ALGEBRA : JURNAL PENDIDIKAN, SOSIAL DAN SAINS

ISSN : 2807-663X e-ISSN : 2807-629X
Journal Homepage : https://algebra.yana.or.id/index.php/ejournal/index
Volume 6 Number 1 (2026)

THE EFFECT OF QUENCHING WITH VARIOUS COOLING MEDIA ON THE HARDNESS OF LEAD SCREW PIN IN A LATHE MACHINE

Muhammad Rizki Akbar[1*], Fenoria Putri[2], Baiti Hidayati[3]
[123]Politeknik Negeri Sriwijaya, Palembang, Indonesia
Correspondence Email: rizkiakbar0212@gmail.com

ABSTRACT

This study analyzes the effect of the quenching process with various cooling media on the hardness of lead screw keys in a lathe. The objective was to determine the most effective cooling media for improving the key's mechanical properties, which play a critical role in the performance and durability of the lead screw. The cooling media tested included water, fresh SAE 10W-40 oil, and used SAE 10W-40 oil. The research method involved heat treatment at 850°C, followed by quenching using each medium, and then testing the hardness using the Rockwell B (HRB) method. The results revealed an unexpected finding: the untreated key had the highest hardness value (97.05 HRB), surpassing all quenched samples. Among the hardened samples, water produced the highest hardness (91.88 HRB), followed by used oil (82.32 HRB) and fresh oil (78.66 HRB). This indicates that the quenching process did not increase hardness and, in some cases, even decreased it. Potential causes include temperature instability during heat treatment and inaccurate material characterization, as SEM analysis failed to confirm the expected composition of the high-carbon steel. This study concluded that the quenching parameters and material characterization methods require refinement. Future research is recommended to utilize more precise temperature control, validate the material composition using techniques such as Optical Emission Spectroscopy (OES), and explore alternative cooling media. These findings emphasize the importance of precise heat treatment process control to achieve desired mechanical properties in industrial applications.

Keywords: Cooling; Lead Screw Keys; Heat Treatment; Rockwell Test.

INTRODUCTION

A lathe is a production machine used to shape cylindrical workpieces through a cutting process by rotating the workpiece and holding the cutting tool (chisel) in a fixed position. One of the important components in a lathe's transmission system is the lead screw, which functions to move the carriage automatically and precisely. The performance of the lead screw is greatly influenced by the strength and hardness of the pin as a torque connecting element. A weak or easily worn pin can cause slippage, wear, and even system damage.

Therefore, a pin material with good tensile strength and wear resistance is required. Heat treatment processes such as quenching are a solution to increase material hardness, where the type of cooling medium plays an important role in determining the final properties of the material. Variations in media such as water, new oil, and used oil will affect the cooling rate, microstructure, and hardness of the material. In the context of the Celtic 14 lathe, lead screw pins often experience friction and wear, so this study was conducted to analyze the effect of variations in quenching media on pin hardness. The results of this study are expected to provide recommendations for optimal cooling media to improve the performance and reliability of components in the lathe transmission system.

RESEARCH METHODS

Research Method

This research method uses an experimental method to analyze the effect of variations in the heat treatment process parameters on the hardness of lead screw pins. This method was chosen because it allows for strict control of the research variables and accurate measurement of the results. The research stages include:

1. Sample preparation: Making S45C lead screw pin samples.
2. Treatment process: quenching temperature (850°C), holding time (15 minutes).
3. Material testing: SEM test and Rockwell hardness test
4. Data analysis: Statistical data processing to determine the optimal parameters.

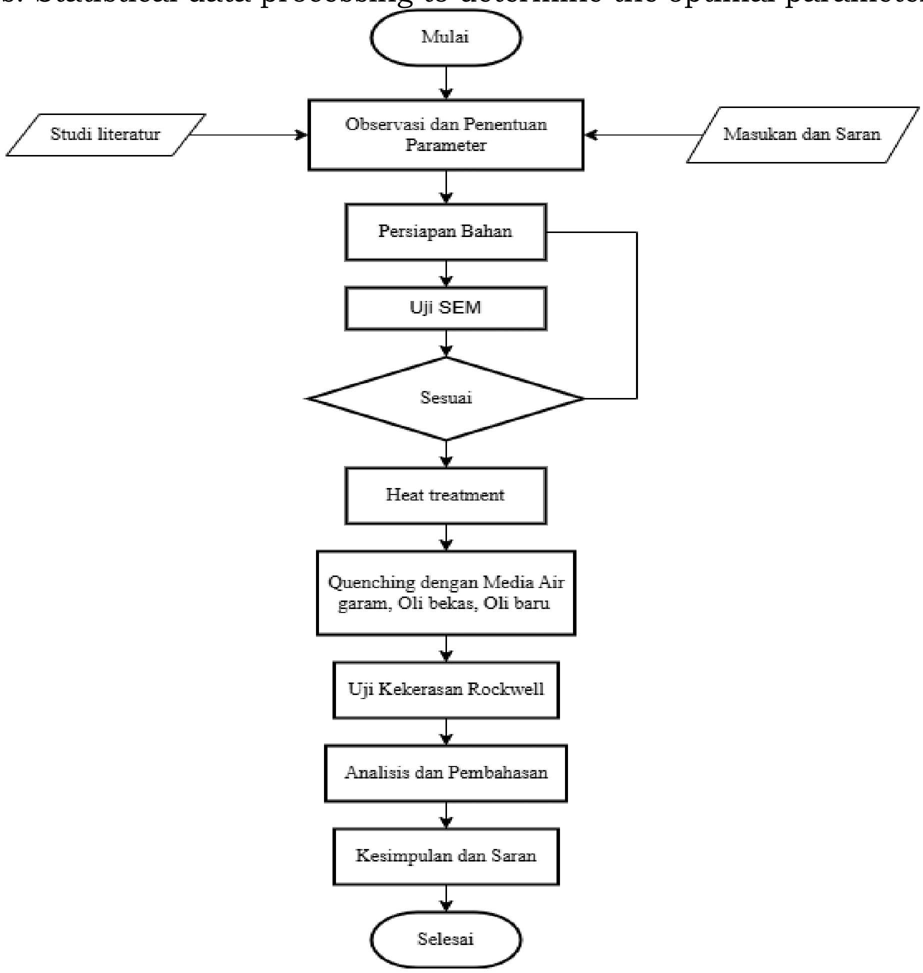

Figure 1. Research Flow Chart

Research Tools and Materials

To conduct this research, the following research tools and materials were needed:

1. Research Tools

   The following tools were used in the research:

   a. Nabertherm Furnace

Figure 2. Nabertherm Furnace

   b. Rockwell Model HR 150 A

Figure 3. Rockwell Model HR 150 A

   c. Caliper
   d. Container
   e. Pliers
   f. Thermometer
   g. Polishing Machine
   h. Gloves

2. Research Materials
   a. Water
   b. New SAE 10W-40 Oil
   c. Used SAE 10W-40 Oil
   d. Resin

RESULTS AND DISCUSSION

Test Results

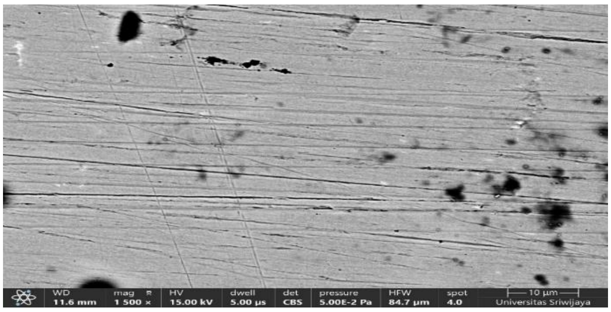

Figure 4. SEM 1500X

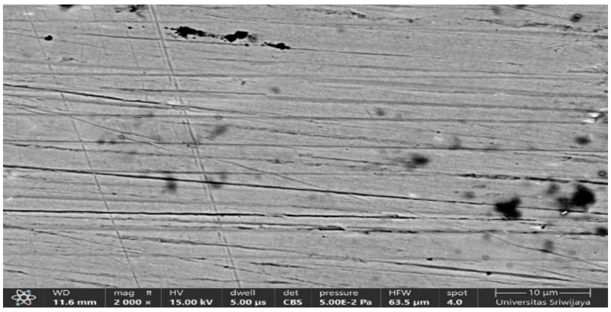

Figure 5. SEM 2000X

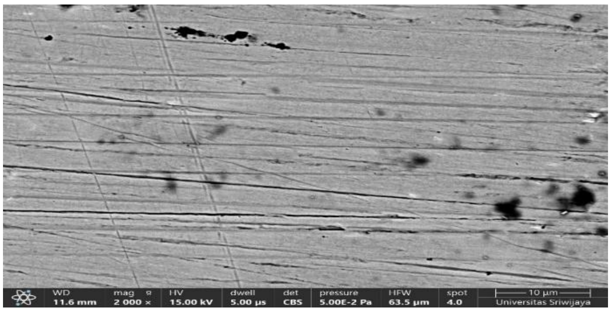

Figure 6. SEM 2500X

Table 1. SEM Testing

Element	Line	At. %	Wt. %	Net Counts	At. % Error	Wt. % Error
C	K	23.0	6.1	8 306	0.3	0.1
Al	K	0.4	0.2	595	0.0	0.0
Fe	K	76.6	93.7	79 815	0.5	0.6

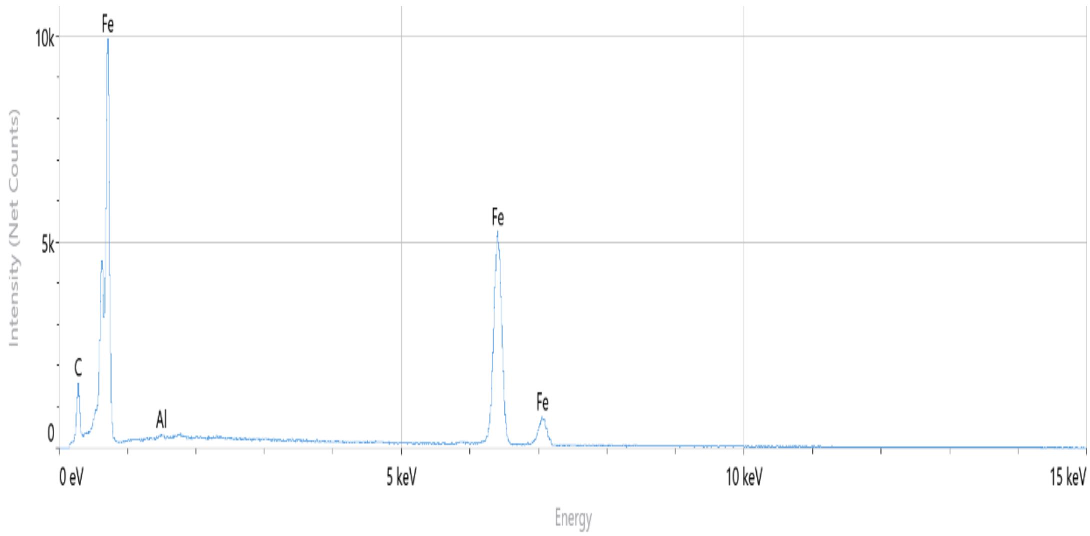

Figure 7. SEM Testing Diagram

The results of SEM (Scanning Electron Microscope) testing with EDS (Energy Dispersive Spectroscopy) on the lathe tool sample show that the main chemical composition consists of the elements Fe (iron), C (carbon), and Al (aluminum). Based on the data in Table 1, the element Fe has the largest atomic composition of 76.6% and a weight of 93.7%, indicating that the main material of the dowel is steel (iron-based alloy). The element carbon (C) was detected at 23.0% atomic and 6.1% weight, indicating that the material belongs to the carbon steel category. The carbon content in metal materials greatly affects mechanical properties, especially hardness and tensile strength. The higher the carbon content, the higher the hardness after heat treatment such as quenching. This is relevant in lead screw applications, which require high resistance to friction and load.

Table 2. Rockwell Hardness Test Results

P (Kg)	Test Material	Indentor	Test Points	HRB	Rata-rata HRB
			1	96.6	
			2	97.4	
100	Broken Peg	Steel Ball 1/16″	3	97.5	97.05
			4	97.1	
			5	96.5	
			1	96.3	
			2	97.4	
100	New Material Peg	Steel Ball 1/16″	3	97.5	96.96
			4	97.1	
			5	96.5	
			1	92.4	
			2	94.5	
100	Quenching Water	Steel Ball 1/16″	3	93.1	91.88
			4	91.7	
			5	87.8	
			1	73.8	
			2	80.5	
100	Quenching New SAE 10W-40 Oil	Steel Ball 1/16″	3	80	78.66
			4	78.9	
			5	80.1	
			1	83.1	
			2	81.6	
100	Quenching Used SAE 10W-40 Oil	Steel Ball 1/16″	3	82.6	82.32
			4	80.7	
			5	83.6	

Rockwell hardness testing showed that the broken dowel and the new dowel material had high hardness, 97.05 HRB and 96.96 HRB, respectively. After heat treatment (quenching), there was a decrease in hardness in all samples, depending on the cooling medium used. Water produced the highest hardness among the cooling media, at 91.88 HRB, while new SAE 10W-40 oil produced the lowest hardness at 78.66 HRB. Used oil produced a slightly higher hardness of 82.32 HRB. These results show that the cooling medium greatly affects the final hardness of the material. Rapid cooling with water maintains higher hardness but risks causing residual stress or cracks. Conversely, slow cooling with oil reduces hardness but is safer from deformation. Thus, the choice of quenching medium needs to be adjusted to the strength and wear resistance requirements of the lathe lead screw pin.

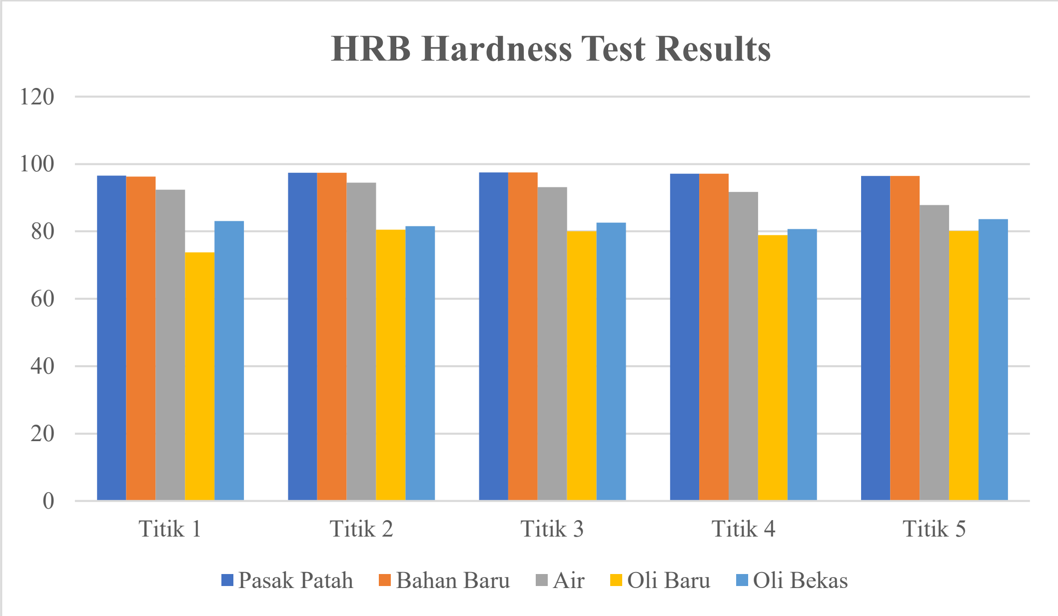

Figure 8. Hardness Test Graph

The following graph shows the results of the Rockwell (HRB) hardness test for lead screw pins with varying quenching cooling media. The untreated material recorded the highest hardness value of 97.05 HRB, surpassing all samples that had undergone the quenching process. Among the three cooling media tested, water provided the best relative results with a hardness of 91.88 HRB, although it was still 5.37 HRB lower than the initial material. This result was followed by used oil (82.32 HRB) and new oil (78.66 HRB), with a significant difference between the fastest (water) and slowest (new oil) cooling media reaching 13.22 HRB. Each sample showed consistency in the test data.

CONCLUSIONS

Based on the results of the study entitled "The Effect of Quenching with Variations in Cooling Media on the Hardness of Lead Screw Machine Tool Pins," it can be concluded that the SEM test results were invalid because the element composition did not accurately represent the characteristic values of carbon steel, which created uncertainty in identifying the pin material. In addition, the heat treatment temperature of 850°C was too high and caused instability in the furnace temperature, which significantly affected the final hardness values and even produced results lower than those of the untreated material. The highest hardness value was found in the untreated dowel, with an average of 97.05 HRB, while quenching with water produced 91.88 HRB, used oil produced 82.32 HRB, and new oil produced 78.66 HRB. These findings indicate that the quenching process did not significantly improve hardness and, in some cases, actually reduced it. Therefore, the study did not succeed in achieving its main objective of increasing dowel hardness through quenching, mainly due to inaccurate material characterization and unstable temperature control during the heat treatment process.

BIBLIOGRAPHY

Adipura, A., & Nafi, M. (2022). Analisa pengaruh *heat treatment temperring* dengan variasi waktu tahan dan media pendingin terhadap sifat mekanik baja karbon rendah. *Prosiding Senakama*, *1*, 203-212.

Anggoro, H. E. H. A. P. (2016). *Analisa Sifat Akustik Dan Morfologi Material Komposit Polypropylene Berpenguat Serat Bambu Dan Rami* (Doctoral dissertation, Institut Teknologi Sepuluh Nopember).

Mangngi, F. (2018). Evaluasi Kondisi Mesin Bubut Harizon T300 Menurut Metode Schlesinger Sebagai Acuan Dalam Melakukan Tindakan Perawatan. *SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin*, *12*(2), 87-99.

Herlina, F., Firman, M., & Najib, M. (2016). Analisa Uji Kekerasan Baja VCN 150 Pada Poros Baling-baling Pisau Mesin Crusher. *Jurnal Teknik Mesin UNISKA*, *1*(02), 28-29.

Mansyursyah, I., & Tamjidillah, M. (2020). Penentuan Parameter Proses Pembubutan Terhadap Kekasaran Permukaan Material ST 42 Dengan Metode Taguchi. *Jtam Rotary*, *2*(2), 183-194.

Sulaeman, M., Budiman, H., & Koswara, E. (2019, August). Proses Uji Dimensi, Uji Kekerasan Dengan Metode Rockwell Dan Uji Komposisi Kimia Pada Cangkul Di Balai Besar Logam Dan Mesin (Bblm) Bandung. In *Prosiding Industrial Research Workshop and National Seminar* (Vol. 10, No. 1, pp. 539-543).

Wibowo, N. S., & Nurato, N. (2018). Analisis Pengaruh Ketidakstabilan Temperatur Terhadap Hasil Kekerasan Meterial dari Proses Heat Treatment Piston. *Jurnal Teknik Mesin Mercu Buana, 7*(3), 138-148.

Rizky, D. A. (2022). *Pengaruh Perlakuan Quenching dengan variasi media pendingin (air, oli bekas, minyak goreng) terhadap kekerasan egrek* (Doctoral dissertation, Politeknik Negeri Sriwijaya).

Aminuddin, R. R., Santosa, A. W. B., & Yudo, H. (2020). Analisa kekuatan tarik, kekerasan dan kekuatan puntir baja ST 37 sebagai bahan poros baling-baling kapal (propeller shaft) setelah proses tempering. *Jurnal Teknik Perkapalan*, *8*(3), 368-374.

Gunawan, S. (2024). Pengaruh Perlakuan Panas Quenching terhadap Ketangguhan Impak pada Paduan Aluminium AC7A. *Jurnal Penelitian Inovatif*, *4*(2), 483-490.

Weriono, W., Rinaldi, R., & Sepfitrah, S. (2020). Evaluasi Pengujian Kekerasan Material Aisi 4140 Menggunakan Full Factorial Design Of Experiment. *Jurnal Rekayasa Material, Manufaktur dan Energi*, *3*(1), 23-28.