

**Ergonomic Intervention on the Stamping Process of Part Body Component  
Improved Work Quality and Satisfaction and Time Efficiency  
at the Stamping Plant Division of PT ADM Jakarta**

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**ABSTRACT**

Part body component of a car is the finished product component that is mainly produced by the big press machine. In the production process of part body component of a car in the stamping plant division, the manual task is performed by two operators to feeding the material sheet into the big press machine simultaneously. After the knobs were pressed together, the big press machine started to stamp the material sheet and the outgoing product is taken by the next operator. This task is performed repeatedly until it is the last one. Manual and comprehensive task that combined with speed in operating the big press machine cause who muscular tension which at the end could cause muscular complaints and premature fatigue, that could decrease production and productivity.

The current study of ergonomic intervention on stamping process of part body component of car was conducted in order to determine whether ergonomic intervention could improve the work quality, satisfaction and time efficiency in the stamping process.

The subjects of study were 10 persons that were taken randomly. It was designed experimentally with treatment by subject design. The method of data collection was by questionnaire distribution and direct measurement of subject's condition, time of stamping process and work environment before and after intervention. The Shapiro Wilk test showed that all of the data had normal distribution and was followed by t-paired for data of work quality, work satisfaction, time efficiency, and the environment data. The significance level is set at 5%.

The research result showed that work quality was improved (muscular complaints was decreased by 6,65%, fatigue was decreased by 5,47% and work boredom was decreased by 5,87%), work satisfaction was improved up to 6,43%, time efficiency of stamping process was improved up to 10,7%, the production was improved up to 2,59% and productivity was improved up to 32,65% as well as company's profit was increased up to 3,95%.

Hence, the study concludes that ergonomic intervention in the production process of part body component of car in the stamping plant division could improve work quality, work satisfaction and time efficiency.

Keyword: ergonomic intervention, redesign of pushing knob, work quality, work satisfaction and time efficiency.

**INTRODUCTION**

The industrial development has grown fast along with the improvement of technology and market competition. Industry becomes the main supportive element in the country in supporting the development. Therefore, healthy, vigorous and productive human resources is needed that could improve the welfare and ability to compete in the free trade competition.

In the free trade era, the tight competition, people's complexity and fast change are challenges the problem of especially in the industrial world. The emerging problems and demand are too complex, must be solved with systemic and holistic approach and using various disciplines. In facing the competition, management ability and individual quality should be improved and should have added-value and should be ready in changing the mindset, work culture and organizational structure<sup>1,2</sup>.

Competitive capacity could be improved when the human resources is tough, ready to work hard, be collaborative and work according to the smart principle (specific, measurable, achievable, realistic and time frame). A very serious attention along with distinct and direct action is needed as an empowerment process; by so doing optimum work performance is achieved and the knowledge should be continually developed/improved<sup>2,3</sup>.

One of the growing industries in Indonesia PT X that is involved in automotive, financial service, agribusiness and heavy duty equipment business. PT. ADM is included as one of the PT X group<sup>4</sup>. The production capacity of PT ADM in the year of 2005 was 10.000 cars per month. The production is increasing continuesly based on market demand<sup>4</sup>.

There are four divisions of production process of car in PT ADM, i.e, stamping plant (part body component stamping), casting plant (automobile machine block foundry), engine plant (automobile machine manufacture) and assy plant (automobile machine assembly). Of the four production divisions processes, the stamping plant division is predominantly involved with manual labor.

The production process output of the stamping plant is automobile part body component. Automobile part body component is the finished part that is mostly procuded by big press machine. Production process of automobile part body component at the stamping plant is dominated by manual job and this means that human factor has an important role in the production process<sup>6,7</sup>. Manual tasks may lead to a work accident and could cause an occupational disease<sup>8,9</sup>.

In the production process of automobile part body component, the operators a workers are involved in taking, lifting and putting the metal material sheets into big press machine repetitively. Using arms and hands involved in repetitive manual tasks continuously and combined with work speed in using the industrial equipment many cause muscle tension that could produce the muscular complaints and premature fatigue<sup>10</sup>.

One of the our protection efforts for the operators from the risk factor in working is by improvement of work condition through ergonomic intervention. The ergonomic principle was applied specifically through application of total ergonomic approach. The total ergonomic approach was conducted integratedly, by combining the SHIP (Systemic, Holistic, Interdiscipler and Partisipatory) approach and Appropriate Technology<sup>11</sup>.

Based on the principle of *fitting the task to the man*, a harmony between human, product, machine/work tool, work method and work environment suitable with ability, skill and limitedness of human will create an optimum product quality<sup>12,13,14</sup>. In order to create a healthy, safety, comfortable and efficient working condition and environment as well as a high productivity, a functional maximal and optimal utilization of human body is required<sup>15</sup>.

Problem identification based on 8 ergonomic problems in 2 A Line showed that nutritional intake while working was not yet optimally implemented. 73,3% of operators reported thirsty after working and their weight was declined 0,71 kg after work. The utilization of muscle power,of the upper part of the body was not in natural position for the task assigned; while the task were repetitively and monotonous with taking, lifting and put/throw the material sheet with weight of 4-8 kg. The work position was not changed as leg and foot supported the body statically and it was done by standing for a long time. The temperature of environment condition was 31,5 °C – 33 °C, relative humidity (Rh) was 56 %, and noise was 97.5 dBA. The schedule of short break or active break time have not been

implemented. The social condition of operator was not yet optimum as there was a lack of opportunity for social interaction among colleagues. The information condition was not well arranged and interaction of human-machine/tool was occurred when pushing the push-button knob that was located behind the operator's body. These data was strengthened by secondary data of PT ADM clinic which reported that musculoskeletal disorders of operator who seek for treatment in the clinic had highest rank. Indeed, the above eight ergonomic problems need a holistic evaluation<sup>16</sup>.

It is suspected that boredom that felt by operator in the stamping plant division was caused by monotonous and repetitive tasks. If this condition could not be solved, this could bring negative impact on the work quality and work satisfaction. In addition, time efficiency was not optimal as the impact from musculoskeletal complaint and fatigue.

Therefore, current study was conducted to determine the contribution of ergonomic intervention toward operator's work performance in the division of stamping plant of PT. ADM Jakarta. It is expected that the bad work body posture and the static/continuous muscle contraction could be corrected; by so doing the work quality, life quality, and the work productivity could be improved.

## MATERIALS AND METHODS

The study was an experimental one, that used treatment by subject design. It was held at 2A Line of Stamping Plant Division in PT. ADM in Jakarta on March–April 2008. The sample was 10 persons who were randomly chosen from the big machine operators.

The research object was a push button at 2A Line at Stamping Plant division in PT. ADM in Jakarta. The object was redesigned because its position was not appropriate and its size did not fit with operator's anthropometric. The redesigning was followed by changing operator's work position on dies shifting, arranging active break time and adding nutrition intake. The shape and dimension of the former push button (the old one) was rectangular with length size of 500 mm, width was 140 mm, thickness was 100 mm and height was adjustable (figure 2). The modified push button (the new one) was U-shape, inner length was 610 mm and outer length was 810 mm, width was 200 mm as well as 100 mm, thickness was 85 mm and the height was adjustable. The other redesigning change was in the position of emergency stop button (figure 1). On button the old one, the emergency stop button was located in the middle while on the new one, it was located in the right side just behind the push button.

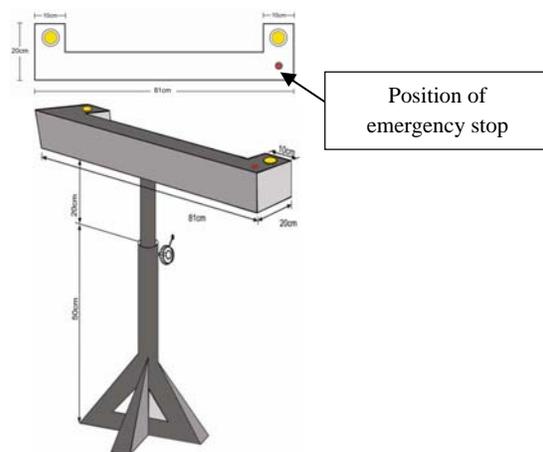


Figure 1. The New One (After Redesign)

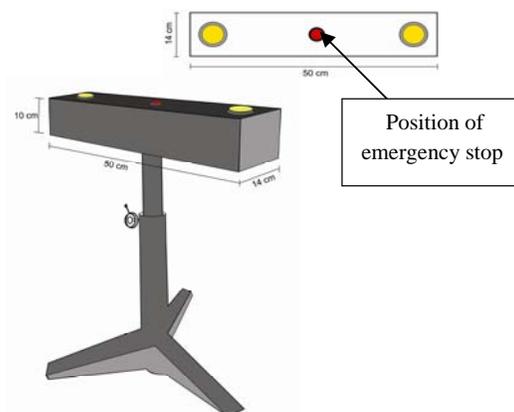


Figure 2. The Old One (Before Redesign)

The chosen sample worked as used to (before applying ergonomic intervention) and worked with ergonomic intervention. Work quality was assessed based on the work load (resting heart rate, working heart rate), musculoskeletal complaints (Nordic Body Map questionnaire), fatigue (Scale Rating Questionnaire of 30 items), and work boredom (work boredom questionnaire). Work satisfaction was rated by using 20 items of Minnesota Satisfaction Questionnaire (MSQ) and the time efficiency was a comparison of process time to produce one part body component between before and after applying ergonomic intervention that was counted using stop-watch. Work environment conditions were recorded in terms of noise with sound level meter, temperature with WBGT-meter, relative humidity with WBGT- meter, and illumination intensity with lux meter. The collected data was tested it's normality by using Shapiro Wilk analysis and t-paired test for data of quality, work satisfaction and time efficiency, while for environment data was analysed by using t-group with significance level of 5%.

## RESULTS

### Subject Characteristic

Subject characteristic of the study is presented in Table 1. At their age average, a person has optimum muscular and physical strength capacity to work. Indeed, they are in the category of productive age that supported the study. Body height and weight was measured to rate the BMI (Body Mass Index) in order to determine the energy balance between energy of nutrition intake body and the expended energy.

Operators were in healthy condition to do their physical work as their average blood pressure were in normal condition. Person's physical fitness level can be shown with his resting heart rate.

Table 1. Operator Data at 2A Line of Stamping Plant Division  
PT ADM Jakarta (n = 10)

No	Parameter	Average $\pm$ SB
1.	Age (year)	21.9 $\pm$ 2.23
2.	Systolic Blood Pressure (mmHg)	107.0 $\pm$ 6.75
3.	Dyastolic Blood Pressure (mmHg)	68.0 $\pm$ 6.32
4.	Resting Heart Rate (bpm)	78.0 $\pm$ 11.43
5.	Body Weight (kg)	58.6 $\pm$ 4.62
6.	Body Height (cm)	171.7 $\pm$ 4.43
7.	Hip + Wrist Width (cm)	47.25 $\pm$ 2.03
8.	Standing Elbow Height (cm)	106.3 $\pm$ 3.29
9.	Body Mass Index (BMI)	19.88 $\pm$ 1.52
10.	Work Experience (years)	1.83 $\pm$ 1.61

Operators' average of resting arterial pulse were normal that indicating their healthy condition. Their work experience indicated that they had sufficient competence.

### Operator's Work Condition before and after Ergonomic Intervention

Measurement result on operator's work condition without and with ergonomic intervention and its economic analysis was shown in Table 2.

Table2. Working Heart Rate, Working Pulse, Work Boredom, Fatigue, Musculoskeletal Complaints, Work Satisfaction, Efficiency of time And Economic Analysis

No.	Parameter	Before		After		t	p
		Mean	± SD	Mean	± SD		
1	Working Heart Rate (bpm)	96.98	± 8.68	94.15	± 6.86	1.96	0.08
2	Working Pulse (bpm)	19.92	± 5.70	15.45	± 6.94	2.11	0.06
3	Work Boredom	60.30	± 4.03	55.00	± 7.26	2.17	0.02
4	Fatigue	5.35	± 2.99	3.10	± 1.59	2.334	0.044
5	Musculoskeletal Complaints	5.65	± 3.84	3.30	± 3.13	2.330	0.045
6	Work Satisfaction	56.60	± 4.83	61.60	± 7.86	-3.00	0.01
7	Process Time (minute)	2.17	± 0.12	1.96	± 0.09	10.33	0.00
8	a. Productivity	0.0291	± 0.0001	0.0386	± 0.00035	3.00	0.00
	b. Profit (Rp)	196.769	300.00	204.538	233.40		
	c. BCR	1.524		1.535			

As shown in Table 2, the average of working heart rate and working pulse there was no significant difference before and after intervention ( $p > 0,05$ ). However, the average of work boredom score, average of fatigue score differences, musculoskeletal complaints score differences, work satisfaction score, process time differences and productivity before and after intervention was significantly different ( $p < 0,05$ ).

#### Operator's Environment Condition Before and After Ergonomic Intervention

The operator's environmental condition without and with ergonomic intervention in the study is presented in Table 3.

Table 3. Work Environment Conditions at 2A Line of Stamping Plant Division in PT ADM Jakarta

Parameter	Before		After		t	p
	Mean	± SD	Mean	± SD		
Noise (dBA)	99.72	± 4.18	100.84	± 2.24	-0.42	0.71
WBGT (°C)	26.19	± 0.48	27.11	± 0.47	-8.72	0.00
Air Temperature (°C)	28.68	± 0.52	30.80	± 0.69	-4.46	0.02
Relative Humidity (°C)	68.48	± 2.36	59.28	± 4.33	3.27	0.04
Illumination (lux)	195.30	± 39.30	271.27	± 31.47	-3.83	0.03

As shown in Table 3, the average of noise before and after intervention was not significantly different ( $p > 0,05$ ). However, the average of WBGT, air temperature, relative humidity and illumination before and after intervention was significantly different ( $p < 0,05$ ).

Table 4. Contribution of Work Environment to NBM, Fatigue, Work Boredom, Work Satisfaction and Processing Time at 2A Line of Stamping Plant Division in PT ADM Jakarta

Parameter	R <sup>2</sup> Value
NBM	0,126
Fatigue	0,030
Work Boredom	0,331
Work Satisfaction	0,272

The regression analysis showed that work environment contributed to the NBM respectively with 12,6%, fatigue was 3%, work boredom was 33,1% and work satisfaction was 27,2%.

## DISCUSSION

### Operator Characteristics

The average of operators' age was in the category of productive age<sup>17</sup>. The average of body height and body weight was measured to calculate the BMI (Body Mass Index) to determine energy balance between energy of nutrition intake into the body and the outwards energy<sup>18,19,20</sup>. Operators were in healthy condition to do physical work activity because their blood pressure was in normal average<sup>21,22</sup>. The physical health level of a person could be indicated by resting heart rate and the result of the study showed that operator's resting heart rate was in normal level. This means that the operators were in healthy condition. Work experience is one of the manifestation factors from mastering skill, ability and familiarity with work condition. Operators in the study had more than one year of work experience. Therefore, they had sufficient experience, skill and mastery on operating the big press machine either using the former push button or the modified push button.

### The effects of Ergonomic Intervention

By redesigning the push button changing the work posture that previously was not in-natural position. The operator's upper extremity position was in abduction position, away from the body with fore-arm and back-arm make a 111° angle (Figure 4). Such position of operator's upper extremity will overload the joint and the muscle of the fore-arm which then created a premature fatigue and injured the musculoskeletal system when this occurred for a longer duration. After using the new design, operator's upper extremity posture was in-natural position, because the redesigned push button is located just in the left and right side of the operator's body. The change permits the fore-arm and back-arm make a wider angle, i.e. 151° (Figure 3) or nearly parallel with body axis. Indeed, this posture reduced the load on the shoulder joint and the muscles while operating the redesigned push button.

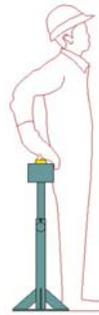


Figure 3. Work Position with the new one      Figure 4. Work Position with the old one

The emergency stop button was positioned at the bottom right side of the push button because most of the operators were using their right hand (right handed). This improvement had significantly reduced the musculoskeletal complaints, fatigue and work boredom ( $p < 0,05$ ), hence, it means that the work quality was improved. This result was followed by reduction of musculoskeletal complaint of 6,65%, fatigue of 5,47% and work boredom of 5,87% which also supported by secondary data that was coming from the clinic in PT. ADM that reported 80% reduction of complaints on musculoskeletal disorder (myalgia) among the operators who visited the clinic.

It is in compliance with the previous study<sup>23</sup> which stated that the usage of hand wheel with vertical handle on pressing tool of coconut grating machine could reduce the musculoskeletal complaints until 23,22%. In addition, other previous study also<sup>24</sup> mentioned that procedure improvement on lifting loading was reduced the musculoskeletal disorder until 36.60% of workers in PT. SR Blahbatuh Gianyar. A study<sup>25</sup> found that applying total ergonomic intervention to the work system of ceramic painting process in Kasongan ceramic industries reduced the boredom level until 18.12%.

However, operator's work load (working heart rate and working pulse) is used as indicator of person's physical load or the work load that related with cardiovascular system that is not significantly different ( $p > 0.05$ ). Working heart rate and working pulse in the study is considered as light work load<sup>26</sup>. It is predicted that such condition originated from the light category of the work load and work mechanism before and after intervention was the same from the fact that manual tasks was improved and yet machinal tasks was still the same.

Musculoskeletal complaints, fatigue and work boredom was reduced because of the new work system (using modified push button), besides the push button was improved, ergonomic interventon was also applied by : (1) arranging work position. Arranging operator's work position during work time has carried out by balancing work load between the left and the right body side. For example, when starting to work with the push button, the operator was in the right position and when changing dies the operator was moved to the left position. Work position management could reduced musculoskeletal complaints and fatigue, could reduced the boredom among the workers; and (2) arranging work organization. Arranging work organization influenced operator's work. Arranging work organization was carried out by changing dies in active break time for 5 minutes because changing dies was carried out by other operator. Active break time was used to have a break (drinking and eating snack) that prepared by the company. Indeed, by activity changing reduced the boredom, it is particularly true , for long duration working time.

This result was in accordance with a study that stated that adding active short break and Balinese pop song could reduced the muscular complaint and boredom as well as increase work productivity<sup>27</sup>.

The operator at Line 2A of Stamping Plant division in PT. ADM Jakarta had exposed to good experience which was manifested by an improvement on work satisfaction while working with modified push button. The such modified push button has decreased the musculoskeletal complaint and fatigue and finally influenced the work satisfaction.

Ergonomic intervention that used total approach permits all operators to participate in the process of push button redesigning. Thus, the opportunity had a great influence toward operator's satisfaction.

### **The Work Environment Conditions**

The work environment condition that was considered in the study was noise intensity, WBGT, air temperature, relative humidity, ball temperature and lighting.

The result of the study showed that there was no significant difference on noise during working with the old and the new design push button ( $p > 0,05$ ). Consequently, ear protection program was implemented by using ear plug that could reduce the noise at about 25 dBA.

WBGT measurement result during work (before ) and (after redesigning push button) showed that work activity in the study was considered as light. Therefore, WBGT in the working place was still in the border line as operators had light work load activity for 8 working hours.

The measurement result of air temperature, humidity (before) and (after intervention) was in tolerated category. Accordingly, job in the light work category was in the air temperature between 33 °C until 35 °C and moderate work category had air temperature range between 29 °C until 31 °C<sup>28</sup>. Air temperature during working with former push button and modified push button was still in the tolerant level that could be accepted by operators without experiencing health complaint. As it is generally accepted Indonesian are able to acclimatize well in the air temperature between 29-30 °C with air humidity between 85-95%<sup>29</sup>.

Measurement result of illumination level (before) and (after intervention) was in a good of previous researcher category. According to the statement stated that the minimal illumination needed to carry tasks well is about 200 lux so that environmental condition of illumination in the former push button and modified push button was considered in good category<sup>30</sup>.

Some work environmental parameters in the study had significant statistical different and this will influence the result of the study. The regression analysis found that work environment contributed to the result of NBM 12,6%, fatigue 3,0%, work boredom 33,1% and work satisfaction 27,2%. With such contribution to the study result, the reduction was related to design factor on musculoskeletal complaints 6,65%, on fatigue reduction 5,47% , on work boredom reduction 5,87% and work satisfaction was increased up to 6,43%.

Such results were evoked by the fact that before intervention applied was in rainy season (March) and during intervention was in dry season (April). The season difference could not be controlled for its natural condition so that work environment had contribution toward the study result.

### **Production Output and Productivity**

The product produced by PT. ADM Jakarta was part body component that was a work-in-process item. The study being examined was chasis with serial W 1032 of dimensions: length = 1830 mm; width = 340 mm; thickness = 1.4 mm and weight = 6.837 kg.

Operator's work productivity in the study was seen from the length time of 1 (one) part body component, starting from putting material sheet until stamping that used big press machine. Process duration for each part is  $2.17 \pm 0.12$  seconds (before intervensi) and  $1.96 \pm 0.09$  seconds (after intervensi). Based on the statistical test, there was a significant difference

on the time process ( $p$  value  $< 0,05$ ). This was indicating that work activity that used modified push button could decrease the time processing and improve operator's work productivity up to 32,65% and the production result was improved up to 2,59%. The height surface of push button fits the height of hand when the operator stands up so that the arm position is straight to the push button.

These are the efforts to make the operators healthier, safer, more satisfied, effective and efficient so that they were more productive. It is in the relationship with the statement that ergonomic application could increase work productivity and people health<sup>31</sup>.

### **Time Efficiency**

The study found that the reduction of manual time processing and efficiency of time processing was 10.7%. The reduction of time processing was caused by changing the push button position and size where it is positioned at a flat surface which previously was located in a vertical surface behind the operator's body that needs more time to reach.

With the processing time reduction, unnecessary movements were omitted so that it was more efficient and effective and the time was shorter. An efficient and effective movement means that work is more productive, muscle complaints were decreased so that the operator's life quality was also improved. According to previous researchers that improvement on productivity means improving efficiency of production process time<sup>32</sup>.

### **Economic Analysis**

This analysis was the practical way to measure project's benefit by determining the ratio between profit and cost of a project<sup>33</sup>. The B/C ratio analysis found 1,527 (before intervention) and 1,536 (after intervention). Both of the treatments had B/C ratio value of more than 1 so that they were economically executable. After using the modified tool, B/C ratio was increased up to 0.58%. Company's total income in the study was Rp 572.581.700,00 (before intervention) and Rp 587.158.900,00 (after intervention) while company's profit was Rp 196.769.300,00 (before intervention) and Rp 204.538.233,40 (after intervention). Therefore, there was an increasing profit of up to 3,95%. The result of the study confirms the previous studies of which mentioned that the improvement of working condition, working system improvement, working place redesign and the activity of lifting and loading caused profit and economic benefit escalation<sup>34,35,36,37</sup>.

### **Research Novelty**

Research novelty is the push button redesign that includes characteristics of: U-shape with inner length of 610 mm and outer length of 810 mm, outer width of 200 mm and inner width of 100 mm, thickness of 85 mm and the height was adjustable. The other improvement was the repositioning of emergency stop button to the right behind of push button while the push button was located just at the left and right side of operator's body. The redesigning was followed by changing operator's work position at dies shifting, work organization arrangement with active break and nutrition intake addition.

### **CONCLUSIONS**

Based on the results of the study, we conclude that total ergonomic intervention has improved work quality, work satisfaction, time efficiency, production and productivity, reduced processing time, and eventually increased the company's profit.

### **SUGGESTIONS**

The current study on ergonomic intervention coupled with total ergonomic approach should be broadened to include other variables such as work environment.

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