Destroyed hub assembly separated into hub and oil deflector

In addition, the metallic foreign substances collected in the oil filter were analyzed by Energy Dispersive X-ray Spectroscopy (EDS). Unfortunately, the destroyed hub assembly was limited in the observation of the integrity of the weld bead since the hub and oil deflector were completely separated into two parts. Therefore, a newly-manufactured hub assembly in the serial production was arbitrarily selected, and the analysis procedure was performed in the same manner as the destroyed hub assembly.

In the present study, to observe the fractured surfaces and microstructures of the damaged parts (hub assembly, retainer, and friction disc) and newly-manufactured hub assembly, microscopic techniques such as stereoscopic microscopy (SM), optical microscopy (OM), and scanning electron microscopy (SEM) were employed.

In the tests and analyses of the damaged parts, no discrepancies with the requirements in the military drawings were found. As a result of observation of the fractured surfaces by macroscopic and microscopic methods, the typical characteristics of fatigue fracture such as beach marks and striations were not observed. Because of the inter-granular fracture mode observed at the fractured surfaces of the hub assembly, as shown in Fig. 4, catastrophic fracture was expected due to the action of unknown instantaneous external force larger than the allowable load. In the EDS analysis results of the metallic foreign substances, it was found that steel, aluminum, and copper compositions were detected. Therefore, it was expected that the substances came from the damaged parts, such as the hub assembly, retainer, and friction disc.

The observation results of the welding heat-affected zone (HAZ) of the destroyed hub assembly revealed typical hydrogen-induced cracking similar to that in the literature [3], as

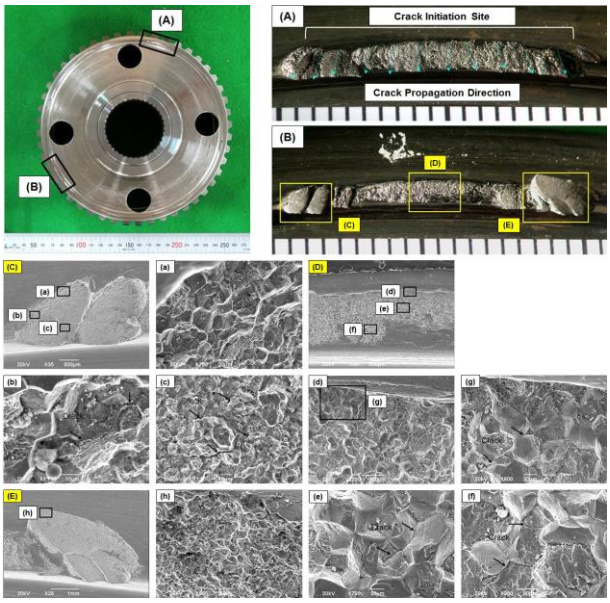

Fig. 4 Macroscopic and microscopic observation of the fractured surfaces of the destroyed hub assembly in the range pack of the transmission

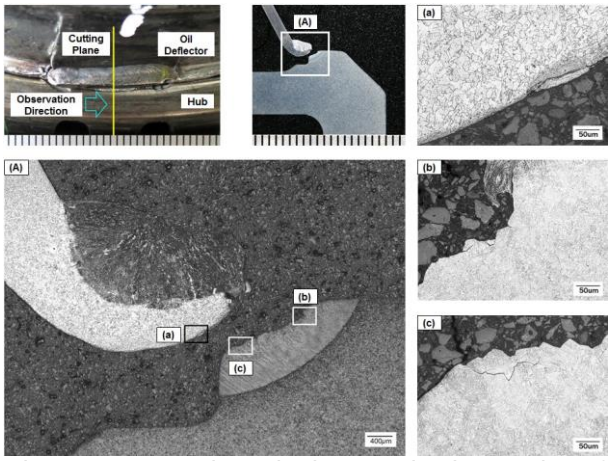

Fig. 5 Macroscopic and microscopic observation of the fractured weld bead of the destroyed hub assembly in the range pack of the transmission

shown in Fig. 5. In addition, a similar result was observed in the welding HAZ of the newly-manufactured hub assembly. Therefore, it was found that the manufacturing process should be improved to prevent recurrence in the future.

3. Activities for Recurrence Prevention

In order to prevent the recurrence of similar cases in the future, welding procedure specification (WPS) was designated, and pre-heating procedures were added before the welding process. In addition, the inspection standard and test report were revised so as to be subdivided into weld beads, and engineering change (EC) was carried out for updating and rationalization of the requirements in the military drawings, which was identified during the follow-up activities.

4. Conclusions

In this study, failure analysis of the transmission for tracked vehicle was conducted to investigate the root cause of the occurrence of metallic foreign substances, and follow-up actions were also carried out to prevent reoccurrence in the future.

Acknowledgments

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