INVESTIGATION INTO THE WELDED FILLING QUALITY OF A LOCALLY RESTORED BALL JOINT

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Due to high cost of new ball joint replacement and recent economic crisis, attention is drawn to repair automotive ball joints and re-use them. Ball joints are designed to give three degrees of freeedom as nodding, rolling and turning. To facilitate these movements, the ball joint is made of a ball, suppported in between top and bottom sockets held within the housing.

A survey was conducted focusing on techniques and technologies used in the ball joint restoration industry in Sri Lanka. All workshops surveyed use the same techniques and technologies. However, different restoring techniques are being used based on the extent of damage to the ball joint components, especially the ball itself. The method to be used for the restoration is based on the extent of damage which is determined after observations made upon dismantling. According to the construction of ball joints, most frequent failures occur in ball joint stud ball surface and socket. Severely worn out stud balls are being restored by filling using arc welding and subsequent machining. The aim of this work is to assess the quality of the welded filling used to restore a severely worn out ball joint.

As the socket is made of a softer material compared to the stud ball, no cases of damage to the stud ball without damaging the socket have been observed. In order to examine the quality of restoration of such ball joints, a restored ball joint was sectioned and observed under the microscope.

The initial investigation of the stud ball shows three distinct regions, core in the middle and the case on the surface. In addition to the core and the case, there was another section which at a glance looked alien. This section can easily be identified as the restored section by local welding and subsequent machining. The depth of the case-hardened layer was about 5mm.

Hardness is a mechanical property that can be used to quantify the resistance of a material to withstand mechanical forces such as indentation, abrasion, cutting or scratching. The hardness was used as the main quantifying parameter in this study. The case was subjected to heat treatment and should be the hardest section. The core is the parent material and is not subjected to surface hardening. The hardness in the case was in the range of 38 to 40 HRC. The core had a hardness of 28.5 to 30 HRC. Ideally, the restored metal filling part also should fuse finely with the parent material and have a higher hardness comparable to that of the case. The analysis revealed that the restored part did not have the required hardness compared to the original case-hardened material and was not fused properly to the parent material upon welding.

It is evident from facts such as the poor fusion with the parent material, and the hardness reduction in the welded zone compared to the parent material that the restoration process is not satisfactory. A hardness reduction of 44% was observed in the welded section compared to that of the case-hardened section of the parent material. It can be recommended to carry out a suitable heat treatment procedure before welding to the parent material to accommodate better fusion and carryout a surface hardening for the restored ball and stud in order to accommodate a homogenous microstructure with high surface hardness.

Keywords: Automotive Components, Restoration, Repair, Welding, Reliability

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INTRODUCTION

Maintaing an automobile in good running condition is an expensive affair. Some of the automotive engine and suspension components require frequent replacement and out of many such components, suspension ball joints are required to replace frequently when vehicles are being driven on roads with irregular surface conditions. The ball joints are designed to give three degrees of freedom as nodding, rolling and turning. To facilitate these movements, the ball joint is made of a ball, suppported in between top and bottom sockets (Li, 2020; Schmidová, 2021). Due to high cost of new ball joint replacement and recent economic crisis, attention is drawn to repair automotive ball joints and re-use them. The aim of this paper is to assess the quality of the welded filling use to restore a severely worn out ball joint.

A vertical cut of the investigated ball joint is shown in Figure 1. The ball and stud is fabricated as one unit from alloy steel and induction hardened. The top and bottom sockets are being made from polymer material such as nylon or teflon. Cold-hot forming is used by the mechanical part manufacturing industries for mass production of small or medium sized mechanical parts, (Davis & Semiatin, 1988). In forging, initial materials which are cut from bars, are formed progressively to final shapes by operations including shearing, upsetting, forward and backward extrusion, piercing, etc. (Im et al., 1999).

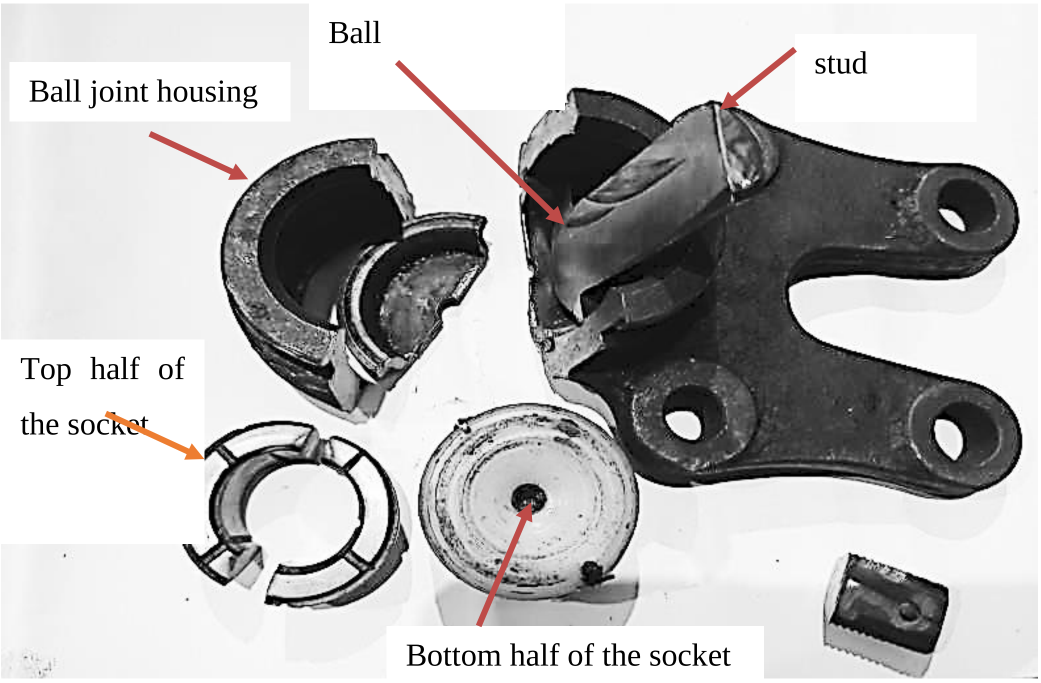

Figure 1- Vertical cut of a ball joint

METHODOLOGY

A survey was conducted in the ball joint restoration industry in Sri Lanka. Different restoring techniques based on the extent of damage to the ball joint components, have been identified. The method to be used for the restoration is determined after observations made upon dismantling.

According to the construction of ball joints, most frequent failures occur in stud ball surface and the socket. As the socket is made of softer material compared to the stud ball, no cases of damage to the stud ball without damaging the socket have been observed. In order to examine the quality of restoration of such ball joints, a restored ball joint was dismantled, and physical examinations were carried out.

RESULTS AND DISCUSSION

A ball joint with severe damage to the stud ball and socket was sectioned for observation. Due to the damage to the ball, the surface of the ball has been filled with welding which was machined subsequently to get the original shape. The sectioned ball stud surface was investigated for the macroscopic appearance and the variation of hardness throughout the original section and the section filled with welding. Further, a microscopic investigation was also carried out in order to investigate the microscopic structure of the interface between the parent material and fusion zone of the weld. The section was mirror polished and was subjected to investigation. The mirror polished section is shown in Figure 2.

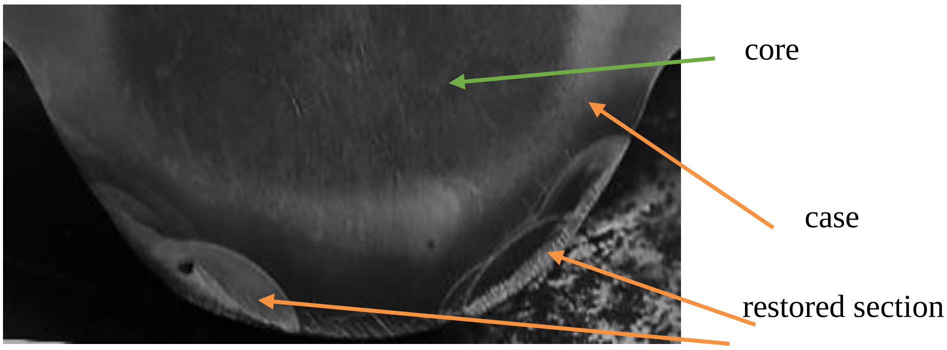

Figure 2 – Section of a locally restored ball of a type A damage stud, 2% Nital etch

The initial investigation of the section in Figure 2 shows three distinct regions, core in the middle and the case on the surface. In addition to the core and the case, there was another section which at a glance looked alien. This section can easily be identified as the restored section by local welding and subsequent machining. The depth of the case-hardened layer was about 5mm. An image of the fusion zone obtained under the microscope is given in Figure 3.

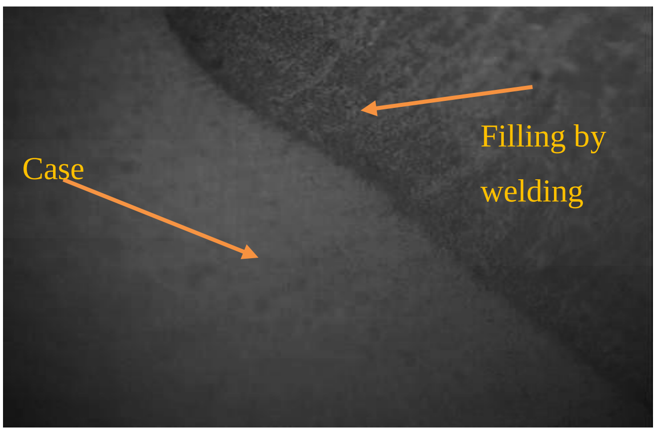

Figure 3 – Fusion zone of case and welded filling

Hardness is a mechanical property that can be used to quantify the resistance of a material to withstand mechanical forces such as indentation, abrasion, cutting or scratching (White & Best, 2009). The hardness was used as the main quantifying parameter in this study. The hardness test points are identified by numbers 1 to 9 in Figure 4 and the results are given in Table 1.

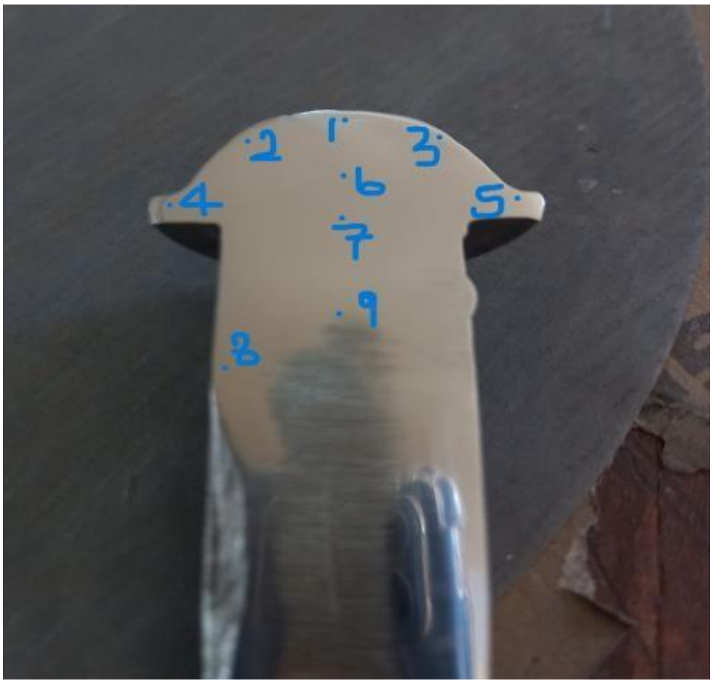

Figure 4 – Hardness measuring points of specimen

Referring to Figure 4, where the hardness was tested in various points on the stud section, the hardness at points 2 and 3 are located in the welded zone, whereas points 7, 8 and 9 are from the core. Points 1,4 and 5 are from the case. The hardness results are given in Table 1.

Table 1 – Hardness variation in the ball and stud of the investigated ball joint

Points on specimen	Hardens Number HRC
1	38
2	22.5
3	21
4	38
5	40
6	30
7	30
8	29
9	28.5

The case was subjected to heat treatment and should be the hardest section. The core is the parent material and is not subjected to surface hardening. The hardness in the case was in the range of 38 to 40. The core had a hardness of 28.5 to 30. Ideally, the restored metal filling part also should fuse finely with the parent material and have a higher hardness. The analysis revealed that the restored part did not have the required hardness compared to the parent material. Further, Figure 3 which depicts the fusion zone shows that the welding zone was not fused properly to the parent material.

CONCLUSIONS/RECOMMENDATIONS

It is evident from the facts such as the poor fusion with the parent material, and the hardness reduction in the welded zone compared to the parent material that the restoration process is not satisfactory. A hardness reduction of 44% was observed in the welded section compared to that of the case-hardened section of the parent material. It can be recommended to carry out a suitable heat treatment procedure before welding to the parent material to accommodate better fusion and carryout a surface hardening for the restored ball and stud in order to accommodate a homogenous micro structure with high surface hardness.

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