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Failure Analysis of the Clutch Brake System in a 400-ton Hyundai Stamping Press

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Abstract: Stamping press machines rely on reliable clutch brake systems to ensure operational accuracy, productivity, and safety. This study presents an empirical failure analysis of a wet-type multi-disc clutch brake system in a 400-ton stamping press that experienced operational failure following flood exposure. Field observations, visual and dimensional inspections, and hydraulic system evaluations were conducted to identify failure mechanisms and root causes. The results indicate that the clutch brake failure was caused by the combined effects of mechanical interference leading to hydraulic hose rupture, improper installation of sealing components, and aging-related degradation of elastomeric seals. Flood-induced contamination significantly accelerated lubrication failure and material deterioration, resulting in hydraulic leakage and loss of system reliability. Corrective actions, including component replacement, lubrication system restoration, and hydraulic pressure adjustment, were implemented and validated through no-load testing, load testing, and production trials using actual stamped parts. Post-repair testing confirmed stable machine operation and acceptable product quality. The novelty of this study lies in demonstrating how environmental exposure interacts with installation errors and material aging to produce system-level clutch brake failure. The findings provide practical guidance for failure prevention, condition-based maintenance, and reliability improvement of heavy-duty stamping press machines operating in flood-prone industrial environments.

Keywords: Clutch brake system, Failure mechanism, Hydraulic leakage, Seal degradation, Flood-induced contamination

INTRODUCTION

Stamping press machines are widely used in the manufacturing of metal components due to their high productivity, repeatability, and dimensional accuracy. In the observed manufacturing facility, a 400-ton capacity stamping press serves as a primary production asset. At the time of this study, the machine was out of operation due to failure of the clutch brake system, accompanied by damage to several related components caused by flooding that partially submerged the machine (Permana et al., 2024; Rifai et al., 2023; Rifai et al., 2020; Sriharti, 2021).

Flood exposure resulted in hydraulic fluid contamination and accelerated degradation of mechanical and hydraulic components, ultimately leading to system malfunction. The clutch brake system (Figure 1) is a critical element of a stamping press machine, responsible for converting rotational motion into linear pressing motion while enabling accurate stopping, holding, and repetition of the stamping cycle in accordance with predefined operating sequences (Orthwein, 2004). Reliable clutch brake performance is essential to ensure production continuity, dimensional accuracy of stamped products, and operator safety.

During inspection, it was identified that the lubrication distribution system of the stamping press was not functioning properly. Lubricating oil from the reservoir was not adequately supplied to the clutch brake unit, resulting in insufficient lubrication. This condition accelerated wear of internal components and contributed to hydraulic leakage, ultimately leading to clutch brake failure.



Figure 1. Clutch Brake

The objective of this study is to conduct a comprehensive failure analysis of the clutch brake system in a 400-ton stamping press based on empirical field data. The scope of the study includes identification of worn and damaged clutch brake components, analysis of failure mechanisms, implementation of corrective repair actions, and evaluation of machine performance through post-repair no-load and load testing (Adin, 2020; Masri et al., 2022; Yunanda, 2023).

METHOD

This study employed a descriptive–analytical approach based on empirical data obtained from direct field observations and technical inspections. The research focused on failure analysis of the clutch brake system installed in a 400-ton capacity stamping press used in a metal component manufacturing process.

Research Object and Scope

The object of this research was the clutch brake system of a 400-ton stamping press that experienced operational failure following flood exposure. The scope of the study included mechanical components, hydraulic systems, lubrication mechanisms, and operational parameters related to clutch brake performance. Electrical control systems were excluded from the analysis.

Data Collection Methods

Data were collected using the following methods:

- a. Field Observation

Direct observations were conducted to assess the physical condition of the stamping press and clutch brake system, including evidence of leakage, contamination, corrosion, and abnormal wear caused by floodwater ingress.

b. Visual and Dimensional Inspection

Disassembly of the clutch brake unit was performed to identify worn, damaged, or degraded components such as seals, friction plates, and internal hydraulic parts. Visual inspection was supported by dimensional measurements to evaluate component wear relative to allowable tolerances.

c. Hydraulic System Evaluation

The hydraulic system was examined to verify oil condition, lubrication flow, pressure settings, and conformity with manufacturer specifications. Particular attention was given to lubrication distribution channels and seal integrity.

Failure Analysis Procedure

Failure analysis was conducted using a systematic approach consisting of (Hairiyah et al., 2024; Masri et al., 2022):

- a. Identification of failure symptoms observed during machine operation;
- b. Determination of root causes related to wear, lubrication failure, hydraulic pressure deviation, and contamination due to flooding; and
- c. Correlation of observed damage patterns with the machine’s operational history.

Repair and Corrective Actions

Based on the failure analysis results, corrective actions were implemented, including replacement of worn or damaged clutch brake components, restoration of the lubrication system, cleaning of contaminated hydraulic lines, and adjustment of hydraulic pressure to comply with design specifications.

Performance Testing

Following repair, the stamping press was subjected to performance evaluation through:

- a. No-load testing, to verify proper clutch brake engagement, disengagement, and system responsiveness without applied forming load; and
- b. Load testing, to assess machine performance under normal operating conditions and confirm stable clutch brake operation during continuous stamping cycles.

The results of these tests were used to validate the effectiveness of the repair actions and the restoration of normal machine operation.

RESULT AND DISCUSSION

Stamping Machine Specifications

The specifications of the stamping press machine used in this study are presented in Table 1. The machine is a Hyundai stamping press with a nominal capacity of 400 tons and is equipped with a wet-type multi-disc clutch brake system. These specifications form the basis for evaluating machine performance, failure characteristics, and post-repair testing.

Table 1. Specifications of the Hyundai 400-Ton Stamping Press

Category	Specification
Model	Hyundai 400-ton Stamping Press
Machine type	Single crank
Press capacity	400 tons (3,923 kN)
Stroke per minute (SPM)	20–40 SPM
Stroke length	350 mm

Category	Specification
Bolster table size	2,500 mm (L) × 1,200 mm (W)
Ram/slide area size	2,500 mm (L) × 1,200 mm (W)
Machine height	6,000 mm
Drive type	Flywheel and clutch brake
Clutch brake system	Wet-type multi-disc
Main motor	55 kW (75 HP) three-phase induction motor
Control system	PLC-based control system
Lubrication system	Automatic
Machine weight	80 tons

These specifications indicate that the machine is designed for heavy-duty stamping operations with moderate stroke speed and high pressing capacity. The wet-type multi-disc clutch brake system plays a critical role in controlling the press cycle and ensuring operational safety, making it a key component in the failure analysis discussed in this study.

Field Observation Results

Based on direct observations in the production area, the Hyundai 400-ton stamping press experienced operational failure primarily in the clutch brake system. Visual inspection revealed hydraulic oil leakage, contamination around the clutch brake housing, and abnormal wear on several components. These conditions indicate a combination of mechanical interference, improper assembly, and material degradation, which collectively contributed to system malfunction and machine downtime.

Root Cause Analysis

The failure analysis identified three dominant root causes responsible for clutch brake malfunction: mechanical damage to the hydraulic hose, improper installation of the clutch brake seal, and material degradation of sealing elements. These failure modes were interrelated and were exacerbated by post-flood operating conditions, which accelerated wear and material embrittlement.

Broken Hydraulic Hose



Figure 2. Hydraulic hose before repair



Figure 3. Hydraulic hose after repair

The hydraulic hose was found to be damaged due to being pinched by the main drive gear (Figure 2). This mechanical interference caused localized stress concentration, leading to hose rupture and sudden loss of hydraulic pressure. As a corrective action, the damaged hose was replaced and rerouted to prevent direct contact with rotating components (Said, 2023; Nasution & Lukman, 2024). This repair restored proper hydraulic flow and improved the overall operational reliability of the stamping press (Figure 3).

Improper Installation of the Clutch Brake Seal



Figure 4. Clutch brake seal before repair



Figure 5. Clutch brake seal after repair

Inspection revealed that the clutch brake seal had been improperly installed, resulting in misalignment and uneven contact surfaces. This condition caused continuous oil leakage from the clutch brake system (Figure 4), leading to lubrication failure and accelerated wear of internal components. Corrective actions included seal replacement and precise reinstatement in accordance with manufacturer specifications (Said, 2023; Nasution & Lukman, 2024). After repair, oil leakage was eliminated and sealing performance was fully restored (Figure 5).

Aged and Brittle O-Ring



Figure 6. O-ring before replacement



Figure 7. O-ring after replacement

The O-ring located in the clutch brake housing cover exhibited clear signs of aging and embrittlement (Figure 6). Material degradation reduced its elasticity, compromising sealing effectiveness and increasing the risk of oil leakage (Said, 2023; Nasution & Lukman, 2024).

The degraded O-ring was replaced with a new component of equivalent specification to restore sealing integrity and prevent future leakage (Figure 7).

Summary of Failure Modes and Corrective Actions

The summary of failure modes and corrective actions are presented in Table 2.

Table 2. Summary of Failure Modes and Corrective Actions

Failure Mode	Root Cause	Impact on System	Corrective Action
Hydraulic hose rupture	Pinched by gear	Loss of hydraulic pressure, machine stoppage	Hose replacement and rerouting
Seal leakage	Improper installation	Oil leakage, insufficient lubrication	Seal replacement and correct installation
O-ring embrittlement	Aging and material degradation	Increased leakage risk	O-ring replacement

The results demonstrate that clutch brake failure was not caused by a single factor, but rather by the interaction of mechanical interference, improper assembly practices, and material aging. Flood exposure likely accelerated seal degradation and increased the risk of hydraulic contamination. These findings highlight the importance of proper component installation, regular inspection of hydraulic routing, and periodic replacement of sealing elements as part of a condition-based maintenance strategy (Maria & Ferro, 2021; Sanjaya & Mutmainnah, 2020; Syah & Zaki Nura, 2019).

Machine Functional Testing

The results of machine functional testing are presented in Table 3.

Table 3. Machine Functional Test Results

Item	Component	Status	Analysis
Power System	Main power supply	OK	The main power supply is stable and functioning properly
	Hydraulic power unit	OK	The hydraulic system operates normally and supports machine operation
	Electrical control panel	OK	Electrical distribution operates without interruption
	Slide movement	OK	Mechanical motion is not obstructed
Press Frame and Slide	Clamping mechanism	OK	The clamping mechanism functions normally
	Cushion	OK	The cushion mechanism operates normally
Safety System	Light curtains	N/A	Component not available
	Emergency stop	OK	Emergency function operates properly
Control System	PLC	OK	The PLC system operates optimally
	Sensors and switches	OK	All detection functions operate normally
Lubrication System	Oil level	OK	Lubrication meets operational standards
	Filter condition	OK	Lubricant is clean and free from particles or contaminants

Performance Testing

1. No-Load and Load Testing

The results of no-load and load testing are presented in Table 4.

Table 4. No-Load and Load Testing Results

Item	Without Dies		With Dies	
	Status	Remark	Status	Remark
Inching	Passed	–	Passed	–
Continuous	Passed	–	Passed	–
Single stroke	Passed	Overload pump replacement	Passed	–

During inching mode, both no-load and load tests were completed without issues. The system operated smoothly, and the clutch brake was able to hold the additional load from the dies during slow movement. In continuous mode, no abnormalities were identified under either condition, indicating stable continuous operation. In single-stroke mode, although the test was passed, an important note was recorded regarding replacement of the overload pump. After replacement, the system returned to normal operation under full working load.

2. Testing with Production Parts

Table 5 presents the results of stamping press testing using actual production parts.

Table 5. Testing with Production Parts

Item	Status	Remark
First trial – 20 pcs, Done (Part: 53216 -BZ250G OK)	Done (Part: OK)	Overload pump malfunction identified after testing; corrective repair performed prior to mass production trial
Second trial – Mass production, 81425-BZ140H	Done (Part: OK)	
Real Production	Quantity: 553 pcs; time: 15:18–17:2	

The first trial produced 20 components of part number 53216-BZ250G, all of which met quality requirements. However, an overload pump issue was detected after testing, necessitating replacement prior to the second trial. The second trial was conducted as a mass production test using part number 81425-BZ140H, producing 553 components. The results were satisfactory, and all products met the specified quality standards.

CONCLUSION

This study analysed the failure of a wet-type multi-disc clutch brake system in a 400-ton stamping press following flood exposure. The results show that the failure was caused by the combined effects of mechanical interference, improper seal installation, and aging-related degradation of sealing components, rather than by a single dominant factor. Flood-induced contamination played a significant role in accelerating material deterioration and hydraulic system malfunction.

The main scientific contribution of this study lies in the integration of empirical field observations with systematic failure analysis to identify the interaction between environmental exposure (flooding), lubrication failure, and installation errors in clutch brake systems. Unlike conventional studies that focus on isolated component failure, this research demonstrates how

external environmental factors can amplify minor assembly and material issues into critical system-level failures.

The implemented corrective actions successfully restored normal machine operation, as confirmed by no-load, load, and production-part testing. The findings provide practical insights for condition-based maintenance planning and offer a reference framework for failure analysis and preventive strategies in heavy-duty stamping press machines operating in flood-prone industrial environments.

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