STUDY OF IMPORTED BOLT MATERIAL USED TO TIGHTEN EQUIPMENT IN CEMENT FACTORY

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ABSTRACT

Aim of the research is to study the mechanical properties and microstructure of imported bolt material used to tighten a lifter liner in tube raw mill of cement industry. Results of the investigation are very necessary as reference especially for local industries interested in producing of the bolts. Production of such bolt has high profit financially for both local industries and cement factory. The mechanical properties of bolt measured were tensile strength and hardness of bolt material. The microstructure observed was form of grains especially on thread area of bolt. Results of investigation show that the average of material strength was 740 MPa. Form of grain in thread area was elongated, meanwhile the form of grains far from the thread of bolt was equiaxed. Also, the hardness distribution in thread area was higher than that far from thread of bolt. It indicated that thread of bolt was formed by cold rolling process.

Keywords: *Bolt, Tensile Strength, Hardness, Microstructure, Grains.*

1. INTRODUCTION

Some kinds of bolt applied in cement factory are very interesting to be manufactured specially by small scale industries, because it can be getting high benefit [1]. Type of such bolt is a lifter liner bolt used in tube raw mill of cement industry. Usually the bolts were still imported due to its high quality and it has high fatigue life [1]. However, no literature informed technical specification in detail such as mechanical properties, microstructure and kind of manufacturing of thread in bolt. The research focused on investigation of bolt in order to obtain the technical specifications.

The bolt has thread that can be processed by turning or by cold thread rolling. Thread manufactured by cold rolling has higher fatigue strength compared by thread manufactured by turning process [2,3]. In addition the hardness in thread area processed by cold deformation tends to increase due to strain hardening mechanism [3]. Therefore, high attention has been given to investigate forming process of the bolt thread applied in the tube raw mill of cement factory.

2. EXPERIMENTAL PROCEDURE

The investigated bolt was supplied by a cement industry in West Sumatera. Figure 1 shows type of a bolt applied in tube raw mill apparatus. Care has been taken to prepare several samples for measuring the tensile strength, hardness and microstructure.

2.1 Measuring Tensile Strength

Some of samples were taken from thread body by dimension based on ASTM A370 [4]. The sample was processed by using cutting machine and it needed cooling media during cutting avoiding the microstructure effect of material. Equipment used for testing was universal testing machine with 30.000 kgf capacity. Testing has been taken place by room temperature with constant strain rate. From testing machine, the force versus elongation of sample was obtained and additionally it has to be converted manually to stress as function of strain.

2.2 Measuring Hardness

Aim of the testing is to measure the hardness especially on area closed to thread. Also, area far from thread of bolt was tested to ensure the different hardness of both locations. Equipment used for hardness testing was a Rockwell Hardness Tester of a Torsee model (RH-3N). Prior to measure the hardness, surface of bolt was sectioned carefully by hand saw machine. During the sectioning the sample was cooled by water to prevent increasing of temperature that affects the mechanical properties of bolt material. In next step, the surface of sample was grinded and polished until the surface was free from etching. Thereafter, the finished surface was indented by hardness tester to obtain the hardness grad of material measured both closed to and far from thread area.

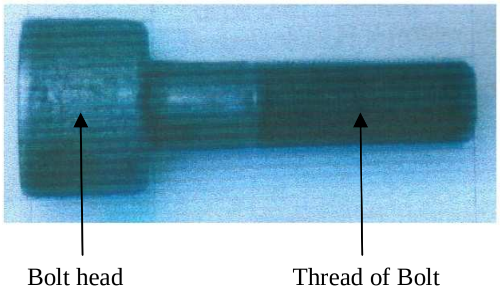

Figure 1. *Type of imported bolt used to tighten a lifter liner of tube raw mill of cement factory [5]*

2.3 Observation of Microstructure

The microstructure observed was a form of grain both closed to and far from thread area. The polished surface of sample was etched by using electric chemical etching apparatus on 30 volt for 60 seconds. Chemical liquid used to etch the sample was solution of HNO_3 and methanol with ratio of 1 and 3. Thereafter, the sample was cleaned with water to free the surface from residual chemical liquid. Grain form of bolt material was observed by using optical microscope.

3. RESULTS AND ANALYSIS

3.1 Stress versus strain

There were two specimens prepared for tensile testing from one bolt as shown in Figure 1. The interesting location of bolt material for testing was in thread bolt area, because the majority failure was in the location. Figure 2 presents the stress versus strain of bolt material carried out at room temperature by constant cross head speed. From the figure can be seen that the elastic region presents straight liner which is closed to the vertical axis. It means that the bolt material has high elastic modulus. The average tensile strength of imported bolt material from the testing was obtained of 740 MPa. The elongation of material was about 0.06. Therefore, the material can be classified that the material has a moderate tensile strength to tighten the tube raw mill equipment.

3.2 Hardness Distribution and Grain Form

Figure 3 shows the result of hardness measuring in two different locations, namely closed to and far from thread area. The measurement location of hardness was carried out at random on both non-thread and thread area. It can be seen that the hardness in thread area was higher than that far from thread area. The rising of hardness may be due to strain hardening phenomenon because of cold deformation [2]. As reported in many literatures that the thread of bolts can be manufactured by cold rolling process [2,3]. There are several advantages obtained from the cold deformation. The thread strength of bolt will enhance or be stronger. The fatigue strength and fatigue limit will be better compared to thread manufactured by turning process.

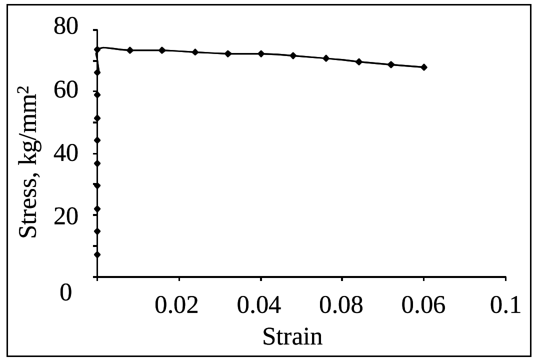

Figure 2*. Stress-strain diagram of bolt material to tighten lifter liner.*

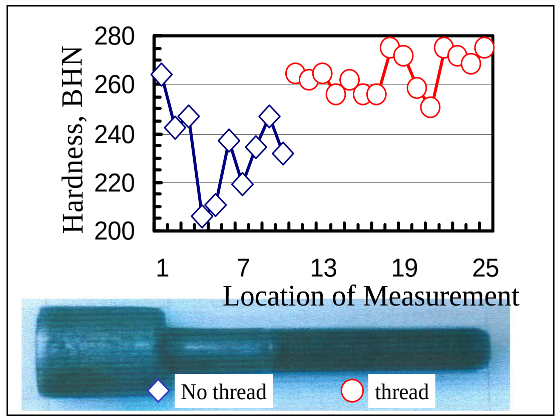

Figure 3*. Distribution of hardness measured at random on non-thread and thread area*

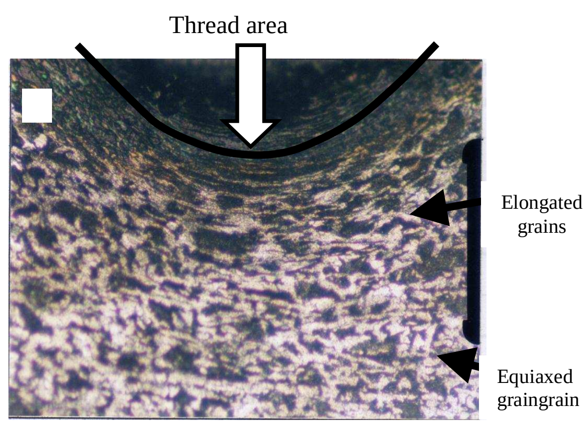

Figure 4. *Form of grains in thread area (mag. 300X)*

Thread of bolt manufactured by cold rolling was usually applied to bolt used to tighten equipments which operate under dynamic load. Such load can encourage an initial crack to propagate in material of bolt. Many failures of bolt were located in thread area due to a sharp corner that can create high stress concentration [6]. Therefore, the thread process of bolt under high dynamic load for long time was manufactured by cold rolling. From Figure 4 the grain forms were elongated that may be due to plastic deformation and thereby it also supports the data as shown in Figure 3 that the hardness located in thread area improves because of strain hardening. Additionally, as shown in the Figure 3 that thread of bolt has a radius. Therefore, the investigation results mentioned above have evidenced clearly that the bolt thread of a lifter liner of tube raw mill in cement factory was processed by cold thread rolling. Because a thread processed by turning will show equiaxed form and has usually a sharp corner on the thread area.

4. CONCLUSIONS

From the result of investigation applied on the imported bolt for tube raw mill in cement factory the necessary information can be concluded as following:

1. The strength of imported bolt material for tube raw mill in cement factory was 740 MPa and elongation 0.06.
2. Hardness in thread rolling area was higher than that far from thread area. Meanwhile, grain form in thread area was elongated and far from thread area was equiaxed. It indicated that thread of bolt was manufactured by cold rolling process. Manufacturing of thread by cold rolling will increase the fatigue strength of material so that its fatigue life will be longer than that of thread manufactured by turning.

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