REDUCING THE WORKPLACE ACCIDENT RATE ON THE ENDLESS MACHINE USING JOB SAFETY ANALYSIS (JSA) AND HIRADC IN THE CHAIN 2 WHEEL DEPARTMENT OF PT DAIDO MANUFACTURING INDONESIA

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Abstract

Occupational accidents remain a persistent problem in manufacturing lines that depend on high-speed mechanical equipment, and the automotive chain assembly industry is no exception. This study examined the Endless machine in the Chain-2-Wheel Department of PT Daido Manufacturing Indonesia, the production stage that recorded the highest number of workplace accidents between January and June 2024. A descriptive qualitative case-study design was applied, combining direct observation, in-depth interviews, documentation review, and literature study. Hazard identification and risk evaluation were carried out through an integrated Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment and Determining Control (HIRADC) framework, supported by Fishbone diagram analysis to trace the root causes. Ten work activities with varying risk levels were identified, three of which were classified as high risk: chain installation into the machine, pin pressing, and machine-area cleaning. Manpower and work-method factors were found to be the dominant root causes. Following the implementation of safety briefings, competency evaluation, and periodic SOP review, the number of accidents declined from seven cases in the baseline period to two cases in the transition period, and to zero cases afterward. These findings confirm that an integrated JSA-HIRADC approach can substantially reduce occupational risk on high-speed mechanical equipment.

Keywords: *Job Safety Analysis, HIRADC, Occupational Accident, Risk assessment, Endless Machine.*

A. INTRODUCTION

Occupational accidents continue to pose a critical challenge in the manufacturing sector, particularly on production lines that rely on high-speed mechanical equipment. Such accidents are commonly triggered by a combination of unsafe worker behaviour, insufficient hazard mapping, and non-compliance with standard operating procedures. Low discipline in safety culture, including negligence in the use of personal protective equipment (PPE), further multiplies the probability of incidents occurring on the shop floor. A structured risk-analysis framework is therefore required to mitigate and reduce the frequency of workplace accidents.

One strategic approach that has proven effective in detecting hazards and evaluating safety risk is the integration of Job Safety Analysis (JSA) with Hazard Identification, Risk Assessment, and Determining Control (HIRADC). JSA functions to break down each stage of an operational task in order to map hidden risks, while HIRADC plays a central role in evaluating the magnitude of risk and formulating the most relevant control hierarchy. Prior empirical studies have shown that combining JSA and HIRADC is reliable for identifying a range of hazards while producing systematic mitigation recommendations in production environments (Marsukik et al., 2024; Rohman & Putra, 2024). Other studies confirm that applying JSA helps companies trace the source of incidents and reduce risk weight once corrective actions are implemented, with risk levels that were initially extreme or high shown to decrease significantly after safety-based recommendations are applied (Reviati & Yuamita, 2025; Paliling, 2025).

Nevertheless, most previous studies tend to apply these methods separately or focus on other industrial sectors such as construction and mining (Pratomo et al., 2024; Riesty & Setiyono, 2024). Research that specifically synergises JSA and HIRADC on an automotive chain assembly line, particularly on the operation of an Endless machine, remains very limited. This indicates a research gap concerning a comprehensive hazard evaluation of each operator work sequence on this machine, together with the formulation of its control measures within a single integrated study. This research was developed to help close that gap.

PT Daido Manufacturing Indonesia, an automotive component manufacturer producing chains for two-wheeled and four-wheeled vehicles, operates a range of mechanical devices that carry considerable safety risk. One vulnerable point is found in the Chain-2-Wheel Department, specifically in the Endless machine area, where the process requires continuous interaction between workers, material handling, and high-speed machine components. Failure to detect and control hazards in this area can directly increase the accident ratio, ultimately harming both worker safety and company productivity.

Preliminary observation confirmed that a track record of workplace accidents was still found in the operation of the Endless machine. The root causes were indicated by incomplete hazard mapping, sub-optimal implementation of work instructions, and worker negligence in using PPE. Based on production and accident data collected from the Chain-2-Wheel Department over the preceding six months, the following distribution of accidents by process was obtained.

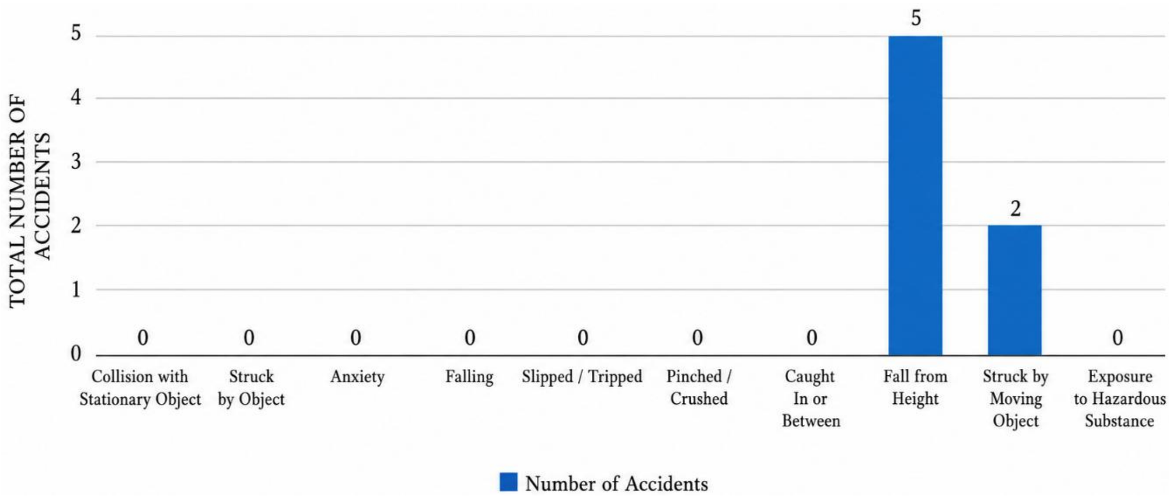

Figure 1. Distribution of workplace accidents by production process in the Chain-2-Wheel Department (January-June 2024)

As shown in Fig. 1, the Endless process recorded the highest number of workplace accidents, with seven incidents during the six-month observation period, while the Appearance Check process recorded two incidents. Other production stages-raw material receiving, part feeder, assembly, calking, part detector, preloading, smoothness area, cutting, preloading after Endless, and finish good-recorded no accidents at all during the same period. This high frequency at the Endless stage indicates that this operational area carries a substantially greater level of hazard exposure than other production lines, driven by the intensity of physical interaction between workers and mechanical equipment, the injury-prone nature of the equipment itself, and the sub-optimal enforcement of standard safety procedures in the field.

Beyond threatening the operator's health and physical safety, the impact of workplace accidents also produces a domino effect that is detrimental to the business, including reduced productivity, disrupted manufacturing flow, escalating medical compensation costs, and cumulative financial losses. This underlines the need for a systematic investigation and risk evaluation to map the root sources of hazard, prioritising the Endless operation that recorded the highest incident record.

The present study applies the Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Determining Control (HIRADC) methods to identify potential hazards and establish an appropriate mitigation hierarchy for the routine operation of the Endless machine in the Chain-2-Wheel Department of PT Daido Manufacturing Indonesia. Specifically, the study aims to describe the Chain-2-Wheel production process, identify unsafe actions and unsafe conditions that contribute to workplace accidents involving the Endless machine, analyze the underlying causes of such accidents using the JSA and HIRADC methods, and formulate and implement appropriate improvement measures to reduce the accident rate and enhance occupational safety in the Endless machine work area.

B. METHODS

The research was conducted at PT Daido Manufacturing Indonesia, centred on the Chain-2-Wheel Department, specifically the operational zone of the Endless machine. This location was selected owing to the intensity of direct interaction between the operator and high-technology mechanical instruments, which inherently carries significant operational hazard potential. This research adopted a descriptive study with a qualitative case-study approach. The procedure was carried out through direct observation of the sequence of operator work activities on the shop floor in order to detect hazards inherent to the job and to estimate the accident risk weight that could arise. This approach allowed the researcher to examine the actual condition of the working environment empirically, so that the hazard profile of each task stage could be mapped comprehensively. In the analysis stage, this research integrates the JSA and HIRADC methods, which help systematise hazard identification, calculate the risk level based on likelihood and severity, and establish the most appropriate control hierarchy to reduce the accident rate.

The population of this study comprised all operators assigned to the Endless machine in the Chain-2-Wheel Department. The sample was drawn from operators directly involved in, and having in-depth understanding of, the Endless machine work flow, so that the information obtained would be accurate and relevant to the hazard-identification and risk-assessment analysis. The research object covered all operational work activities within the scope of the Endless machine, from raw-material preparation through to the retrieval of finished goods.

Data were collected through four complementary techniques: field observations of the direct interaction between operators and the Endless machine; in-depth interviews with operators and supervisors to obtain qualitative information regarding perceptions of working conditions and the effectiveness of existing controls; a review of relevant documentation, including Standard Operating Procedures (SOPs), Work Instructions (WIs), and accident reports; and a literature study of academic references related to the application of Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Determining Control (HIRADC). The main research instruments consisted of an observation sheet, a JSA analysis matrix, and a HIRADC risk-evaluation table. Data processing was conducted through five sequential stages, as illustrated in Fig. 2. First, work activities were identified by mapping the operator's complete workflow, from material preparation through the final finishing stage. Second, hazards were identified by examining the physical work environment, mechanical equipment operations, and human-machine interactions to detect potential mechanical, physical, and ergonomic hazards. Third, JSA analysis was performed by breaking down each work activity into specific task stages and identifying the inherent hazards and corresponding preventive measures. Fourth, risk assessment was conducted using HIRADC by calculating risk ratings based on the multiplication of likelihood and severity scores. Finally, risk controls were determined according to the hierarchy of controls, consisting of elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE), with the aim of reducing or eliminating workers' exposure to hazards associated with the Endless machine.

C. RESULTS AND DISCUSSION

1. Chain-2-Wheel Production Process

PT Daido Manufacturing Indonesia, established in 1997 as a subsidiary of Daido Kogyo Co., Ltd. of Japan, manufactures automotive roller chains for two- and four-wheeled vehicles supplied to Yamaha, Honda, Kawasaki, Suzuki, and Harley-Davidson. Within the Chain-2-Wheel Department, production proceeds sequentially through raw-material receiving, part feeder, assembly, calking, part detector, preloading, smoothness test, cutting, the Endless process, preloading after Endless, appearance check, and finish good. Each stage involves the use of machinery, material handling, and operator activity that carries a distinct hazard profile. Among these stages, the Endless process - in which the two ends of a chain are joined into a single continuous loop through a pressing and clamping mechanism - was identified as the stage with the highest accident frequency, consistent with the distribution presented in Fig. 1.

2. Unsafe Action and Unsafe Condition on the Endless Machine

The Endless machine joins the chain ends into one complete loop through a pressing and heating process, which places it among the highest-risk stages of the production line. Table 4.4 of the accident log for January-June 2024 recorded seven incidents on this machine, all classified as minor injuries with zero lost workdays; these were dominated by bruises, abrasions, and lacerations to the fingers and hands, mainly arising from contact with the clamping mechanism, stiff chain segments, and sharp material edges.

Figure 2. Endless Machine in the Chain-2-Wheel Department

Field observation and worker interviews identified several structural hazard characteristics of the Endless machine: the presence of a clamping area with a pinch-point that can trap fingers, the proximity of the operator's hand to moving components during the chain-joining process, and the machine guard being frequently removed or left open by operators who prefer to make manual adjustments while the machine is still running. These findings align with prior research showing that unsafe action is strongly correlated with the occurrence of workplace accidents (Haroetikanti, 2025), while unsafe condition, such as an inadequately guarded moving part, independently increases accident risk in a foundry-type production environment (Rusdiana et al., 2025).

Table 1 summarises the identification of unsafe action and unsafe condition obtained from direct observation and interviews with operators, leaders, and the general safety officer.

Table 1. Identification of Unsafe Action and Unsafe Condition on the Endless machine, Chain-2-Wheel Department

No	Observed Condition / Behaviour	Safe / Unsafe	Category
1	Fingers pinched by machine parts during chain installation	Unsafe	Unsafe Condition
2	Hand exposed to press mechanism pressure	Unsafe	Unsafe Condition
3	Hand struck by stiff chain segments	Unsafe	Unsafe Condition
4	Fingers pierced by sharp chain material edges	Unsafe	Unsafe Condition
5	Operator slips due to oil-contaminated floor	Unsafe	Unsafe Condition
6	Operator does not wear protective gloves	Unsafe	Unsafe Action
7	Operator does not wear safety shoes	Unsafe	Unsafe Action
8	Operator works inconsistently with Work Instruction (WI)	Unsafe	Unsafe Action
9	Operator inserts hand into the machine zone while it is still running	Unsafe	Unsafe Action
10	Operator loses focus due to work fatigue	Unsafe	Unsafe Action
11	Operator inspects the machine before use	Safe	Safe Action
12	Operator uses complete PPE as required	Safe	Safe Action
13	Work area is clean, tidy, and free of oil spills	Safe	Safe Condition
14	Machine guard functions properly	Safe	Safe Condition
15	Operator follows SOP/WI and JSA-HIRADC results while working	Safe	Safe Action

Unsafe action refers to worker behaviour that deviates from procedure, such as not wearing PPE, working hastily, or ignoring the SOP, while unsafe condition refers to an environmental or machine condition that has the potential to cause an accident, such as an unguarded machine, a stiff chain, or a slippery floor. As shown in Table 1, ten of the fifteen observed items were categorised as unsafe, indicating that both worker behaviour and machine/environment condition contribute jointly to the accident risk on the Endless machine, a pattern also reported for PPE-compliance studies in other manufacturing settings (Tanjung & Susilawati, 2024; Salsabia et al., 2025).

Interviews with operators, leaders, and the production supervisor consistently indicated that accidents were frequently triggered by a lack of concentration and by workers rushing to meet the daily production target, causing the hand to strike or become trapped during the chain-straightening process. Respondents also noted that although the SOP is available, experienced operators tend to rely on habitual practice rather than strictly following the documented procedure, and that safety briefings and refresher K3 training are still needed on a more regular basis to keep operators aware of the hazard inherent to the Endless machine.

3. Root Cause Analysis

A Fishbone diagram was used to trace the root causes of workplace accidents on the Endless machine, since this tool is capable of systematically illustrating cause-and-effect relationships across multiple contributing dimensions (Monoarfa et al., 2021). The root causes identified in this study were grouped into five elements: Manpower, Method, Machine, Material, and Environment.

On the Manpower dimension, the operator competency assessment system used by the company classifies workers into categories A to E based on a combination of trouble-detection tests, theoretical and practical process tests, and on-the-job training results. Operators in category C, D, or E still require supervision and have not consistently applied PPE according to the SOP/WI, indicating that competency gaps remain a contributing factor to unsafe action. On the Machine dimension, the three main safety-related parts - the sensor, the emergency stop, and the machine guard - were found to function properly according to specification (main air pressure 0.2-0.5 MPa; calking pressure 0.2-0.4 MPa). On the Method dimension, the SOP/WI had not yet been equipped with a documented risk assessment as a reference for risk control, indicating a gap between the written procedure and the actual hazard profile of the job. On the Environment dimension, workplace cleanliness and illumination were maintained within the 300-500 lux standard, while on the Material dimension, chain dimensional tolerances (inner width, outer width, and pin-rivet diameter) were actively monitored by Quality Control against specification.

Beyond machine-related conditions, several supporting factors were also observed to contribute to accident risk: an inconsistent preventive-maintenance schedule, a work area that becomes narrow and slippery from lubricant residue, elevated ambient temperature that accelerates operator fatigue, and high machine noise that hampers communication between operators. Together with the competency-assessment findings, these observations informed the construction of the Fishbone diagram shown in Fig. 4.

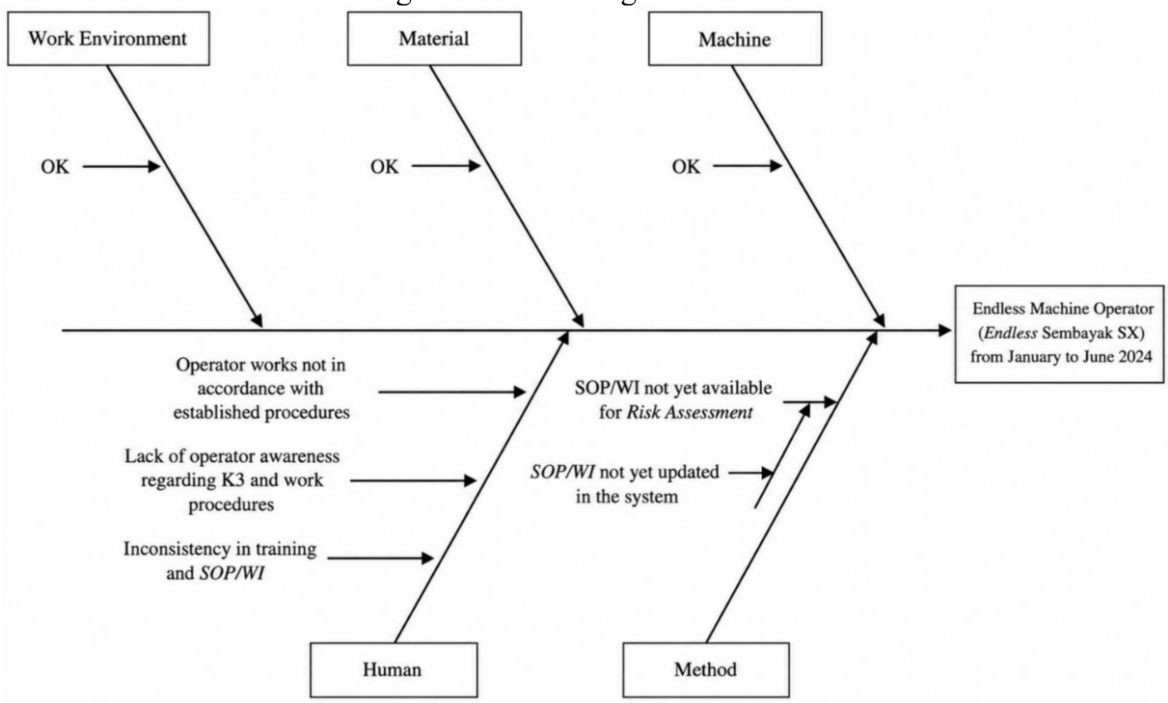

Figure 4. Fishbone diagram of the causes of workplace accidents on the Endless machine, Chain-2-Wheel Department

The Fishbone analysis identified Manpower and Method as the two dominant root-cause factors behind the seven recorded incidents of operators being struck by the Endless machine during January-June 2024. On the Manpower factor, the underlying problem was the absence of operator awareness regarding K3 and standard work procedures; three improvement alternatives were proposed - JSA/HIRADC-based K3 training, HIRADC-based daily safety briefing, and a reward-and-punishment scheme tied to JSA compliance. On the Method factor, the underlying problem was the absence of a periodic SOP/WI update mechanism integrated with JSA and HIRADC review; three corresponding alternatives were proposed - triggering SOP/WI revision from JSA/HIRADC review results, socialising the SOP/WI whenever a revision occurs, and conducting routine SOP/WI compliance audits referencing JSA and HIRADC.

Each alternative was evaluated against the QCDSME criteria (Quality, Cost, Delivery, Safety, Morale, and Environment) and found to satisfy all six dimensions: the proposed measures were judged to reduce operator error, require only modest cost, avoid disrupting the production flow, lower accident risk, raise operator morale and competence, and support a more orderly working environment. A 5W+1H framework was subsequently used to translate the selected alternatives a pre-shift safety briefing for the Manpower factor and periodic SOP/WI review for the Method factor into concrete implementation steps covering who is responsible, where and when the activity takes place, and how it should be executed.

4. **Job Safety Analysis (JSA)**

The implementation of Job Safety Analysis (JSA) was directed at reducing the accident rate on the work activities carrying the highest risk classification. JSA served as an analytical guide to map the potential hazard embedded in each task stage and to form the basis for formulating a targeted control action, so that workers are equipped with a thorough understanding of operational hazard mapping before an incident or occupational illness occurs (Mindhayani & Permatasari, 2023).

Ten operational task stages on the Endless machine were decomposed using JSA, with the risk weight of each stage calculated from the product of its likelihood (L) and severity (S) scores. Table 2 presents the complete JSA results.

Table 2. Job Safety Analysis (JSA) results for the Endless machine, Chain-2-Wheel Department

No	Work Activity	Potential Hazard	Cause	Risk Control / Anticipation	L	S	R	Level
1	Chain material preparation	Hand contact with sharp chain edges	Careless handling; sharp material edge; cramped, poorly lit storage area	Rubber gloves; improve area lighting	3	2	6	Low
2	Lifting chain material	Non-ergonomic lifting posture	Fatigue ignored under production pressure; no written lifting-weight limit	Set lifting-weight limit; use hand trolley	3	3	9	Moderate
3	Installing chain into the Endless machine	Hand trapped by moving machine part	Procedure skipped; rushed due to output target; guard used	Rubber gloves	3	4	12	High

			inconsistently; cramped, dim area					
4	Installing connecting link on chain	Hand pinched by hammer mechanism	Hand positioned too close to press area; press in damaged condition	Rubber gloves	3	3	9	Moderate
5	Pressing two green buttons simultaneously	Mechanical press pressure	Two-hand control / light curtain malfunctioning; procedure ignored by habit; noise diverts attention	Ensure sensor and button function normally	2	5	10	Moderate
6	Visual inspection of finished product	Hand contact with chain during inspection	Rushed inspection; illumination below 500 lux	Rubber gloves	3	2	6	Low
7	Measuring chain length on jig	Prolonged stooping posture	Jig height fixed; no ergonomic assessment programme	Redesign jig to match operator posture	4	2	8	Moderate
8	Pulling and arranging chain on jig	Chain friction against hand	Worn/torn gloves; rough chain surface (burr); cramped area	Rubber gloves	3	2	6	Low
9	Dipping chain into anti-rust solution	Contact with anti-rust chemical liquid	Irritant/corrosive liquid; inadequate ventilation; vapour accumulation	Rubber gloves	3	3	9	Moderate
10	Cleaning the machine area	Slippery floor from oil spillage	No drip tray; 5R programme not running; no anti-slip mat	Install drip tray and anti-slip mat; run daily 5R	4	3	12	High

Note: L = Likelihood; S = Severity; R = Risk rating (L x S). Risk level: R >= 12 High; R 8-11 Moderate; R < 8 Low.

As shown in Table 2, three of the ten task stages fell into the high-risk category: installing the chain into the Endless machine (score 12), triggered by an inconsistently used machine guard; pressing the chain pin (score 10), caused by a two-hand control or light-curtain sensor that was not fully active; and cleaning the machine area (score 12), caused by lubricant spillage arising from an under-implemented 5R (sort, set in order, shine, standardise, sustain) culture. The remaining seven activities fell into the moderate-risk range, with scores between 6 and 9, generally driven by supporting factors such as non-ergonomic posture, inadequate lighting, limited safety training, and inconsistent PPE use.

These findings indicate that the Chain-2-Wheel production line requires a holistic, integrated risk-control strategy, encompassing engineering improvements to work facilities, stricter enforcement of the SOP, and strengthened operator competency and K3 awareness - consistent with findings reported for JSA applications on other high-speed production equipment (Kurniawan et al., 2024; Marsukik et al., 2024).

5. HIRADC-Based Risk Assessment

Hazard identification under the HIRADC framework was carried out through direct shop-floor observation, in-depth operator interviews, and intensive monitoring of the operational dynamics during the manufacturing process. The review confirmed that operational activity on the Endless machine carries exposure ranging from the hand being trapped in the pressing mechanism, physical contact with sharp-edged chain components, exposure to material fragments, and non-ergonomic working posture, to non-compliance with PPE requirements. Beyond these behavioural deviations, the investigation also found several hazardous-condition parameters, reflected in restricted working space, an untidy material storage layout, and minimal guarding on moving mechanical parts.

Risk assessment was subsequently conducted to evaluate the weight of each identified hazard, following the same likelihood-severity multiplication logic applied in the JSA stage (see Table 2). Grouping the ten identified hazards by their underlying source, as summarised in Table 3, shows that the risk profile of the Endless machine is dominated by mechanical and ergonomic hazard sources rather than chemical or biological ones.

Table 3. Grouping of Risk Sources on the Endless Machine

No	Risk	Hazard Source
1	Abrasion and laceration of the hand	Sharp edge of chain material
2	Muscle soreness and work fatigue	Manual handling activity and non-ergonomic posture
3	Fingers trapped by the machine	Moving part of the Endless machine
4	Fingers trapped during connecting-link installation	Hammer mechanism and Endless machine component
5	Fingers exposed to press pressure	Press machine (mechanical / hydraulic pressure)
6	Bruising of the hand	Direct contact with chain material / chain table
7	Back pain and fatigue	Continuous stooping posture
8	Abrasion of the hand	Friction between chain and hand
9	Skin irritation	Anti-rust chemical liquid
10	Operator slipping	Slippery floor from oil spillage

Overall, the risk assessment confirmed that work activity on the Endless machine is dominated by mechanical and ergonomic risk, so that a more optimal application of K3 measures is required, particularly for the activities previously classified as High and Moderate risk in Table 2.

6. Risk Control (Determining Control)

Following the hazard identification and risk-evaluation stages, the final and most essential phase of HIRADC is the determination of risk control. The control strategy in this study was formulated according to the hierarchy of control, comprising five levels applied sequentially from the highest to the lowest degree of protection: elimination, substitution, engineering control, administrative control, and the use of personal protective equipment (PPE). Table 4 presents the recommended control measures for each of the ten activities on the Endless machine.

Table 4. Risk control (Determining Control) for the Endless machine, Chain-2-Wheel Department

No	Activity	Cat.	Engineering Control	Administrative Control	PPE
1	Chain material preparation	M	Install an edge guard on the material storage rack	Add SOP/OPL for chain-material handling; install safety signage	Rubber gloves mandatory
2	Lifting chain material	M	Provide a trolley for heavy material	Ergonomic manual-handling training; limit individual lifting to 15 kg	Back supporter mandatory for loads above 10 kg
3	Installing chain into the Endless machine	H	Install a pinch-point guard on the moving part	Pre-setting procedure; K3 machine training; safety signage	Rubber gloves and safety shoes
4	Installing connecting link on chain	H	Install two-hand control / hand sensor so the hammer only activates when both hands are in the safe zone	Strict connecting-installation SOP; refresher K3 training	Rubber gloves
5	Pressing two green buttons simultaneously	H	Ensure the two-hand control functions normally	Periodic safety-device audit; pre-operation SOP check; press-hazard training	Rubber gloves
6	Visual inspection of finished product	M	Design an inspection jig that minimises direct hand contact with the chain edge	Safe chain-inspection technique; safety signage in inspection area	Rubber gloves
7	Measuring chain length on jig	H	Modify jig height to match operator anthropometry (ideal working height 80-90 cm)	Mandatory stretching exercise; ergonomic posture training	Rubber gloves
8	Pulling and arranging chain on jig	M	Provide a jig to pull the chain without direct hand contact	Correct chain-pulling technique; periodic chain-condition inspection	Rubber gloves mandatory
9	Dipping chain into anti-rust solution	M	Use a closed / semi-automatic dipping system to reduce direct exposure	Safe dipping technique; first-aid kit available nearby	Chemical-resistant rubber gloves and apron
10	Cleaning the machine area	H	Install anti-slip flooring; improve	Routine cleaning schedule; 'Slippery	Oil-resistant anti-slip safety shoes mandatory

			the lubricant-storage system	Floor' signage; daily 5R	

Note: Cat. = risk category; H = High, M = Moderate.

As shown in Table 4, the control measures recommended for high-category risk prioritise engineering solutions, such as machine guarding, automatic sensors, anti-slip flooring, and ergonomic equipment adjustment, in line with the control-hierarchy principle of addressing risk at its source before relying on administrative measures or PPE (Rahmawati & Puji, 2024; Rahmadani et al., 2023). Moderate-category risk is primarily addressed through a combination of administrative control - such as SOP strengthening, training, and periodic audit - together with consistent PPE use, an approach consistent with recommendations reported for other manufacturing risk-control studies (Alega et al., 2025; Nugroho & Muliawan, 2026).

7. Improvement Implementation and Results

Guided by the Fishbone root-cause analysis, improvement was focused on the two dominant contributing factors: Manpower and Method. On the Manpower factor, three measures were implemented: JSA/HIRADC-based K3 training, a five-to-ten-minute safety briefing delivered by the supervisor or leader before every shift change, and a reward-and-punishment scheme tied to operators' compliance with the SOP/WI, PPE use, and JSA evaluation results. On the Method factor, three complementary measures were implemented: a periodic review and update of the SOP/WI referencing the JSA and HIRADC outcomes, socialisation of the SOP/WI to all operators whenever a revision occurs, and a routine compliance audit conducted by the supervisor and the K3 team.

Observation during the improvement period also confirmed that a stiff-chain condition - segments of the chain link that could not move as flexibly as the rest of the strand - was a contributing material factor behind several bruising incidents, as operators needed to apply greater manual force to straighten the chain before it could be installed on the machine, occasionally causing a sudden release of tension that struck the operator's hand or the work table, as illustrated in Fig. 5. As a control measure, the company introduced a pre-use chain inspection, segregated stiff-chain material, and trained operators on the safe handling technique for this condition.

Figure 4. Comparison Between a Stiff Chain Condition and a Normal (OK) Chain Condition

Following the consistent implementation of these measures, all ten activities that were originally classified as High Risk (five activities) or Moderate Risk (five activities) were targeted to be reduced to Low Risk. This is reflected in the accident trend recorded across three consecutive periods: seven accidents in the baseline period (January-June 2024), declining to two accidents during the transition period (July-September 2024) once the JSA/HIRADC-based hazard elimination and risk assessment began to take effect, and further declining to zero accidents in the subsequent period (October-December 2024). Overall, this represents a 100% reduction in workplace accidents on the Endless machine, from seven incidents to none, confirming that the integrated application of JSA and HIRADC provided a tangible contribution to improving occupational safety and health at PT Daido Manufacturing Indonesia, a finding that echoes the effectiveness of similar integrated risk-based interventions reported elsewhere in the manufacturing and construction sectors (Berawi et al., 2023; Simbolon et al., 2024; Saari et al., 2024).

D. CONCLUSION

This study analysed the workplace-accident risk on the Endless machine in the Chain-2-Wheel Department of PT Daido Manufacturing Indonesia using an integrated Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment and Determining Control (HIRADC) approach. The Chain-2-Wheel production process was found to comprise a sequential flow from material preparation, chain installation, and pressing to product inspection and finished-goods storage, each carrying a distinct hazard potential when not executed according to the applicable work procedure. Accidents on the Endless machine were found to originate from both unsafe action - such as incomplete SOP compliance and inconsistent PPE use - and unsafe condition - such as a restricted work area and machine parts capable of trapping the operator's hand.

The JSA-HIRADC analysis identified three activities in the High-risk category and seven in the Moderate-risk category, with the highest risk associated with activities directly involving the machine's moving parts and the chain-installation process. Improvement measures implemented in response - comprising an updated JSA and HIRADC, pre-shift safety briefings, strengthened PPE compliance, installation of safety visual media, and periodic SOP review - reduced the number of recorded accidents from seven cases to zero over three successive observation periods, confirming the practical effectiveness of the integrated approach in strengthening the safety culture of the Chain-2-Wheel Department.

Future research is encouraged to extend this work by applying complementary risk-analysis methods or by evaluating the long-term effectiveness of the implemented controls, so as to produce a more comprehensive understanding of occupational risk management on high-speed automotive chain-assembly equipment

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