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Improper Materials Selection in Motorcycle Stud Bolt

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During the investigation of a motorcycle accident, it was noted that a bolt had fractured that was part of the rear wheel suspension. The shoulder bolt was located underneath the main frame of the two passenger vehicle. The left rear shoulder bolt broke causing the motorcycle to become unstable. Others were evaluating the dynamics of the incident. We were asked to determine the nature of the bolt failure, whether the bolt was appropriate for the attachment of the air suspension system to the motorcycle, and if the bolt was fit for use.

The shoulder bolt "head" was not recovered from the scene of the incident, but the threaded portion of the bolt was retained by the frame connection flange. The primary focus of the initial inspection was the analysis of the bolt fracture surface and engineering aspects of the remaining threaded bolt end. We were specifically requested to evaluate the metallurgical aspects of the incident.

Items recovered include the motorcycle swing arm, rear suspension component (as removed), 3 bolts as seen in Figure 3 and 5 washers, and a small black cushion. In addition ASTM E 1351 acetate replicas were prepared to secure debris and replicate the fracture bolt and witness mark areas on the subject motorcycle.

Some of the work performed included: 1) directed X-Ray Radiography testing, 2) prepared ASTM E –1351 Acetate Tape Replica Nondestructive impressions as shown in Figure 4; and 3) performed an engineering analysis of all evidence, materials received and testing.

1. The shoulder bolt was fabricated from a resulfurized steel that conforms to an AISI (American Iron and Steel Institute) 1137 grade as seen in Table 1. Generally, this steel is used to fabricate "screw machine parts" where machinability is the primary concern. Its microstructure consisted of manganese sulfide particles in a matrix of tempered martensite.

2. Re-sulfurized steels are generic, un-graded, and typically NOT acceptable for use in high stress and high cycle vibrational fatigue life, such as for bolted fasteners.

3. The shoulder bolt failed by the growth of several "notches" in the perimeter of the thread root by a progressive "fatigue" failure mechanism as observed during SEM examination.

4. Metallographic examination and hardness testing, presented in Table 2, revealed the shoulder bolt was heat treated using a classic quench and temper treatment as seen in Figure 1. It is likely that a quench crack at the root of one or more threads was responsible for crack initiation and progression as seen in Figure 2.
5. Prior to production, an engineering analysis and testing should have been performed on the connecting fasteners between the frame swing arm and suspension components in order to justify use of an ungraded bolt.

	C	Si	Mn	P	S	Cr	Mo	Ni	Cu
Frame	0.19	0.23	0.78	0.016	0.20	0.03	0.01	0.02	0.07
Bolt	0.33	0.06	1.49	0.019	0.11	0.04	0.02	0.05	0.09

Table 1. Chemical Analysis Results Indicating Frame to be AISI 1018 and Bolt as 1137

Fractured Bolt (LR)	Right Rear Bolt	Left Front Bolt	Right Front Bolt	Swing Arm
27, 29, 30 HRC	26, 29, 30 HRC	30, 28, 27 HRC	28, 31, 30 HRC	89, 88, 89 *HRB*

Table 2. Hardness Test Results

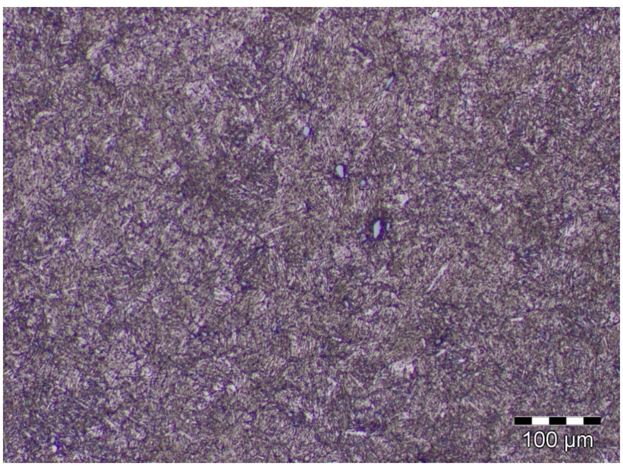

Figure 1. Typical example of microstructure of fractured bolt.

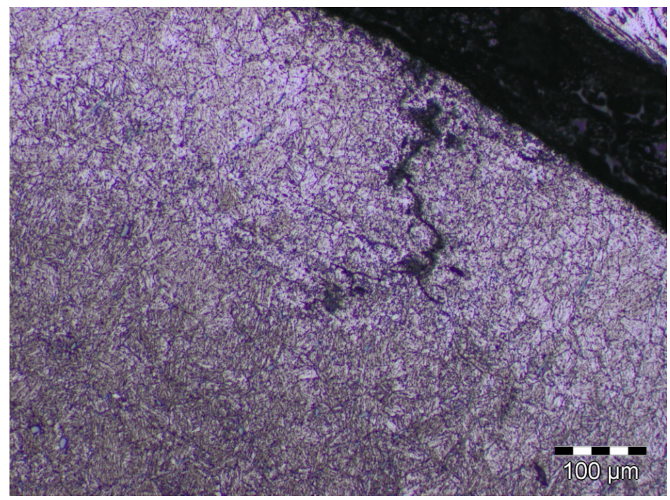

Figure 2. Example of secondary crack near outside of bolt.

Figure 3. Example of an unfractured bolt.

Figure 4. Replication of the bolt fractured surface.

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