Case Study: Feasibility of AI-Based QR Code Marking on Track Fittings

Background

Indian Railways uses millions of track fittings every year, including elastic rail clips, liners, rail pads, and concrete sleepers. Currently, there is no effective way to identify or trace each component once it has been installed. This causes problems with monitoring, warranty validation, and maintenance tracking.

To address this, our project proposes using AI-enabled laser-based QR code marking for each track fitting. These QR codes will contain the complete data for the component, including vendor, batch number, supply date, and inspection details. They can be scanned through a mobile app linked with the User Depot Module (UDM) and Track Management System (TMS).

Field Visit and Observations

During our visit to the Permanent Way (P.W.) Office in Erode, we interacted with engineers and maintenance staff to understand real-world conditions.

We found that many staff members are hesitant due to their limited experience with digital tools. Most are used to manual processes and were initially unsure how this would work in their daily tasks.

After we explained how the laser marking and QR scanning process functions, the officials understood the practical benefits of the system. They also stressed that training and awareness would be essential during the implementation phase.

The main takeaway from the visit was that adopting new technology must include proper training for personnel to ensure the system's success.

Technical Feasibility for Engraving

1. Elastic Rail Clips (ERC)

- **Material:** High-strength silico-manganese spring steel (20–25 mm diameter)
- **Laser Type:** Fiber laser
- **QR Size:** 15×15 mm to 20×20 mm
- **Engraving Depth:** 0.1 – 0.2 mm
- **Positioning:** On the outer arm surface, avoiding the toe or curve under load.

2. Liners

- **Material**: Glass-filled nylon (GFN) or metal (3–6 mm thickness)
- **Laser Type:** CO_2 laser
- **QR Size:** Up to 25×25 mm
- **Engraving Depth:** 0.1 – 0.15 mm
- **Positioning:** On flat areas away from contact zones with the rail or clip.

3. Rail Pads

- **Material:** Rubber or composite (6–10 mm thickness)
- **Laser Type:** CO_2 laser or surface embossing
- **QR Size:** Around 20×20 mm
- **Engraving Depth:** ≤ 0.1 mm
- **Positioning:** On flat regions not in direct load or groove areas.

4. Concrete Sleepers

- **Material:** Pre-stressed concrete (150–300 mm section depth)
- **Laser Type:** CO_2 laser
- **QR Size:** 40×40 mm or slightly larger
- **Engraving Depth:** 0.5 – 1 mm
- **Positioning:** On the top or side face, away from the tendon or high-stress zones.

Each engraved code can be sealed with a protective fiber-reinforced coating to keep it readable despite exposure to rain, dust, heat, and vibration.

Conclusion

From our interactions in the field and the technical analysis, it is clear that laser-based QR code marking is practical and safe for all major railway track fittings, provided that specific material parameters are followed.

However, successful adoption will rely on staff training, awareness sessions, and a gradual rollout across depots. With proper handling and testing, this approach can create a reliable digital method to trace and monitor every track fitting throughout its lifecycle.