ESi

CASE STUDY

METALLURGICAL EVALUATION FROM A REFEREE STANDPOINT

An investigation was performed to identify the root cause of “stardust” defects on a plated firearm, to determine their nature, location, and provide corrective actions.

SITUATION

A firearms manufacturer was frustrated by the presence of tiny visual defects – nicknamed “stardust” – on random lots of die castings. The manufacturer took great pride in both the functionality of the firearm and its appearance. Although these defects were typically less than 0.003" in diameter, they detracted from the required flawless appearance of the firearm. The die casting is designed to have a mirror finish. It is cast, deburred, cleaned, polished to a high luster and then copper and nickel plated for corrosion protection and aesthetics.

The manufacturer was losing money as hardware was being rejected by the quality control department because of this defect. The die casting shop (who is responsible for the polishing) blamed the plating shop. The plating shop blamed the die caster. The manufacturer called needing a referee to identify who was at fault and what was the root cause of these defects.

Practice: Materials Science

ESi Consultant

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Services Utilized

- X-Ray CT Scanning
- Scanning Electron Microscopy/ Energy Dispersive Spectroscopy (SEM/EDS)
- Metallography
- Optical Microscopy

About ESi

For over 30 years, ESi has leveraged its multidisciplinary team of engineers, scientists, and professional technical staff to investigate many major accidents and disasters. Our technical expertise, hands-on experience and state-of-the-art facilities, combined with diagnostic, analytical and physical testing capabilities create an ideal environment for quickly identifying and interpreting the facts of a case.

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SOLUTION

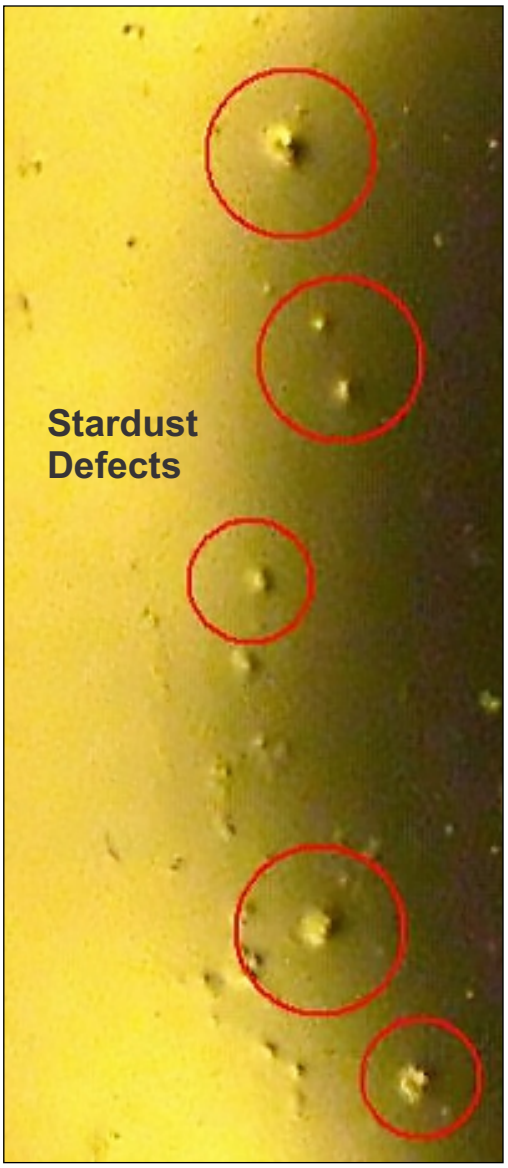
Initial examinations were performed with optical microscopy, using various lighting conditions. This was important as optical examination of highly polished surfaces can be problematic due to reflectance issues.

Samples were then examined using scanning electron microscopy (SEM) to identify exact defect location and if the defects were open to the surface. The SEM uses electrons for imaging so any problems associated with reflected light were eliminated. It was determined the defects were not open to the surface but were subsurface in origin.

Additionally, several metallurgical mounts were cross sectioned to pinpoint the defect areas. This technique determined the nickel-plated top layer was acceptable and that the defects were present in the initial layer of plated copper.

Other samples were then examined using X-ray CT scanning. This technique provides a three-dimensional (3D) scan of the part. A CT scan dataset allows for virtual cross-sectioning of the area of interest on any plane. The metallographic sectioning technique only provides information on the one sectioning plane obtained with that mounted sample.

The CT scanning was performed to determine if porosity, inherent to the die casting process, was responsible for the defects noted in the copper plating layer.



RESULTS

The CT scans coupled with the metallographic cross-sections identified the root cause of the “stardust” defects as originating in the plating, specifically in the copper plated layer, not the nickel-plated layer. The “stardust” was not originating from any die casting material defects (i.e. porosity, shrink, etc.). Inherent porosity was noted in the castings but was located much further beneath the surface and was not connected to the surface plating layers, where the defects were located.

To determine the exact nature of the copper layer defects, the metallurgical mounts were then examined by SEM/EDS (Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy). This technique identified aluminum oxide particles trapped in the plated copper base layer. These particles caused the “stardust” appearance on the surface of the hardware, which was mirrored in the nickel plated layer. The fault of the defects was from the plating supplier. Filtration of the copper plating bath eliminated the problem.

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Engineering Consulting and Forensic Investigation

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Why ESi. The Materials Science and Engineering practice group is comprised of consultants with backgrounds in:

- Metallurgical Failure Analysis
- Destructive & Non-Destructive Testing
- Optical Microscopy
- Metallography Evaluations
- Microstructure Evaluations
- Materials Analysis
- Scanning Electron Microscopy
- X-ray Computed Tomography (CT Scans)
- Chemical Analysis
- Process Evaluations
- 3D Laser Scanning
- Corrosion Evaluation
- Fatigue & Fracture Mechanics
- Mechanical Testing