Failure Analysis of Selected Fasteners Used During World War II

by:
Charles C. Roberts, Jr.
ccr@robertsarmory.com

It is often helpful to look back in history and examine what fasteners were used in the past, as it shows prior art and also serves as a basis for new ideas. During World War II, development of fastener usage reached a feverish pitch. Each country rushed various designs into production, often without thorough testing. An often overlooked fastener used throughout World War II was the connector that fastened tank track sections into a continuous track. Their development was influenced by testing and experience during combat which often resulted in redesign.

This article deals with fasteners used on military vehicles to connect track sections during World War II. Tank track fasteners were a problem in World War II. The ideal fastener would connect tank track sections together, allowing flexibility of the sections as they traveled around the drive sprocket and idler wheel. The ideal fastener would allow for tight track adjustment to avoid throwing a track and have minimal wear. The following are selected examples of track section fastener applications during World War II.

Figure 1A is a view of a 1943 M22 light tank with Cardon-Loyd designed track.

Fig. 1A — U.S. M22 light tank 1943.

Figure 1B is a view of the dry pin track fastener that connects the tracks on this vehicle. There were two drive sprockets contacting the outer round surfaces of the track sections. The round retainer at the bottom middle in **Figure 1B** is placed on the connector shoulder and staked into position using a punch die that spreads the steel shoulder and secures the circular retainer as shown in **Figures 1C** and **Figure 1D**.

Fig. 1B — Two Cardon-Loyd track sections with pin and retainer.

Fig. 1C — Staking the retainer onto the track pin.

Fig. 1D — View of pin head end and staked end.

To remove the track fastener or connector, one has to drive it out using a sledge and special tool to shear off the circular retainer. A new fastener is required to reassemble the track. The hardness of the track pin was approximately 25 RC. There was variability in track retention because skill was required to install the track pin. The circular retainer had to be properly secured by the deformation to the shoulder of the track pin or detachment would occur.

Wear of the fastener was also a problem. Severe wear would occur from road dust and sand, causing the holes in the track section to elongate and the track pins to decrease in diameter as shown in **Figure 1E**. A tight track tension caused the highest wear rate, so track tension was reduced as shown by the track sag in **Figure 1A**. This increased the chance of throwing a track under certain conditions. It should be noted that at each connection, the track pin would rust in and not allow pivoting, while the neighboring track section would pivot on the track pin. That explains the severe pitting on one part of the pin as well as the smooth wearing on the other in **Figure 1E**. Failure modes included severe wear and throwing of a track from lack of track tension.

Fig. 1E — Wear pattern in the center with pitting corrosion to the left and right.

This fastener design was deficient in that skill was required to properly deform the retainer, resulting in unreliability and severe wear from easy dirt entry into the track pin bearing surfaces.

Figure 2A is a view of a T16 carrier used by the British in World War II. **Figure 2B** shows the tracks sections used in this vehicle. This track utilized a single sprocket design that engaged the track in the center. Track pin connectors had a donut-style retainer that was held in position by a roll pin. The retainer worked well, but as with many dry pin designs, severe wear resulted as shown in **Figure 2C**. Again, rust secures the pin on one track section, but allows rotation on the neighboring track section. There is also evidence of bending deformation from the center drive sprocket as the pin and track sections wear. **Figure 2D** shows track twist from wear and bending deformation of track pins. Failure modes for this pin design were severe wear and bending, resulting in track twist.

Figure 3A is a photo of a Russian T34 tank which was manufactured by the thousands in WWII. Like many tanks of that era, it utilized a pin to connect the tracks. This was an unusual design in that the track pin did not have a retainer. It was a floating pin inserted from the inside of the track to the

Fig. 2A — British T16 carrier.

Fig. 2B — Two track sections with pin, donut retainer and roll pin.

Fig. 2C — New upper pin and used lower pin showing wear and pitting corrosion patterns.

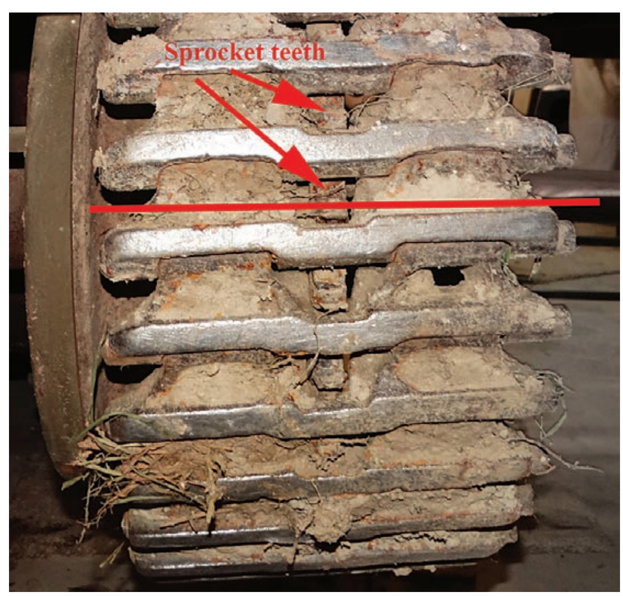

Fig. 2D — Track twist from excessive wear and bending of track pins.

outside (**Figure 3B**). It had a round head at one end to prevent the pin from working its way outboard. The design was such that the pin would float toward the inside, but be pressed back into position as the tracks turned, by a shoulder welded to the hull as shown in **Figure 3C**. This apparently worked, but was noisy as the pins were getting smacked back into position. This tended to increase wear since it added translation

Fig. 3A — Russian T34 medium tank.

Fig. 3B — Track pins working out of position in a T34 (courtesy of Doug's Heavy Metal Gallery).

Fig. 3C — Track pin shoulder pin relocater welded on the side of the hull (courtesy of Doug's Heavy Metal Gallery).

movement to the pin as well as the normal rotary movement of the track pin. Long-term reliability of such a system is in doubt, but the expected life of such a vehicle in WWII was on the order of days. Also there was the danger of a loose pin working out quickly while the vehicle was moving slowly and engaging on some other location on the hull. This design was inexpensive but suffered from excessive wear and the likely pin interference and fracture when the pin engaged the hull in a location other than the shoulder.

Figure 4A is a photo of the U.S. light tank M5A1 which used rubber block track sections. The steel tracks that have been shown previously tended to damage paved road surfaces. The rubber block tracks do not and are very quiet. The track pins are pressed into the track block with rubber bushings around the pins as shown in **Figure 4B**. A track guide and connecter was pressed into the track pin, seen in **Figure 4C**. A "T" wedge fastener is inserted in the connector and the lock nut tightened so the track blocks are secured as shown in **Figure 4C**. Movement of the track sections relative to each other is allowed by the rubber bushings that surround the track pins. This movement is limited, but the drive sprocket and idler wheel are large as shown in **Figure 4A** and the limited relative movement of the track sections is easily accommodated.

It should be noted that when several track blocks are connected as shown in **Figure 4D**, there is a curve to the assembly. Since there is limited rotary movement between track blocks on this system, the flats on the track pins are set up so that when the track is laid flat there is a residual torque applied to the pins in one direction that reverses when the track assembly travels around the sprocket and idler wheel. Each pin has a limited amount of flexibility as a result of the rubber bushing

Fig. 4A — M5A1 light tank.

Fig. 4B — Two track sections, connector guide and wedge lock fastener.

Fig. 4C — Track guide and connecter was pressed into the track pin.

and each pin rotates a given amount.

This system, although more complex than the dry pin design, does not experience wear at the track pins. The wear occurs on the rubber block outer surface as a result of road contact. The failure mode on this system is the tearing of the rubber track block. As the track travels around the idler wheel, the gap between the track blocks opens up and if a rock or some other hard object falls into the gap, it tears out the rubber when the track sections straighten out. Consequently, the track had to be changed every 400 to 1000 miles depending on the type of terrain encountered. Another deficiency in this design is that when the tank was hit and caught fire, the rubber track blocks would burn and the track would not be salvageable by field personnel. The steel track was not bothered by a fire and was readily salvageable. There was a steel version of this system, but it tended to severely damage paved roads.

Fig. 4D — 70th Tank Bn of WWII assembling track sections, circa 1941 (courtesy of Taynton family collection).

Four track pin connector schemes from World War II have been reviewed. There were several more systems, attesting to the conclusion that there was no one design that satisfied all conditions at that time. Although the dry pin systems were inexpensive to manufacture, they suffered from severe wear from road dust and other debris. The rubber bushing system worked well but was expensive and required periodic replacement as a result of road debris damage. It also did not survive a fire if the tank were hit.

Fastener designs for tank tracks during World War II were not always optimal, but good enough to make it through several battles. FTI