

Original Article

ANALYSIS OF WORK POSTURE AND MENTAL WORKLOAD AMONG PRODUCTION OPERATORS IN THE PRODUCT MANAGEMENT DEPARTMENT OF PT PETROKIMIA GRESIK USING THE OWAS AND NASA-TLX METHODS**Muhammad Misbah Shofiyulloh^{1)*}, Tranggono²⁾, Rizqi Novita Sari³⁾**^{1,2,3)} Industrial Engineering Study Program, Faculty of Engineering and Science, Universitas Pembangunan Nasional “Veteran” Jawa Timur, Surabaya, Indonesia*Corresponding Author, E-mail: muhammadmisbah127@gmail.com

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ABSTRACT

Background. Repeated material handling may expose production operators to non-neutral postures and substantial mental workload.

Research Purpose. This study assessed work-posture risk and operator mental workload in the Product Development Partnership unit of PT Petrokimia Gresik and formulated ergonomic improvements.

Research Method. The study was conducted from February to June 2026 with eight production operators. Direct observation and posture documentation were used for OWAS analysis of eight solid- and liquid-product activities. Mental workload data were collected using a NASA-TLX questionnaire with pairwise weighting and ratings for Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration Level.

Findings. OWAS classified five activities in risk category 3, requiring immediate corrective action, and three activities in risk category 2, for which improvement may be required. NASA-TLX scores ranged from 68.33 to 88.33. Two operators (25%) had high mental workload and six (75%) had very high mental workload. Physical Demand provided the largest average weighted contribution, while Frustration provided the smallest.

Conclusion. The results indicate a need for work-posture improvement, ergonomic standard operating procedures, a hand pallet for solid-product handling, a drum stacker for liquid-product handling, and routine stretching.

Keywords: Ergonomics, Work Posture, Mental Workload, OWAS, NASA-TLX.

BACKGROUND

Ergonomics aligns work demands, tools, and work environments with human capabilities and limitations. In production settings, this alignment is important because operators must maintain output while managing physical exertion, attention, and environmental pressures. Appropriate ergonomic design supports worker comfort, safety, and productivity, whereas poor task design can produce fatigue and unsafe compensatory movements [1].

Work-related musculoskeletal disorders are a central concern in manual production. Repeated lifting, trunk flexion, prolonged standing, and repetitive upper-limb movements increase loading on the back, waist, shoulders, and lower extremities [2]. Manual lifting becomes more demanding when load position, movement frequency, and workstation height require the operator to work away from a neutral posture [3]. Sustainable control therefore requires assessment of the task and work system, not merely a response after discomfort has appeared [4].

Physical exposure often occurs together with mental workload. Production operators must remember quantities, monitor process quality, coordinate successive tasks, respond to time pressure, and remain attentive near operating machinery. Subjective workload assessment is useful in this context because it captures how operators experience combined mental, physical, temporal, performance, effort, and frustration demands [5]. Persistent high workload can reduce concentration and increase the possibility of error, particularly when demanding physical activity is performed under production targets and noise.

PT Petrokimia Gresik operates a Product Development Partnership unit within its Product Management Department. Eight operators in this unit work one eight-hour shift and produce solid products, including Biofertil and Petro Gladiator Padat, and liquid products, including Petro Gladiator Cair, Petro Fish, and Phonska OCA Plus. Production involves material preparation, quality checking, weighing, mixing, final quality checking, filling, and packaging. Daily work includes repeated lifting and transfer: solid production reaches 550 kg with 11 lifting cycles, while liquid production reaches 350 L with 24 lifting cycles.

Initial company records documented 47 mental-workload complaints from April 2025 to March 2026. The most frequent complaints were reduced concentration (10 reports), mental fatigue (9), stress associated with production targets (7), and operational time pressure (6). A Nordic Body Map completed by the eight operators also identified concentrated discomfort in the lower back and back. In the lower-back region, 50% reported pain and 38% reported severe pain; in the back, 50% reported pain and 25% reported severe pain. These patterns were consistent with tasks involving bending, repeated manual handling, and prolonged standing.

The Ovako Working Posture Analysis System (OWAS) was selected because it classifies the positions of the back, arms, and legs together with the handled load and links the resulting code to a corrective-action category. Its whole-body structure is suitable for dynamic production tasks and material handling [6]. The NASA Task Load Index (NASA-TLX) was used to complement the posture assessment because it represents workload through six dimensions and produces a weighted subjective score. NASA-TLX has been applied to identify demanding dimensions and improvement priorities in industrial operations [7].

Previous studies have applied OWAS to identify postural risk [6] and NASA-TLX to evaluate perceived workload [7]. Considering both dimensions is useful when production work involves manual handling, sustained attention, production pacing, and quality responsibility. This study therefore aimed to analyze work posture and mental workload among production operators at PT Petrokimia Gresik and to formulate improvements that address the physical and mental characteristics of the work unit.

RESEARCH METHOD

The study was conducted from February to June 2026 in the Product Development Partnership unit of the Product Management Department at PT Petrokimia Gresik, Gresik, East Java, Indonesia. It involved eight production operators engaged in the production of organic fertilizers and product-development products. Their ages ranged from 23 to 55 years and their job tenure ranged from 4 to 25 years.

Primary data were obtained through direct observation, work-posture documentation, and a NASA-TLX questionnaire. Observations covered actual work during operating hours. Photographs or video frames representing the working condition were selected for eight activities: pouring material, receiving material, mixing, transferring the solid mixing

output, filling liquid material, passing liquid material, pouring liquid material into the mixing tank, and transferring the liquid mixing output. The observed activities represented both solid- and liquid-product plants.

For OWAS, each representative posture was coded using four digits. The first digit represented the back, the second the arms, the third the legs, and the fourth the handled load. The code was matched to the OWAS action matrix. Category 1 indicates a normal posture that does not require improvement; category 2 indicates a posture that may require improvement; category 3 indicates a harmful posture requiring immediate corrective action; and category 4 indicates a highly harmful posture requiring urgent corrective action. The analysis focused on the final code and risk category for each activity.

Mental workload was assessed using six NASA-TLX dimensions: Mental Demand (MD), Physical Demand (PD), Temporal Demand (TD), Performance (PE), Effort (EF), and Frustration Level (FR). Each operator first completed 15 pairwise comparisons to obtain the dimension weights. The operator then assigned a rating from 0 to 100 to each dimension. A product value was calculated by multiplying each dimension rating by its weight, and the six product values were summed to obtain the Weighted Workload (WWL). The final score was calculated as NASA-TLX score = WWL/15.

Final NASA-TLX scores were classified as low (0–9), moderate (10–29), moderately high (30–49), high (50–79), or very high (80–100). The OWAS and NASA-TLX results were then analyzed to identify the work activities with the highest ergonomic risk and to formulate recommendations. The recommendations included work-posture improvement, standard operating procedures for the solid- and liquid-product plants, and work aids suited to field conditions and requirements.

FINDINGS

Table 1 presents the ages and job tenures of the eight respondents. Their ages ranged from 23 to 55 years, and their job tenure ranged from 4 to 25 years.

Table 1. Characteristics of the production operators

Respondent	Age (years)	Job tenure (years)
Respondent 1	23	4
Respondent 2	38	16
Respondent 3	42	17
Respondent 4	43	15
Respondent 5	23	5
Respondent 6	35	12
Respondent 7	41	18
Respondent 8	55	25

Source: Primary Data, 2026

The OWAS assessment identified risk in every observed activity. Five activities were assigned to category 3: pouring material, receiving material, mixing, transferring the solid mixing output, and transferring the liquid mixing output. The remaining three activities filling liquid material, passing liquid material, and pouring liquid material into the mixing tank were assigned to category 2. The detailed posture codes are presented in Table 2.

Table 2. OWAS results for the observed activities

No.	Activity	Back	Arms	Legs	Load	OWAS category
1	Pouring material	2	1	2	3	3
2	Receiving material	2	1	2	3	3
3	Mixing	2	1	3	3	3
4	Transferring solid mixing output	2	1	4	3	3
5	Filling liquid material	2	1	2	2	2
6	Passing liquid material	4	1	7	2	2
7	Pouring liquid into mixing tank	4	1	7	2	2
8	Transferring liquid mixing output	4	1	7	3	3

Source: Data Processing Results, 2026

The category 3 activities combined non-neutral trunk positions with unstable or mobile leg positions and substantial loads. In solid production, pouring and receiving material used the code 2-1-2-3, mixing used 2-1-3-3, and transfer of the mixing output used 2-1-4-3. The liquid-output transfer used 4-1-7-3. By contrast, liquid filling used 2-1-2-2, while passing liquid material and pouring it into the mixing tank used 4-1-7-2. Although these three codes were classified as category 2, they still indicated posture conditions requiring evaluation and possible improvement.

NASA-TLX pairwise weights and ratings produced WWL values between 1,025 and 1,325 and final scores between 68.33 and 88.33. Respondents 1 and 5 were in the high category; the other six respondents were in the very high category. Table 3 summarizes the dimension products, WWL values, final scores, and classifications. Physical Demand had the largest average weighted product across respondents, whereas Frustration had the smallest average weighted product.

Table 3. NASA-TLX weighted products, WWL values, scores, and categories

Resp.	MD	PD	TD	PE	FR	EF	WWL	Score	Category
1	300	60	210	0	130	425	1125	75.00	High
2	475	65	340	240	0	140	1260	84.00	Very high
3	160	475	75	360	0	255	1325	88.33	Very high
4	160	475	75	340	0	270	1320	88.00	Very high
5	375	55	280	195	0	120	1025	68.33	High
6	150	450	70	340	0	240	1250	83.33	Very high
7	150	475	60	360	0	240	1285	85.66	Very high
8	160	475	0	360	75	255	1325	88.33	Very high

Source: Data Processing Results, 2026

Table 4. Combined OWAS and NASA-TLX results

No.	Work activity	OWAS category	NASA-TLX category
1	Pouring material	Risk 3	High
2	Receiving material	Risk 3	Very high
3	Mixing	Risk 3	Very high
4	Transferring solid mixing output	Risk 3	Very high
5	Filling liquid material	Risk 2	High
6	Passing liquid material	Risk 2	Very high
7	Pouring liquid into mixing tank	Risk 2	Very high
8	Transferring liquid mixing output	Risk 3	Very high

Source: Data Processing Results, 2026

The combined OWAS and NASA-TLX classifications for the eight work activities are shown in Table 4. Pouring material and filling liquid material were paired with the high NASA-TLX category, while the other six activities were paired with the very high category.

DISCUSSIONS

The OWAS results showed that five of the eight work activities were in risk category 3 and required immediate corrective action, while the other three activities were in risk category 2 and might require corrective action. The main factors affecting ergonomic risk were non-ergonomic working postures, manual material handling, prolonged standing, and repetitive movements. Bent-back postures occurred in the observed work activities; prolonged standing occurred in activities 1, 2, 3, 5, 6, and 7; and manual handling occurred in activities 2, 3, 4, 6, 7, and 8. These findings were used as the basis for work-posture improvement, standard operating procedures, and proposed work aids [6, 8].

NASA-TLX showed that Physical Demand had the highest average value and Frustration had the lowest. Two respondents (25%) were in the high mental-workload category and six respondents (75%) were in the very high category. These results were associated with lifting and transferring 50 kg sacks and 15 L containers, remembering and recording the quantities produced each day, a rapid and tiring work rhythm, and frustration associated with machine noise. The total NASA-TLX score was obtained from the combined weighted values of all six dimensions [5, 7, 9].

The combined OWAS and NASA-TLX recap was used to determine ergonomic-improvement priorities. Five activities were reported as OWAS risk category 3 and three as category 2, while the paired NASA-TLX classifications consisted of two high and six very high classifications. The recommended improvements focused on work-posture correction, standard operating procedures for the solid- and liquid-product plants, and work aids suited to field conditions [10].

The proposed posture improvements were intended to make the operator's body position more upright and closer to neutral during pouring, receiving, mixing, passing liquid material, pouring liquid into the mixing tank, and transferring mixing output. For liquid filling, no posture change was recommended because the operator had to bend slightly to inspect the drum contents; instead, the activity was recommended to be moved to a more suitable work area. The proposed standard operating procedures covered ergonomic lifting and transfer techniques, body position, work sequence, and light stretching.

For the solid-product plant, a hand pallet was proposed to transfer mixing output. Its estimated use was 11 times per day, 66 times per week, and 242 times per month. With an equipment price of IDR 3,500,000, the estimated total monthly cost was IDR 577,090, or approximately IDR 2,384 per transfer. For the liquid-product plant, a drum stacker was proposed for 24 transfers per day, 144 per week, and 528 per month. With an equipment price of IDR 9,800,000, the estimated total monthly cost was IDR 1,304,166, or approximately IDR 2,470 per transfer.

This study has several limitations that should be considered when interpreting the findings. First, the study involved only eight production operators from a single Product Development Partnership unit, which limits the generalizability of the results to other production settings or operator populations. Second, OWAS assessment was based on direct observation and documented work postures during selected production activities; therefore, the assessment may not fully capture variations in posture, task duration, work pace, or handling techniques across different shifts and working conditions. Third, mental workload

was assessed using the NASA-TLX questionnaire, which relies on operators' self-reported perceptions and may therefore be influenced by individual experiences, expectations, or temporary conditions at the time of assessment. Finally, the study used a cross-sectional assessment and did not evaluate the effectiveness of the proposed ergonomic interventions after implementation. Future studies should involve a larger and more diverse operator population, repeated observations across shifts and production conditions, and longitudinal evaluation to determine whether ergonomic interventions lead to measurable improvements in posture risk, mental workload, and operator well-being.

Routine stretching before work was also recommended. The program was expected to reduce muscle tension, improve flexibility, reduce fatigue caused by repetitive work, and help maintain operator fitness [11]. Future research was recommended to evaluate the effectiveness of the standard operating procedures, work aids, and workload arrangements using other ergonomic methods as a comparison.

CONCLUSION

Work-posture analysis showed that five of eight activities were in OWAS risk category 3 and required immediate corrective action, while three activities were in category 2 and might require improvement. The principal physical risk factors were a bent or twisted back, manual material handling, prolonged standing, walking while carrying loads, and repeated movement. NASA-TLX classified two operators (25%) as having high mental workload and six operators (75%) as having very high mental workload. Physical Demand was the most dominant average weighted contribution, whereas Frustration was the smallest.

The study recommended work-posture improvement, standard operating procedures for the solid- and liquid-product plants, and work aids suited to field conditions. Improvement was prioritized for activities classified as OWAS risk category 3 and very high mental workload. The proposed work aids were a hand pallet for the solid-product plant and a drum stacker for the liquid-product plant. Routine stretching before work was also recommended.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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