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Technical Review of Manufacturing Defects in Cold Forged M6 Nuts

Vidisha Joshi[1,*], Pratik Kikani[2], G.D. Acharya[3]

Abstract

This review delves into the intricacies of M6 cold forged nuts, a pivotal component in many assemblies. These nuts are essential for maintaining structural integrity, yet their production can often lead to defects that compromise their performance. Key issues include material flaws, such as impurities and inconsistencies, dimensional inaccuracies that can affect fit and function, and surface roughness that can impact the nut's strength and durability. Material flaws can arise from the quality of the raw materials or from the forging process itself, leading to weaknesses in the final product. Dimensional inconsistencies often result from deviations in the manufacturing process, leading to nuts that do not meet precise specifications. Surface roughness, another critical defect, can reduce the fatigue life of the nuts and lead to premature failure under stress. The impact of these defects on assembly performance and safety cannot be overstated. Defective nuts can lead to inadequate load distribution, increased wear, and ultimately, structural failures. This underscores the importance of stringent quality control measures during production. Advanced detection methods, such as ultrasonic testing, X-ray inspection, and surface profiling, play a vital role in identifying defects early in the manufacturing process. Preventive strategies, including precise control of raw material quality and adherence to manufacturing protocols, are crucial in minimizing defects. By understanding these challenges and the corresponding solutions, researchers, engineers, and manufacturers can enhance the quality and reliability of M6 cold forged nuts. Ensuring rigorous quality control and employing advanced detection techniques are essential steps toward achieving defect-free production, ultimately safeguarding the performance and safety of assemblies that rely on these critical components.

Keywords: Cracks, defects, fasteners, fracture, M6-Nut

INTRODUCTION

Bolts and screws play an important role in machine performance. Most fasteners are subjected to variable loads, leading to the well-known fatigue phenomenon that is responsible for most premature bolt failures. Many parameters such as thread pitch, thread angle, root radius, and material can affect the performance of a screw or bolt. Bolts and nuts are usually manufactured using either fine or coarse threads [1].

Points and bolts are used in various products, machines, and structures. It is a type of industrial fastener in which fasteners are used to join, hold, or assemble one or more components. Bolts and nuts belong to the category of head and threaded fasteners, respectively. A bolt is a metal rod raised at one end and threaded at the other end. Nut is an element above this thread. Nuts and bolts have various shapes, designs, and sizes. There are many industries that produce these nuts and bolts of various sizes, but the demand is also increasing, and the raw materials for the products are readily available locally. The

***Author for Correspondence**
Vidisha Joshi
E-mail: Vidishajoshi72@gmail.com

[1]PG Scholar, Department of Mechanical Engineering, Atmiya University Rajkot, Gujarat, India
[2]Assistant Professor, Department of Mechanical Engineering, Atmiya University Rajkot, Gujarat, India
[3]Professor Emeritus, Department of Mechanical Engineering, Atmiya University Rajkot, Gujarat, India

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basic raw material is a mild steel wire coil/rod with the required diameter. The material composition controls the quality of nuts and bolts. Points and bolts were divided into two categories: (i) usage and (ii) head shape. In terms of use, nuts and bolts come in many forms, including larger bolts, machine bolts, studs, foundation nuts, and bolts. In terms of appearance, nuts and bolts are classified by head shape, such as hexagonal head, square head, round head, pan head, and head truss [2].

MATERIAL USED

Points, bolts, and fasteners are composed of various materials. Steel is the most commonly used material for the fabrication of nuts, bolts, and fasteners. Apart from this mixture, silicon, bronze, brass, aluminum, chromium, titanium, plastic, and other exotic materials are used to make these products. Some of these materials can be further divided into different categories. This was done to explain the special mixture of compounds, their hardening, and the process involved. In addition, there are several nuts and bolts with different coatings. This is done to alter the fastener's look and increase corrosion resistance. Characteristics such as strength, softness, resistance to corrosion, galvanic corrosion, etc. Considering that the reinforcement material is important in the selection process, the cost of the material is an important factor in determining which material should be selected to manufacture the product [3].

MANUFACTURING METHOD

Hot-forged nuts and bolts are produced by hammering or pressing when the material is hot or above its recrystallization temperature. The process of forming products by hot forging is recycled because this process provides certain advantages to the products, which are produced only by work. These include material savings, better grain structure and flow, increased strength, and higher productivity. Simultaneously, it is tested after the manufacturing process to control the mechanical properties of the components [4].

When a nut is produced, a hexagonal rod of the desired size is procured, and the nut is cut in an automatic cutting machine. Next, the nut blanks were drilled, and the nut was pressed into the tapping machine. Finally, it is separated into shiny barrels [5].

MANUFACTURING PROCESS

Spheroidize Annealing

This process is used to facilitate the machining of steel by keeping it near the Ac1 temperature line for a long time and converting the carbides into spherical shapes via slow cooling (furnace cooling) after active swing annealing in this region. This process was also designed to increase ductility.

Cold Forging

Cold forging is a process that occurs at temperatures close to room temperature. This is achieved by placing the workpiece between two dies and then placing it against the dies until the metal takes its shape. Cold forging is performed, and the nut has a basic shape.

Machining

Machining is a manufacturing process that involves cutting and machining material that is removed from a larger material to obtain the desired shape or part; Machines are is usually made of metal material. Modernized machine operation with CNC and VMC turning centers ensures high accuracy and precision.

Thread Rolling and Nut Tapping

Thread rolling is a metal forging technique in which threads are shaped to match the pattern of a roller die. Unlike metal cutting, grinding, or chasing, this process does not involve the removal of any material from the workpiece. Hardened steel dies with tooth-like structures press against the outer diameter of the cylindrical blanks to reshape their surfaces. The pressure exerted by each tooth pushes the material outward, conforming to the profiles of the thread rolls. Consequently, the resulting part features threads that replicate those of the die, with the displaced metal forming thread crests.

The thread-rolling shop has automatic tangential thread-rolling machines equipped with an autofeeding conveyor system.

A nut tapping machine is utilized for machining internal threads within nuts positioned inside holes of varying specifications, whether through holes or blind holes. The nut-tapping process involves several distinct stages: feeding, tapping, reversing, retracting, and discharging. During tapping, the nut enters the tap, initiates the cutting action, removes chips, and achieves bottoming tapping. Subsequently, in the reverse phase, the nut remains positioned at the final cutting edge of the tap, while the tap rotates in the opposite direction. In the retraction stage, the nut disengages from the tap. Because there is no cutting action in the reverse direction of the tap, torque is generated through the friction between the nut and tapped threads. Finally, in the discharging phase, the nut moves away from the tap with the untapped nut pushing the tapped nut forward.

Heat Treatment

Heat treatment is a method aimed at enhancing wear resistance through material hardening. It involves heating a metal or alloy to a precise temperature and subsequently cooling it to achieve hardness. This technique can be applied at various stages of the manufacturing process to alter the specific properties of the metal or alloy. To ensure part reliability and durability, a heat treatment was performed. Phosphating is performed to provide corrosion resistance during part application under different weather conditions.

Hydrogen De-embrittlement (Stress Relief)

Hydrogen embrittlement is a phenomenon that causes the loss of ductility in high-strength materials with plating as a surface treatment, thus making it brittle.

Thus, to eliminate this possible failure of the 10.9 and above graded parts (fasteners having hardness more than 32 HRC), the hydrogen de-embrittlement process is carried out immediately after platting the OR phosphate process by a continuous conveyor-type Hydrogen De-embrittlement furnace (Stress Relief Furnace) [6].

DEFECTS IN NUT FASTENERS

Retaining nuts are a common component of the connectors. The following surface defects are common in fastening nuts: cracks (hardening cracks, shear cracks, forging cracks, slag cracks, cracks in the locking part of the all-metal effective torque lock nut, or cracks in the nut-washer assembly on the seal seat), crease, dent, cut, and damage.

Cracks

A crack is an open fracture (crystalline) at the grain boundary or behind the grain and may contain foreign elements. Cracks are often caused by excessive stress during forging or other forming processes, or during metal heat treatment, and can also be caused by raw materials. When the workpiece is heated, half of it is usually colored, owing to the sharpness of the oxide scale [5].

Quenching Cracks

During the heat treatment process, quenching cracks can occur owing to the excessive thermal stress and strain. Quenching cracks are usually irregular and occur at irregular locations in the nuts. Note: Quenching cracks of any depth, length, or part are not allowed to exist [7–9] (Figure 1).

Forging Cracks

Causes of cracks and slag joint cracks: Intrinsic cracks can occur during cutting or machining and can be on the top or bottom surface of the nut or at the junction of the top (Figure 2).

Cracks in the Locking Part

Cracks in the key part of the all-metal effective torque lock nut can be produced during cutting, machining, or lapping (smoothing), and can also occur on the outer or inner surface [10] (Figure 3).

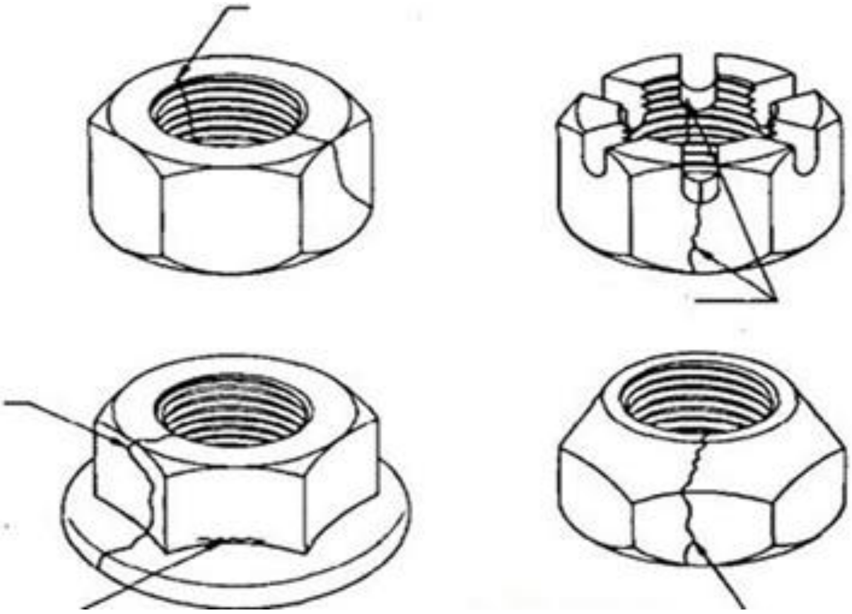

Figure 1. Quenching cracks.

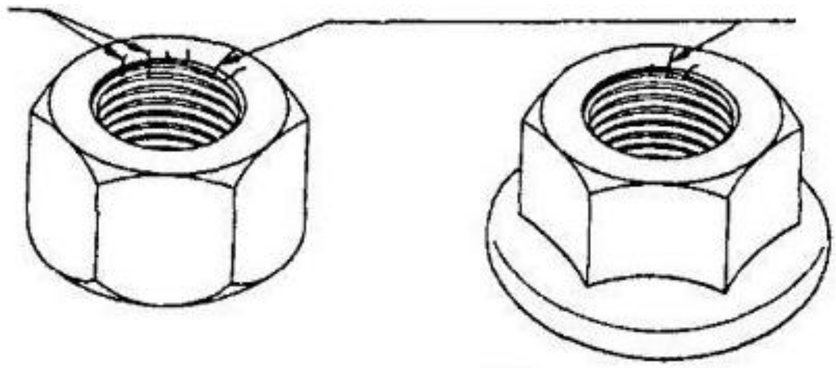

Figure 2. Forging cracks and slag cracks.

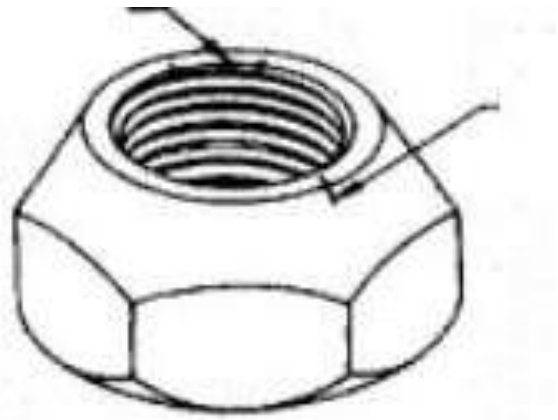

Figure 3. Cracks in the locking part of the all-metal effective torque lock nut.

Cracks in the Washer Seat of the Nut-washer Assembly

A fracture seat washer is a crack on the edge of the metal, and a convex part is used to fix the washer on the nut. Causes of Gas Seat Crack Nut-Washer Assembly: During the process of assembling the bowl, the pressure on the edge or raised part can cause the seat of the bowl to crack [11] (Figure 4).

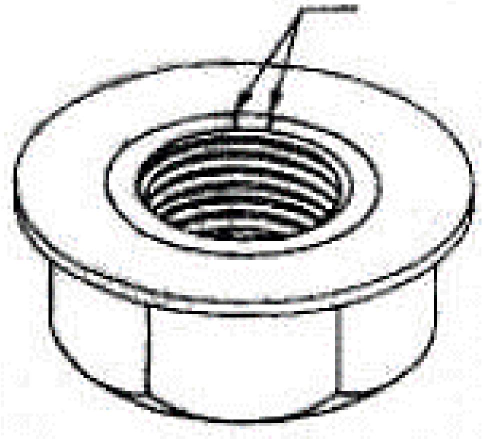

Figure 4. Cracks in the washer seat of the nut-washer assembly.

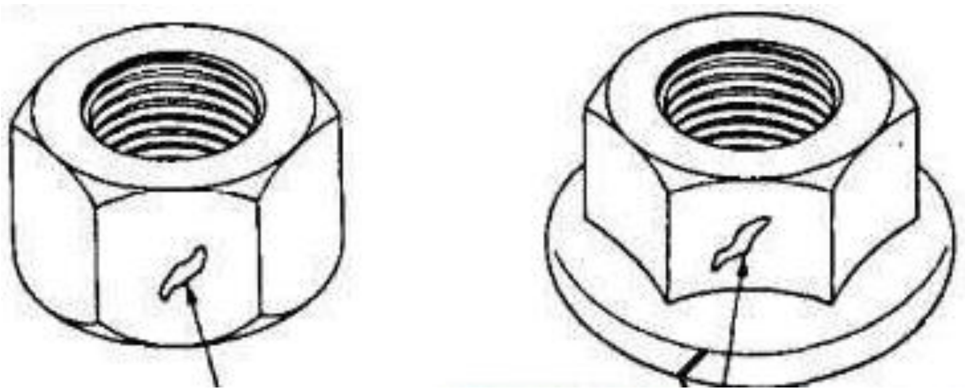

Figure 5. S-Sheer burst.

Shear Burst

Shear cracks are metal-surface cracks. Causes of shear cracks: Shear cracks can occur on the outer surface of the nut or around the surface of the nut flange. Usually, the shear is divided by the axis of the nut axis at approximately 45° (Figure 5).

CONCLUSION

This study investigates the manufacturing defects in cold-forged M6 nuts, which are critical for ensuring assembly integrity. Despite their importance, there is limited research on defects arising during the manufacturing process. Common issues include material flaws, dimensional inaccuracies, and surface roughness, all of which can compromise nut performance and safety. Even minor defects can lead to significant failures, highlighting the need for stringent quality-control measures.

Understanding and addressing these manufacturing defects are essential to prevent assembly failures. Advanced detection methods and strict adherence to manufacturing protocols are crucial to identify and mitigate these issues. By focusing on these defects, this study aims to enhance the reliability and durability of M6 nuts, ensuring their effectiveness in various applications. Addressing these concerns is vital for improving the overall product quality and safety in assemblies that rely on cold-forged M6 nuts.

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