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# Effect of Heat Treatment Methods on the Fatigue Behaviour of Hammermill: A Review

# Effect of Heat Treatment Methods on the Fatigue Behaviour of Hammermill: A Review

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**Abstract-**
The production of reliable and sustainable hammermill involves heat treatment which is part of overall cost of production. Heat treatment has engrossed a lot of interests since it is one of the main production methods to improve corrosion resistance of coatings, enhancing malleability, hardness and strength to lessen mechanical or chemical damage. Nevertheless, various heat treatment procedures had resulted to hammermill failure as a result of material wear, erosive wear, impact wear, machine clogging and shock loading wear which eventually affects the efficiency of the hammermill. The study thus engrossed on some particular thermal treatment on mild steels and their impacts on hammermill applications. Progressive loss of material (wear) is a common failure that leads to hammermill fatigue due to cyclic stress posed on the hammers based on literature reviews. The mode of quenching and especially the discrepancy in the concentration affects the efficiency of the crushing unit. The fatigue performance of materials is being enhanced due to stress- relief heat treatment which makes it possible to increase the strength and ductility of the samples. However, the utilization of experimental model and simulation approach for stress prediction for the study is further recommended.

**Keyword**: Fatigue, Hammermill, Heat treatment, Production

## 1. Introduction

The significant changes in the external behaviour and properties of metallic materials and their alloys are made possible by heat treatments [1]. The microstructure and configuration of steels are being affected by heat treatment thereby altering the mechanical properties of steels. Thermal treatment also helps lower the effects of cold work, enhances dimensional balance for machining, softening the HAZ and thus enhancing toughness, improving the resistance to stress erosive cracking, enhancing ductility, etc [2]. Different types of thermal treatment can be emphasized according to on the component of hammermill to be thermal treated to obtain the high toughness of low carbon steels. They include case hardening, direct hardening, nitriding, nitrocarburization and carbonnitriding [3]. The component usually fails prematurely due to low strength in the material [4]. This frequent failure is also attributed to manufacturing method such as the stiffness of the tool used in hammer mill fabrication [5]. High strength S690 steels are produced through quenching and tempering being the heat treatment technique

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extensively used with considerable amounts of costly alloy elements [6]. Heat treatment enables high strength S690 steels achieve their better strength but welding operation may subsequently reduce their strength [7]. Phase change, re-crystallization and grain growth in microstructures of these steels are initiated during welding operation due to heating/cooling cycle induced. The highest temperatures during the joining of metal steels and the cooling rates after the joining are to be appropriately monitored so as to avoid defects like porosity, incomplete fusion, undercut and cracking which can cause a substantial decrease in their mechanical properties [8]. The impact of heat treatments in coating formation rate, phosphate crystal size and coating anti-erosive wear properties cannot be overlooked [9]. The fatigue performance of materials is being enhances due to stress- relief thermal treatment which makes it possible to increase the strength and ductility of the samples [10].

## 2. Mild Steel

Mild steel is well known for its low carbon content but generally accepted in many engineering applications due to its better malleability, weld-ability and less expensive. The surface of mild steel had engrossed a lot of interests for many studies focused on the surface of mild steel as a result of its poor mechanical damage property, corrosion and, abrasion phenomena, thus, change of the outer layer of mild steel and verification of its friction-wear property are very essential. The utilisation of the mild steel in friction wear applications is limited due to a critical wear evolution mode [12]. Therefore, change in the outer layer of mild steel is pertinent to the interaction of the surface relative to motion so as to overcome the friction wear. However, the crack formation on the outer layer of the mild steel is the drawback induced by the secondary phase procedure for mechanical damage and corrosion application [13].

## 3. Quenching and tempering of mild steel hammermills

The degree of wear and impact of falling knobs is high in the head of hammers made of costly wear safe material while its arm comprised of low alloy steels in quenched and tempered condition tending to rotational fatigue, reactive effect however insignificant wear. Severe loss of money and man hours can be diminished or eliminated where the yearly shut-down rather than multiple delays and disruption in manufacture is put in place [11]. Ensuring a high-quality production, the wear and breakage of a crushing tool must be monitored as worn or damaged devices can develop new problems within the crushing procedure [12]. High temperature generated below the surface of the grinding balls caused a severe impact of fatigue failure of the mill liners and a phase alteration [13].

## 4. Case Hardening of mild steel hammers for crushing

The surface abrasion and wear resistance of steels are enhanced without affecting the weaker core through surface hardening to enhance the hardness of low carbon steels [14]. The surface hardenings are accomplished by increasing the degree of hardening elements like carbon, boron and/or nitrogen content at the outer layer by means of diffusion. Case hardening is pivotal surface treatment required for functional engineering that are exposed to tribology interactions but associated with some hitches that has to do with contact fatigue [15]. However, several studies have been carried out on case hardening which is a pivotal surface treatment required for functional engineering that are subjected to tribology interactions but

associated with some hitches that has to do with contact fatigue, expensive and compound treatment [16].
Areitioaurtena et al, degradation in regular elements under continuous interaction loading is based on the enduring stresses and the hardness within the case, as well as coarseness of the outer layer and other superficial parts [17]. Obviously, the fatigue failure of the hammermill increases due to cyclic stress imposed on the set of hammers, misalignment of the hammers on the rotor(shaft) thereby causing vibration and wobbling of the hammers. The reliability of abrasion-resistant steel is influenced by one of the factors called hardenability. Thus, modelling and simulation approach can be adopted for hardenability of hammermill since the hardness produces a martensitic structure at the outer layer of the hammer also the compressive remaining stresses in the absence of external loading. Therefore, the contact fatigue behaviour of the crushing hammers can be reduced [18]. Research investigation shows that untreated materials display critical failure during test while the treated steel materials generally exhibit abrasive wear properties at low load, [19].

## 5. Carburisation and nitriding of hammers for crushing

Carburisation is one of the heat treatment method that enhances the hardness and mechanical damage properties of steel materials. The even carbon diffusion into the low carbon materials is an innovative and conceivable procedure of enhancing the properties of the steel required for sustainability of hammermill for bone crushing application [20]. Various application or assessment had been noted to be related with the enhancement of mechanical properties of heat treated alloy steels during performance evaluation. The protection of mild steel (MS) in diverse chemical environment have been carried out utilizing the several developed organic based coatings [21]. This frequent failure is also attributed to manufacturing method such as the stiffness of the tool used in hammer mill fabrication [22]. The manufacturing error in production of high-precision mechanical components due to continuous chatter vibrations occurring during machining processes will lead to wear failure of the component [23]. Improved wear characteristics is found using organic carbon to enhance hardenability and strength of cast iron and metal steels. Material modifications becomes essential for proper design and reliability for industrial advancement in manufacturing applications. Hence, the material used for development of hammermill require enhancement with the use of organic carbon against continuous failures due to the level of its tear and wear behaviour when being exposed to industrial application [24]. The new surface hardening methods and processes intensify manufacture rate, components value also lessen the cost. There is reduction in the risk of crack formation and less warpage with use of surface hardening compare to the conventional heat treatment methods [25].
Nitriding is a thermal treatment method used to case hardened the surface layer of a material so as to improve its mechanical properties. The diffusion of nitrogen gas into the surface layer of material enhanced the tribological properties, fatigue strength and corrosion resistance [26]. The popularity of gas nitriding and secondary phase hardening techniques used to further improve the strength of the outer layer, toughness of steels and mechanical damage resistance cannot be overlooked due to the formation of martensite [27]. The thermal treatment is typically carried out on less-carbon and alloy –steels but still with high degree of wear rate. However, its applications are restricted due to poor wear resistance, hardness, toughness and corrosion resistance [28]. Research studies showed that there was non uniformity in the weight or mass of the hammers causing noise as a result of vibration and unbalance. Therefore,

consistent mass or weight should be ensured to avoid loss of mass and surface toughness of the hammers must often be upgraded [29]. Hardness variation do occur in components despite massive improvement in the hardness when unrestrained parameters are utilized during nitriding procedure [30,31]. Avoiding the mass loss, surface toughness of the hammers should always be improved to avoid the mass loss.

## 6. Conclusions

Constant cyclic stress would result to permanent warp due to exhaustion caused by stress as a result of contact between two mating. Hammers are distorted majorly when there is discrepancy in procedure parameters during thermal treatment. Hence, investigation must be carried out to determine the appropriate heat treatment to be used. Research studies showed that, alteration of heat-treated hammers are often much in carburized or case hardened hammers because of methods for diffusion, absorption and method of quenching as related to induction hardened hammers. Hence, the study of limitations which can be enhanced during the procedures to lower the tendency of deformation becomes necessary. High convective thermal exchange as quenching medium will be suitable for toughness enhancement. Water can be appropriate in this case as a universal solvent.

Examination contemplates demonstrated that, modification of warmth rewarded hammers are frequently much in carburized or callous sledges because of methods for dissemination, retention and method of extinguishing as identified with acceptance solidified mallets. Henceforth, the investigation of boundaries which can be improved during the procedures to bring down the propensity of distortion gets vital. High convective warm exchange as extinguishing medium will be appropriate for sturdiness upgrade. Water can be fitting for this situation as an all inclusive dissolvable.

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