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सं: धा०र०/ऍम०आई०टी०/आई०एंड टी०/3 दिनांक: .07.2023

# धातुकर्मीय अन्वेषण रिपोर्ट संख्या : 74/2023

## 1. RDSO personnel involve in metallurgical investigation:-

| Prasenjit Prajapati (M.S/Research) | Sandeep Tigga (ARO/M&C) | R. C. Rahate (Dy. Dir./M&C) | Rajesh Srivastava (Dir./M&C) | S. K. Srivastava (AED./M&C) | B. L. Bairwa (Exe. Dir./M&C) |
|---|---|---|---|---|---|
| Tested & draft report framed by | Draft report prepared by | Draft report reviewed by | Draft report approved by | Report approved by | Report issued by |
| | | | | | |

**विषय: Metallurgical investigation of Bell Crank Lever**

**सन्दर्भ: ADE/Wagon's note no- MW/APB/BMB/Escorts , Dated -11/05/2023**

Reference above, a fractured Bell Crank Lever was received for metallurgical testing. The details are as under:

## 2. Particulars of sample (as furnished)

| **Sample ID** | **74/2023** |
|---|---|
| Component/System Identity (coach/Loco/Wagon etc.) | **Wagon** |
| Location is system if part of assembly | BMBS |
| Date of failure | 14/04/23 |
| Place/Railway | ECR-DHN DN |
| Drawing No./Specification No. | 3EB9792 Alt-00 |
| Manufacturer | M/s Escorts |
| Identification mark on the component. | -- |
| Date of Manufacture | -- |
| Date of fitment | -- |
| Function of Component in Brief | Force transfer |
| Nature of stresses/loading | -- |
| History of repair/maintenance | -- |
| Failed in service/assembly/ Maintenance | failed in service |
| Caused derailment/accident | RNG |
| Train no. In case of accident | -- |
| Working Environment (Tem./hum. etc) | Indian environment condition |
| Document allowing welding repair if any | -- |
| Last NDT testing/results if applicable | -- |
| Expected service life | -- |
| Condemning criterion | -- |

## 3. M&C Lab. Identification No.

| Sl. No. | M&C Lab. No. | Component | Paint Marking |
|---|---|---|---|
| 1. | 74/2023 | Bell Crank Lever | ----- |

## 4. Visual Examination

A fractured Bell Crank lever is received for Metallurgical investigation **(fig 1).** Visual examination revealed that bell crack lever had breakage in fatigue manner **(fig. 2&3).** Topography of the fracture face revealed that fracture had initiated from weld and parent metal interface in fatigue manner. Shear lips were also noticed at the initiation point **(fig 3).** Counter fracture face was not received.

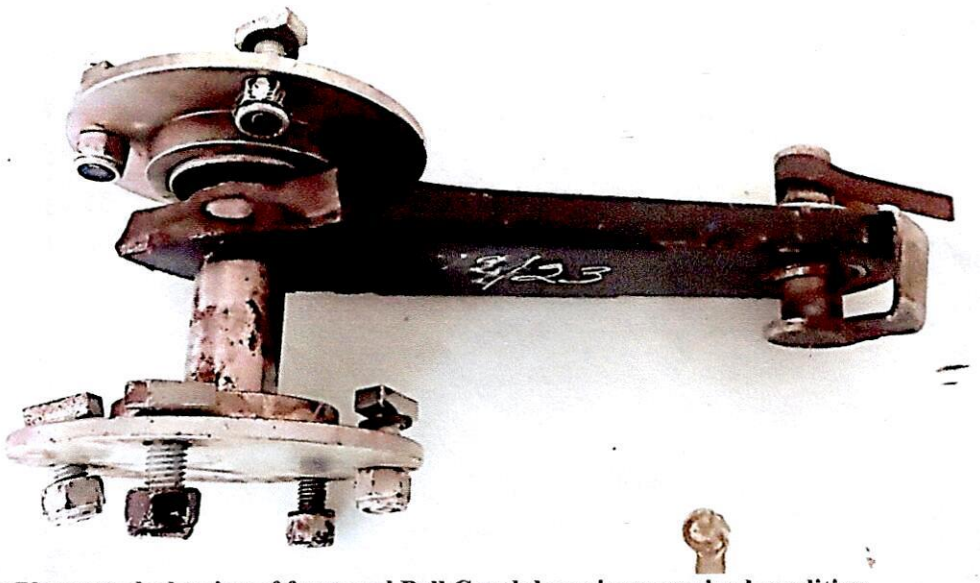


**Fig.1: Photograph showing of fractured Bell Crank lever in as received condition.**

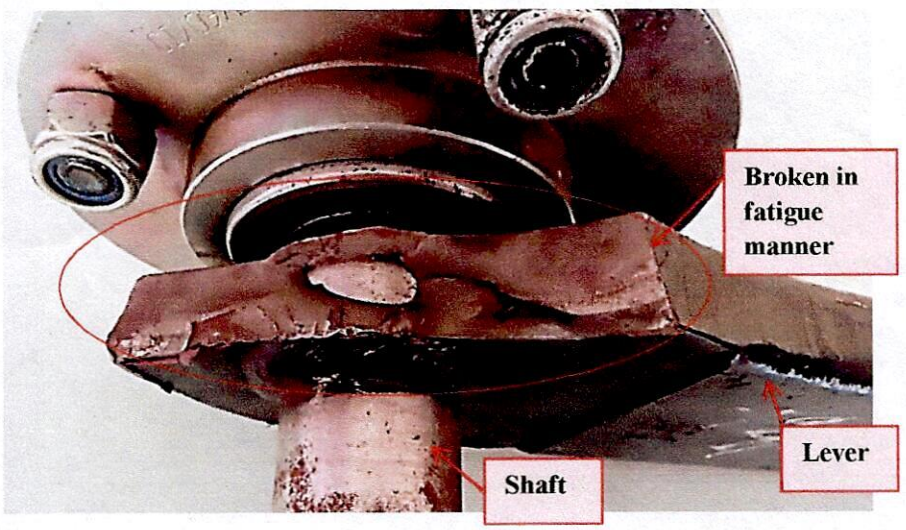



**Fig.2: Photograph showing breakage of Bell Crank lever in fatigue manner.**

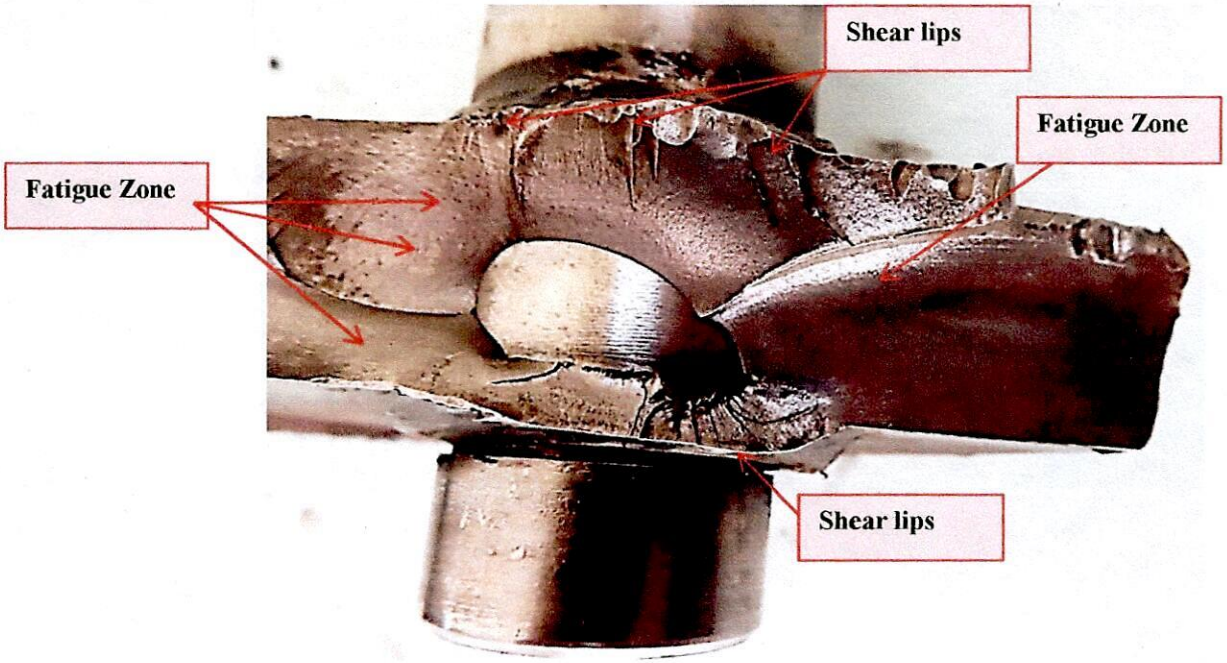



**Fig.3: Close view of fig.2 showing fatigue initiation in shear lips forms.**

## 5. CHEMICAL COMPOSITION

| Sample No. | %C | %Mn | %Si | %P | %S |
|---|---|---|---|---|---|
| 74/2023 (Bell crank lever) | **0.37** | 0.80 | 0.21 | 0.028 | 0.006 |
| **Specified as per IS 1875,class;4** | **0.40-0.50** | **0.60-0.90** | **0.15-0.35** | **0.40 max** | **0.40 max** |
| **Permissible variation** | **±0.05** | **±0.07** | **±0.04** | **+0.010** | **+0.010** |

## 6. TENSILE TEST

Tensile test was conducted along the rolling direction on bell crank lever and the results are given as under:

| Sample No. | Y.S. ($N/mm^2$) | UTS ($N/mm^2$) | Elongation% |
|---|---|---|---|
| 74/2023(Bell crank lever ) | 431.39 | 669.21 | 28 |
| **Specified as per IS 1875, Class 4, along the rolling direction.** | 320 Min | 620 Min | 15 Min |

## 7. HARDNESS

| Sample No. | Hardness in BHN |
|---|---|
| 74/2023(Bell crank lever) | 185,183,177 |
| **Specified as per IS 1875,class 4** | 175 Min |

## 8. MACROEXAMINATION

Macro-examination test was conducted at the fracture initiation location. It revealed weld profile & welding defects **(fig.4)**

## 9. MICRO-EXAMINATION

Micro-examination was conducted on the macro piece in and around the vicinity of the weld zone. Observations are made as under:

| Sample No. | Locations | Observations | Specified as per IS 1875, class 4 |
|---|---|---|---|
| 74/2023(Bell crank lever ) | Lever | Revealed as rolled ferrite pearlite structure along with directionality **(fig.8)** | **Normalised structure** |
| | Weld | Revealed as cast columnar grains structure along with inter granular crack in welded portion(fig.7) | --- |
| | Initiation zone & HAZ | Revealed martensite structure **(fig.5 &6)** | -- |

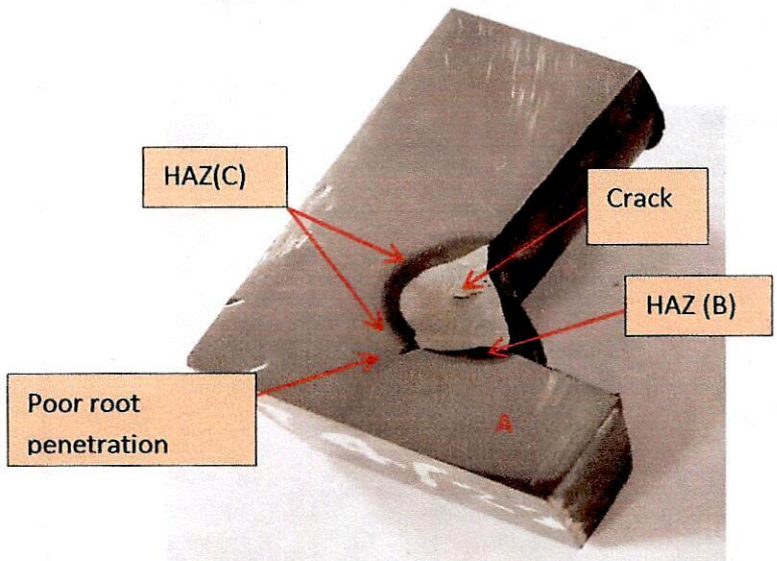
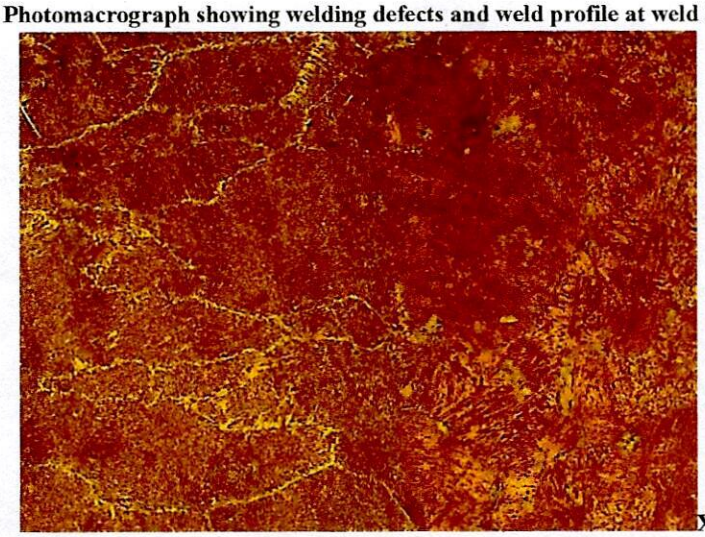
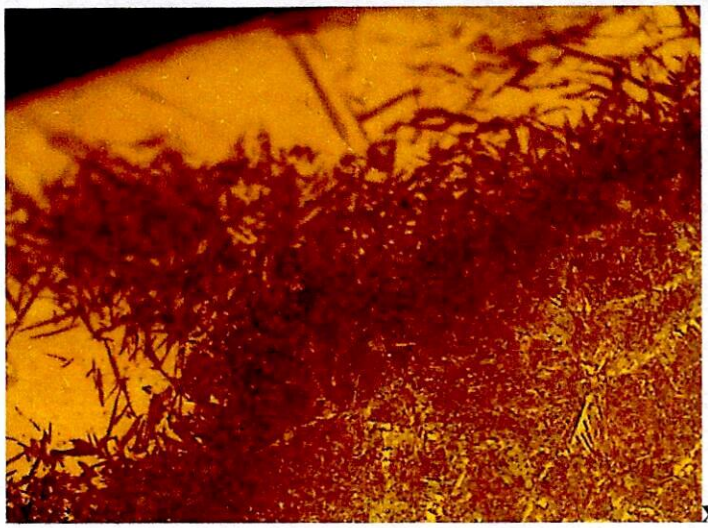



**Fig.4 Photomacrograph showing welding defects and weld profile at weld Zone.**



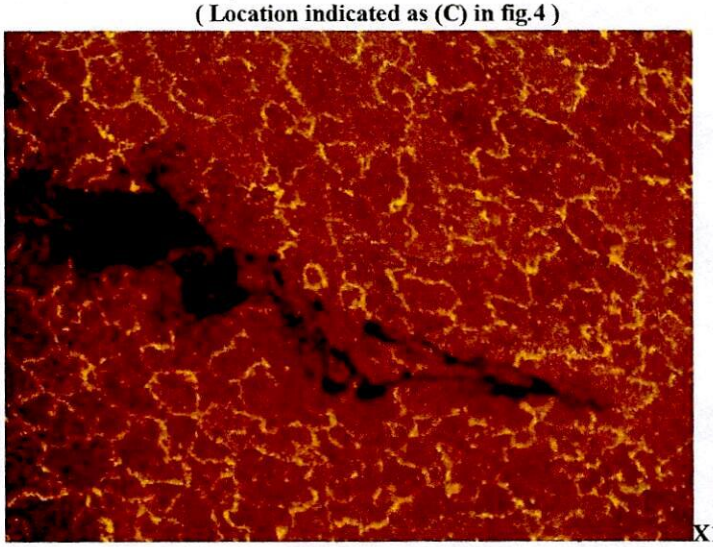
**X500**

**Fig.5 Photomicrograph showing martensite structure at thefatigue initiation zone in HAZ ( Location indicated as (B) in fig.4 )**



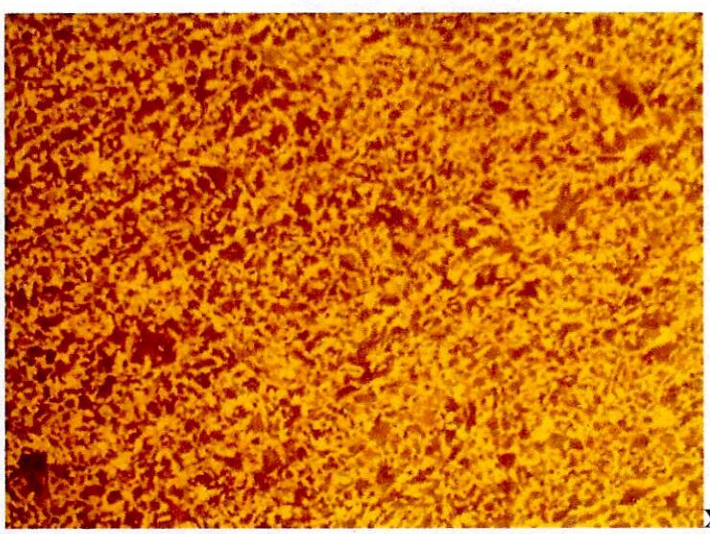
X500

**Fig.6 Photomicrograph showing martensite structure at the fatigue initiation zone in HAZ ( Location indicated as (C) in fig.4 )**



X100

**Fig.7, Photomicrograph showing as cast columar grains structure along with intergranular crack in weld portion.**



X100

**Fig.8, Photomicrograph showing as rolled ferrite pearlite structure along with directionlity ( Location indicated as (D) in fig.4 ).**

## 10. DISSCUSION

**Chemical composition** of Bell crack lever conforms to the relevant specification IS 1875 Class-4.

**Hardness** values are obtained within the specified limit.

**Tensile properties** of the bell crank lever conform to the relevant specification.

**Macro examination** of the fracture location containing (weld portion & parent metals), revealed welding defects such as lack of penetration, crack etc.

**Microstructure** of the bell crank lever revealed directional as rolled ferrite pearlite structure against normalized structure indicative of manufactured from plate instead of forging. Microstructure of weld portion revealed cast columnar grain structure with a micro crack in welded beads. Microstructure at the initiation zone revealed needle like martensite structure prone to crack formation.

It is evident from above tests that metallurgical properties of bell crank lever conform to the relevant specification. Topography of the fracture face revealed that fracture had initiated from weld and parent metal interface ie HAZ. Martensite structure in HAZ indicates that weld and HAZ has undergone fast quenching.

Presence of welding defects such as poor root penetration & cracks in weld profile are also observed. Contour of weld profile may be considered satisfactory.

The failure of bell crank lever might be attributable to combined effect of brittleness of weld and presence of needle like martensite structure in HAZ resulted in initiation of fatigue crack leading to the failure of Bell crank lever under cyclic load.

## 11. CONCLUSION

The metallurgical properties of bell crank lever conform to the relevant specification. However, directionality in microstructure of bell crank lever revealed that it has been manufactured by as rolled plate instead of forging. The failure of bell crank lever may be attributable to combined effect of brittleness of weld and presence of needle like martensite in HAZ which resulted in initiation of fatigue crack leading to the failure of Bell crank lever under cyclic load.

## 12. RECOMMENDATION

(i) Welding procedure may be looked into to avoid as such type of failure.

(ii) Material must ensure as per relevant specification.

11/7/2023

(बी॰एल॰बैरवा)
कार्यकारी निदेशक /धा॰र॰

**ED/Wagon**