Available online at www.sciencedirect.com

ScienceDirect

Defence Technology 12 (2016) 380–387

www.elsevier.com/locate/dt

Metallurgical analysis of a failed maraging steel shear screw used in the band separation system of a satellite launch vehicle

S.V.S. Narayana MURTY *, Sushant K. MANWATKAR, P. Ramesh NARAYANAN

Material Characterization Division, Materials and Metallurgy Group, Vikram Sarabhai Space Centre, Trivandrum 695 022, India

Received 13 January 2016; revised 4 May 2016; accepted 13 May 2016

Available online 24 May 2016

Abstract

Maraging steels have excellent combination of strength and toughness and are extensively used for a variety of aerospace applications. In one such critical application, this steel was used to fabricate shear screws of a stage separation system in a satellite launch vehicle. During assembly preparations, one of the shear screws which connected the separation band and band end block has failed at the first thread. Microstructural analysis revealed that the crack originated from the root of the thread and propagated in an intergranular mode. The failure is attributed to combined effect of stress and corrosion leading to stress corrosion cracking.

Keywords: M250 grade maraging steel; Shear screw; Separation system; Mermen band; Stress corrosion cracking

1. Introduction

Maraging steels are high strength steels widely used for aerospace applications where a combination of high specific strength and fracture toughness are the basis for selection. These steels are based on the discovery about the fact that controlled additions of cobalt and molybdenum to the iron-nickel martensitic matrix result in a combined age hardening effect significantly higher than the additive effects of each of these elements [1]. Further, minute additions of titanium and aluminum make the iron-nickel-cobalt-molybdenum matrix amenable to supplemental age hardening [2]. Maraging steels of different grades have been designed to obtain high proof strength and optimum toughness catering to varied applications [3]. Among the family of Ni-Co-Mo maraging steels, 18Ni-8Co-5Mo (with a 0.2% yield strength of "1700 MPa" or "250 kilo pounds per square inch") steel is widely used. Some of the applications in aerospace systems include solid rocket motor casings, merman bands for stage separation, fasteners requiring a good strength and toughness combination [4]. In recent years, there is an increased interest in these materials in view of their uses for a range of applications [5–8].

In one of the applications, M250 grade maraging steel was used to fabricate shear screws used in the Mermen band separation system of a satellite launch vehicle. These Mermen band separation mechanisms are generally used in the upper stages of launch vehicles, where higher shock levels are not allowed due to proximity to satellite and other sensitive avionics system packages. These types of systems are also used to separate the payloads from the launch vehicles as well as for circumferential separation of the payload fairing. This system consists of a fore end ring attached to the upper stage and an aft end ring connected to the lower stage [9]. The fore and aft end rings are clamped together by floating wedge blocks and are held together at the flanges by two preloaded semi-circular bands which are known Mermen bands. The separation system consists of 40 Nos. of wedge block integrated with two merman bands and band end block by wedge block holder and shear screws. The band assembly is connected by a bolt assembly and bolt cutter. The bolt cutter cuts the bolt and two band assemblies separate the stages. Failure of any of the components of separation system will lead to the mission failure. Therefore the fabrication and quality control are important aspects in the development of these critical systems. Separation mechanisms

Peer review under responsibility of China Ordnance Society.

* Corresponding author. Tel.: 0091 471 256 3628.

E-mail address: susarla.murty@gmail.com (S.V.S.N. MURTY).

http://dx.doi.org/10.1016/j.dt.2016.05.001

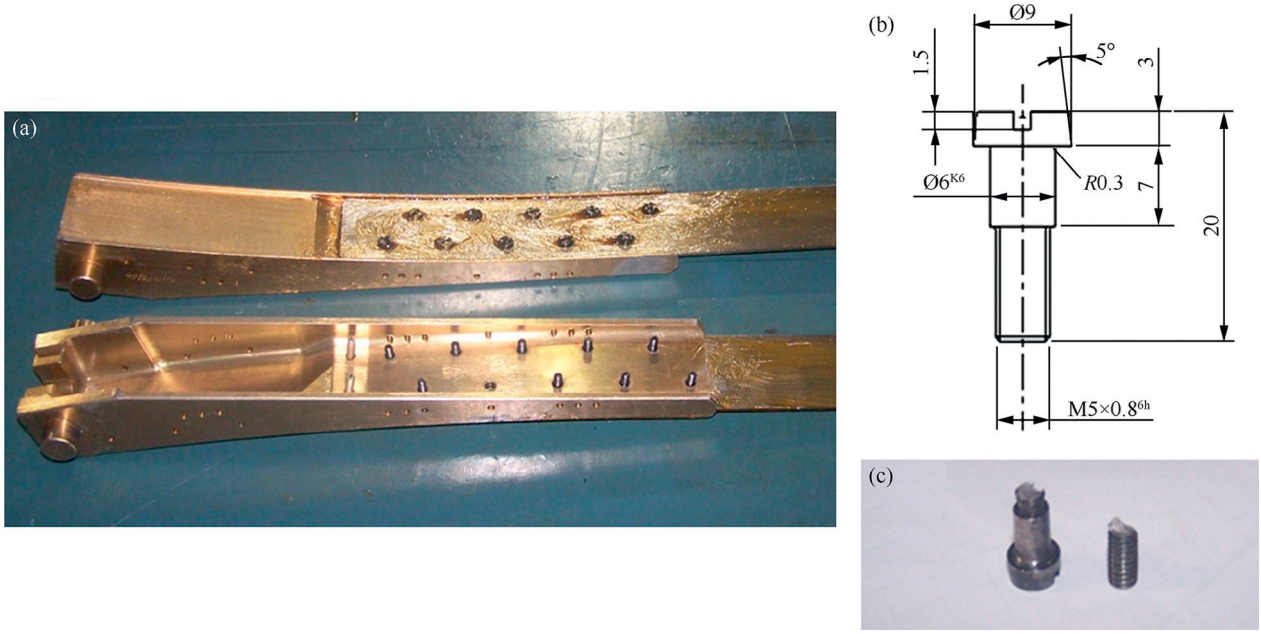

Fig. 1. (a) Photograph of the band with shear screws in place (except the failed one left with an empty slot) along with (b) drawing of the fastener and (c) photograph of the failed shear screw head (left) and shank (right).

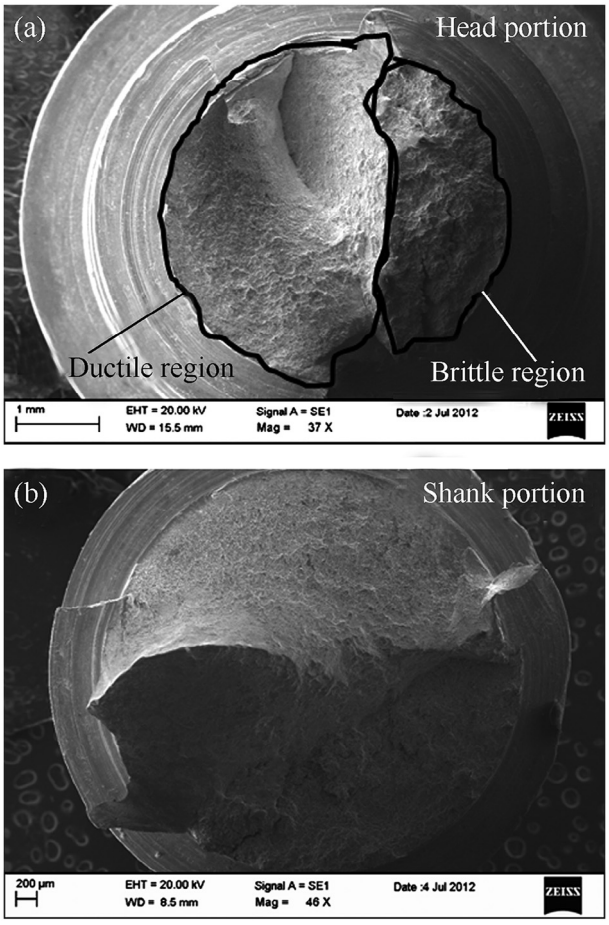

Fig. 2. Scanning electron micrograph (a) showing the fracture surface (head portion) of the shear screw having two distinctly separate regions (marked ductile region and brittle region) and (b) showing the fracture surface of the failed counterpart shank portion. Note the minor difference in the magnification of two photographs.

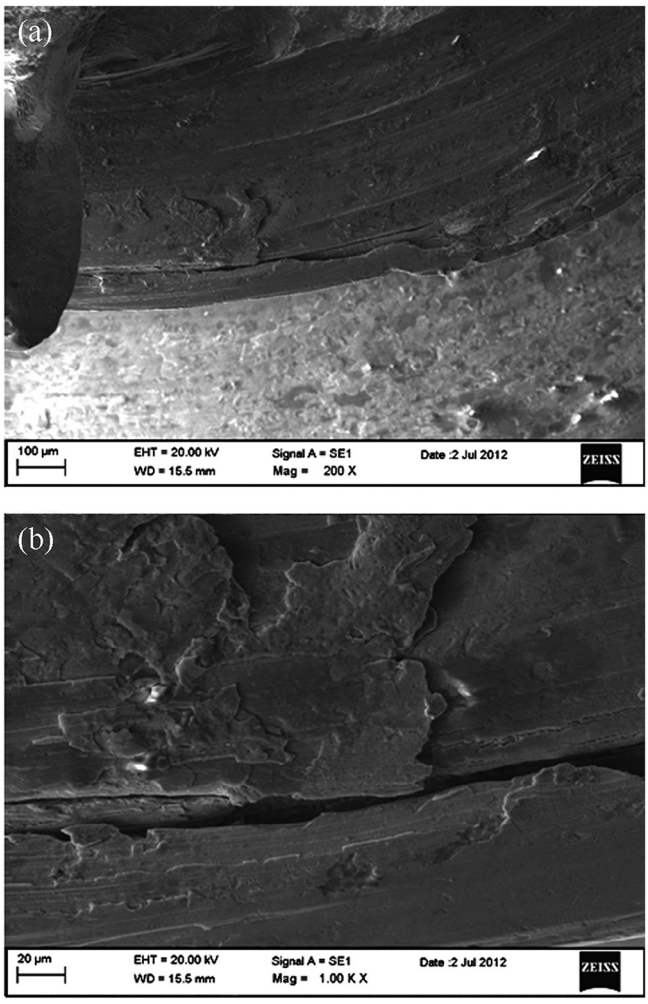

Fig. 3. Scanning electron micrographs showing defects in thread regions of the shear screw showing local attack and cracks.