

The Comparison of the Level of Exposure to the Skin Surface Temperature and Worker Fatigue in the Metal Casting Industry Induction Kitchen System; Using One-operator Ladle-Kowi and Two-Operator Ladle-Kowi

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Abstract

Ladle-kowi is a liquid steel of tool transportation coming from the induction industry. There are two designs of Ladle-kowi such as Ladle-kowi designed to be operated by one-operator weighing at 15 kg and Ladle-kowi operated by two-operator weighing at 50 kg. Diverse design drafts of Ladle-kowi affect the differences in physical and mental burdens received by every worker. Up to now, the use of Ladle-kowi in the metal casting industry of induction system has become a necessity that functioned as a tool for the transport and distribution of liquid steel into the molds. Problems faced by many workers are on the selection of ladle-kowi which will affect the physiological condition of the human body in the form of exposure and fatigue on peripheral skin surface temperature. Human nature has the ability, skill and limitations of laboring which has not been used as a parameter for determining comfortable and safe working conditions. This study aims to determine the level of exposure of the skin surface temperature and the level of fatigue which is then used as the basis of proposals to improve working conditions and serve as the basis of recommendations for a more convenient and safe Ladle-kowi usage. The subjects in this study were workers in the metal casting industry using the facility in the form of Ladle-kowi with one-operator with a capacity of 15 kg filled with molten steel and Two-operator Ladle-Kowi filled with liquid steel capacity of 50 kg. This study belongs to the category of taxonomic research in the form of cross sectional analytic. Subjects were randomly selected from all workers in the metal casting industry of induction system. Samples taken were 14 people who have been taken and met the criteria for inclusion and exclusion. The results showed that exposure to the skin surface temperature is lower (0.03°C) than when workers used one-operator ladle-kowi compared with workers using two-operator ladle-kowi. There is a strong positive correlation patterns of exposure time to the degree of exposure to the skin surface temperature. The mean score of fatigue in general when using one-operator ladle-kowi is 97.25 ± 10.75 consisting of activities fatigue by 32.67 ± 4.78 , motivational fatigue by 33.50 ± 5.58 , and physical fatigue by 31.08 ± 6.10 , while the mean score of fatigue in general when using two-operator ladle-kowi reached 93.58 ± 10.25 consisting of activities fatigue by 29.33 ± 2.00 , motivational fatigue by 31.83 ± 6.14 , and physical fatigue by 32.42 ± 5.35 . Only in aspects of activities fatigue, they experienced the highest fatigue differences of 10.20% ($p < 0.05$) using one-operator ladle-kowi than to using the two-operator ladle-kowi. Conclusion: The use of one-operator ladle-kowi is better when compared with the use of two-operator ladle-kowi, seen from the level of exposure of the surface temperature of the skin, but two-operator ladle-kowi is better when compared to using a one-operator ladle-kowi, seen from the average value of general fatigue (down 3.77%). One-operator ladle-kowi needed improvements in the form of a working re-organization so that workers' fatigue can be lowered, while the two operators ladle-kowi required the addition of a shield mounted on a frame ladle-kowi to reduce the radiated heat of molten steel.

Keywords: *The surface temperature of the skin, Fatigue, Ladle-kowi.*

Introduction

Working attitude on the metal casting activities, especially workers who operate Ladle-Kowi vary widely, ranging from the process of holding the handle for wear and the tool set-up process. Operating the one-operator ladle-kowi requires expertise and special skills. If the worker is not accustomed to using this tool, then after carrying out the process of pouring molten steel into molds, one will experience bodily complaints in certain parts such as waist, back or L5 / S1 on the spine, and complaints on the upper shoulder and hand.

Bodily complaints will be growing along with the unnatural use of the work attitude. For instance, on the use of one-operator ladle-kowi, there happens a load imbalance occurs the right and left parts of the body. The imbalance in the body loading on the right and left parts of one body have an impact on the non-aligned use of hand muscles and body muscles and the pedestal on footwork.

In contrast to the use of two-operator ladle-kowi, it can be seen that the muscle loading in the left and right parts of body as well as both legs pedestal is already balanced. However, during the process of pouring molten steel into molds, it was found that movement that uses a body loading only on one side, a process of rotating the members of excess body happens so that it requires the balance and stability of the motion between the body on the right side and left side. The process of using ladle-kowi does not yet pay attention to the condition of users' comfort and safety.

The selection of the melting furnace investment affected the air pollution level and the employee performance. The metal industry is an industry of high risk to the environment [1], therefore the environmental management industry has become mandatory [2]. In general, the work processes of combustion and the metal smelting of raw materials at high temperatures cause air pollutions. Induction kitchen investment selections were categorized into technologies that emit the

most minimal environmental pollution when compared with other investments using a kitchen like cupola and semi cupola [3]. The level of environmental performance and employee performance are determined on how impactful the side effects of the undertaking processes are.

Although induction kitchen investment has given the most minimal environmental impact, but then it did not also guarantee the optimal employees' productivity. In industries that serve as the research subject, it was found that some work activities should be a concern for immediate repairs.

Work activities in question is the process of pouring molten steel into a mold; the workers are still exposed to high-temperature heat radiation originating from liquid steel, as well as the activities of pouring molten steel into molds. Up to now, there is no investment mechanism that takes the side effects affecting the *users* into account. Industrial development is quite rapid and not followed by continuous improvement of the working environment and working equipment, therefore it will certainly cause interference with health conditions [4].

One of the major parameters of occupational health is exposure of radiated heat temperature of molten steel received to the peripheral surface of the skin.

The smaller the level of exposure received by the body is, it can be said that the higher performance of employees will be. In the transport and pouring molten steel activities that uses one-operator ladle-kowi, it was found that an exposure to temperatures continue to increase with the addition of the frequency of rotation of work starting from the queue of making liquid steel process, the activities of bringing molten steel to the location of the printing, the activities of pouring molten steel into a mold, to the activities of transporting molten steel into the induction kitchen.

Work organizations on transportation activities and pouring molten steel into a mold has been determined, though still requires adjustments on the work attitude, so the challenge to make a change becomes another problem because of the work habits that have long become habits. Human nature dictating us not to easily accept changes and considerations of local cultural values that should make the issue simple turns it into a complex one.

Thus, the first step need to do is approaching the needs of users, including the joint observations so that the various impacts on the work that has been done during this meeting can be recognized simultaneously. Proposed alternative solutions and proposed improvement work can be started from ideas from the workers themselves, as well as raising awareness to pay attention to health and safety at work place itself.

The impact felt by the workers' bodies on activities of transportation and pouring molten steel into molds using one-operator ladle-kowi and two-operator ladle-kowi, among others, is an exposure to peripheral skin surface temperature. Although workers have experienced a long-period mechanism acclimation, so that the condition of a high temperature is interpreted by the worker's body as being at the point of normality, but he potential to damage tissues of the body's skin still could happen thus disturbing signal receptors on the skin, generally the peripheral skin which is vulnerable against dust irritation or burning conditions. Another impact that can be felt is a cardiovascular disorder which affects the decrease in concentration at work [5], thereby potentially increasing job stress conditions.

Work fatigues can be measured subjectively [6]. The fatigue measurement results can be in the form of general fatigue, fatigue from the aspects of activities, fatigue from the physical aspects, and work fatigue from motivational aspects.

Work fatigue experienced by workers in the activities of transporting and pouring molten steel into a mold cannot be measured objectively because workers move from one

place to another or use dynamic movement and until now there has not been found the process of measuring workers' fatigue in the metal casting industry objectively, but the approach done is by measuring a subjective fatigue that is by asking some questions related to operators' fatigue after completing work activities. The results of the analysis of the level of exposure of the skin surface temperature and fatigue becomes initial reference and recommendations for improvement of labor based on *fitting the job to the man* before the use of *fitting the man to the job* improvement approach.

Method

This study belongs to the category of taxonomic research or non-experimental form of cross sectional analytic. Subjects were randomly selected from a population of 120 workers in the casting metal industry of induction kitchen system.

Samples numbered 14 people who have been and meet the inclusion and exclusion criteria. Subjects' criteria in this study are workers in the metal casting industry using the facility in the form of one-operator Ladle-kowi with a capacity of 15 kg filled with molten steel and two-operators Ladle-kowi filled with liquid steel capacity of 50 kg. Characteristics of the subjects are workers between the ages of 30.88 ± 4.31 years, weighing at 59.31 ± 4.54 kg, with heights of 163.85 ± 3.86 cm, with work experience of 19.02 ± 8.32 years.

Activities researched started from the process of molten steel poured into a Ladle-kowi container, the activity of the appointment of liquid steel using ladle-kowi to the location of the molds, the activity of transfer and distribution process of liquid steel into a mold, work attitude and mechanisms of casting molten steel into a mold, the attitude of holding the empty Ladle-kowi back to cast of molten steel in the induction kitchen. Criteria for the production of molds that serve as a sampling are molds that have been created using quartz sand and ready to do the casting of liquid steel upon.

Data of workers' exposure to their skin surface temperature between using one-

operator Ladle-Kowia of 15 kg, and workers' skin surface temperature exposure data of using two-operator Ladle-Kowi of 50 kg are taken by measuring the temperature of the skin surface of the workers directly through the forehead using a forehead thermometer. Every worker gets the same turn, work shifts of seven times in each period. The implementation of the skin surface temperature data collection was repeated for 4 times a day for 3 days of work, so that the total overall data were up to 12 times of the data retrieval in every worker.

A measurement of subjective fatigue (*subjective feelings of fatigue*) was performed using a questionnaire developed by the *Subjective Self Rating Test on Industrial Fatigue Research Committee* (IFRC) Japan[7], consisting of 30 items of rating scale comprised of three categories; weakening of labor activities, decrease in motivation, physical fatigue[8].

Result

Activities of Casting Molten Steel Using Ladle-Kowi with a Capacity of 15 kg

The pouring of molten steel into a mold is an activity that is always done by a worker using human muscle power. Thus it can be understood that, during the work activity, static muscle contraction occurs, blood vessel is pressed by the pressure of the muscle tissue, thus influencing on blood rotation to the muscle tissue [9]. The higher the work activities, the more impact on the body's metabolism it will be [10], therefore the need for fresh air (O_2) is also characterized by the greater frequency of the pulse continuing to rise continuously.

There is a technology which enabled the tools to facilitate the holding of molten steel, i.e. the ladle capacity of 500 to 1000 kg, but this ladle cannot serve as the means of distribution of molten steel into a mold, because the mold made has a specification or relatively small size; and the design is varied thus the different volume also vary. Molds were made to order, so fluctuations in industrial design are very diverse.

Up to now, there has not been found liquid steel after coming out of the induction

kitchen then get distributed into the mold without using human muscle power. Therefore, a repair on work attitude that is more secure and humane, paying attention to the rules of nature in working in their activity using one-operator Ladle-Kowi for pouring molten steel becomes necessary to be considered. Activities that occur generally in the metal casting industry do not pay attention to health and safety, thus physiologically, what is considered light work can become more severe conditions coupled with environmental aspects in addition to the work in the form of dust and heat [11].



Figure 1: One-operator ladle-kowi with capacity of 15 kg liquid steel

Working attitude on the activity of pouring molten steel using one-operator ladle-kowi (Figure 1) appears to be an unnatural working movement, the twisting of the body along with the weight of 15 kg and requiring a high concentration to cast molten steel into a mold, the focus of the eye that needs to be maintained in a certain period of time affects the performance level.

The process of pouring molten steel using ladle-kowi was performed for 7 laps during the period and at least 4 times in each period every day so that the work attitude (Figure 1) is experienced by workers on a daily basis as much as 28 repetitions of labor movement.

The mechanism of repetition of labor movement has an impact on the emergence of various pains in certain parts of the body caused by the use of inconvenient working facilities such as ladle-kowi.

Activities Cast Molten Steel Using Ladle-Kowi Capacity of 50 kg

The fundamental difference from the process of pouring molten steel using ladle-kowi with a capacity of 50 kg is that the operation process should be run by two-operators in a position of facing each other. At the time of appointment or the transport distribution of liquid steel, one man walked to the front and another man walked backwards, this condition is most at risk because of a potential fall, slip or even the legs being exposed to the objects around the mold as a result of walking with no view on the front side.



Figure 2: Two-operator Ladle-Kowi with capacity of 50 kg liquid steel

Based on Figure 2, it appears that the radiation of molten steel directly exposed to the front of the body and the surface of the skin on the body and on the legs, also the radiated heat can directly be felt on the hands and the face of the operator. Even as the eye can see directly toward the heat of molten steel, another impact that occurs is the possibility in the decrease in visual acuity in both eyes at a certain period.

Holding process and distributing the 50 kg of molten steel caused tension on arms and footstool, these conditions may result in premature fatigue. Hot working conditions resulted in increased metabolism that is characterized by perspiration from the body as part of the process of evaporation body to remain in a state of equilibrium.

Skin Surface Temperature Exposure Level

The level of exposure to the skin surface temperature showed great health conditions

of workers. The higher the level of exposure received by the surface temperature of the skin, the higher the impact on health improvement will be; thus it will affect the improvement efforts in a relatively close period of time. However, if the temperature received as a result of the radiation of heat to the surface of the skin is still within the tolerance limits, work activities can be recommended to keep being run for a long time without any changes and improvements in said working conditions.

Whereas, if they were non-ergonomic working conditions, when left unchecked and not treated immediately, it may cause problems in health, comfort, and safety [12]. Specifically, ergonomics will provide several benefits to the efficiency of the use of the muscles, energy, time and the reduction of fatigue, occupational accidents, occupational diseases and the improvements on comfort and job satisfaction, product quality and productivity of work, thus affecting the costs resulting from accidents and occupational diseases would be reduced[13]. To determine the level of exposure of the skin surface temperature, data need to be analyzed further using statistical tests.

Results of statistical test toward the skin surface temperature exposure data is a data normality test using the Shapiro-Wilk; thus data for surface skin temperature during the use of one-operator Ladle-kowi by 38.43 ± 0.82 , $p = 0.321$ was obtained, while data on the skin surface temperature when using two-operator Ladle-Kowi amounted to 39.53 ± 1.52 , $p = 0.930$.

Because the value of ($p > 0.05$), the skin surface temperature exposure data were normally distributed. Based on table 1, the results of different tests (*paired samples T test*) between one-operator ladle-kowi with two-operator ladle-kowi, it was obtained the value of $t = -2.510$, $p = 0.46$ which means that there are differences in the level of the skin surface temperature exposure of workers when using one-operator ladle-kowi and using two-operator Ladle-Kowi ($p < 0.05$). The use of one-operator Ladle-kowi provides a smaller exposure to the skin surface temperature when compared with the level of exposure received by workers

who use two-operator ladle-kowi. The difference in skin surface temperature exposure from both kinds reached a value of

0,03°C.

Table1: Results of different data tests on the exposure of the skin surface temperature of workers between using One-operator ladle-kowi and ones with two-operators kg (n=14)

The surface temperature of the skin b.15kg - The surface temperature of the skin b.50kg	Paired Differences				t	p
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
				Lower Upper		
	-1,10286	1,16267	,43945	-2,17814 -,02757	-2.510	0.046

Based on Table 1, it was indicated that the results of different data test on the exposure of the skin surface temperature of workers between using one-operator ladle-kowi and two-operator ladle-kowi, it was obtained the value of $t = -2.510$, $p = 0.045$, which means that there are differences in skin surface temperature received by workers when using one-operator Ladle-kowi with a two-operator ladle-kowi. This condition occurs because there is a difference of attitude in carrying and pouring molten steel into a mold, the organization and distribution process of pouring molten steel into a mold; there is cooperation and interaction in a structured and continuous ways between the two operators.

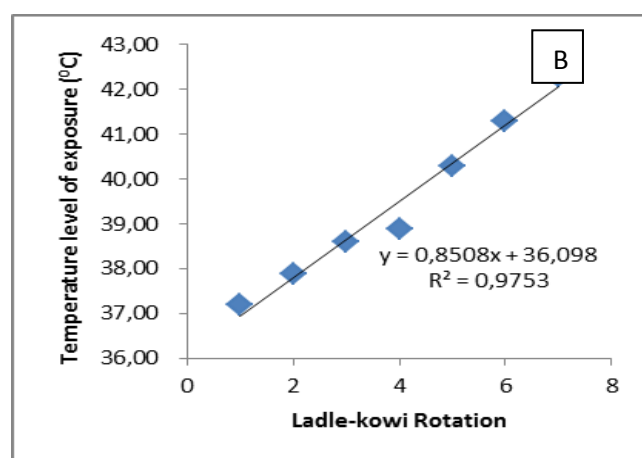
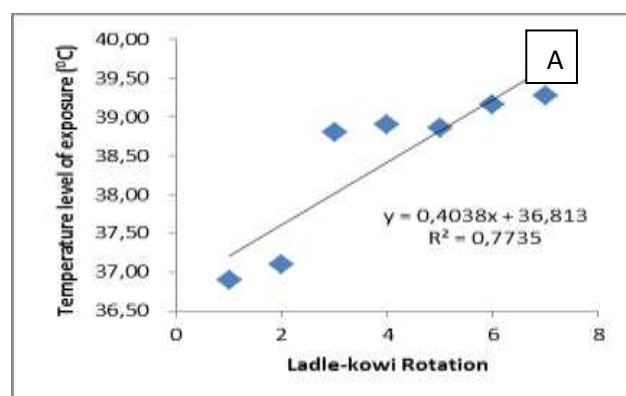
Working organizations on operating activities of two-operator ladle-kowi is more complex when compared to the operating activities of one-operator ladle-kowi. Differences in levels of exposure to the skin surface temperature affect the performance of the operator.

Relations of Skin Surface Temperature Levels of Exposure with the Conditions of Workers

A measuring of the level of exposure of the skin's surface temperature can give you an overview of the position of the temperature peak point received by workers from the effects of radiation heat of molten steel.

The value of temperature of the skin surface can maximally be used as a basis for a recommendation whether or not it is necessary for active breaks or breaks to reduce the heat exposure received directly by the skin of the peripheral body of workers, as to which states that employees who are above the ability of the need for improved methods of work in order to obtain the

equilibrium conditions in working (ergonomic balancing) [14]. If a large maximum value passing the normal limits of human was found, then the work activities should be immediately stopped and sought for alternative solutions so that the equilibrium condition of the body is maintained or they still worked with considering the ability and skill of man. The relations of length of time or number of turns on the skin surface temperature affects the physiological state of workers which can be seen directly in the form of a decrease in work performance.



Scatter diagram of the temperature level of exposure to the skin surface to the increase

in Ladle-kowi of 15 kg rotation (n = 14 employees); B. Scatter diagram on the temperature levels of exposure to the skin surface to increase in Ladle-kowi of 50 kg rotation (n = 14 employees)

Based on Figure 1, it can be concluded that the skin surface temperature exposure relationship to the number of one-operator Ladle-kowi rotations in each period of the rotation of casting the molten steel into a mold underwent an increase with *direct linier* line pattern and the correlation coefficient of 0.7735, which means they have a "**strong**" correlation (Figure 1.a), while the surface temperature exposure of skin to the number of two-operator Ladle-kowi rotation in each period of the rotation of casting the molten steel into a mold underwent an increase with *direct linear* line pattern and the correlation coefficient of 0.9753, which

means they have a "**very strong**" correlation (Figure 1.b).

Workers Fatigue Level When operating the Ladle-kowi

Workers fatigue is a condition in which workers in the metal casting industry particularly on operators in the ladle-kowi underwent a decrease of work performance, an increase in unnatural posture or movement works, a slowing in movements and reactions of work, starting of errors or irregularities in work the movement and attitude beyond the determined operational standards procedures, an indication of stolen breaks or rest breaks to relieve fatigue at the moment. Fatigue can be categorized into general fatigue, fatigue on aspects of the activity, fatigue aspects of motivation and fatigue on the physical aspect.

Table 2: Results of statistical analysis worker fatigue (n=14)

Parameter	Labor amenities	Average score	Difference (%)
General fatigue	Ladle-Kowi 15kg	97,25±10,75	3,77
	Ladle-Kowi 50kg	93,58±10,25	
Activities fatigue	Ladle-Kowi 15kg	32,67±4,78	10,20
	Ladle-Kowi 50kg	29,33±2,00	
Motivation fatigue	Ladle-Kowi 15kg	33,50±5,58	4,98
	Ladle-Kowi 50kg	31,83±6,14	
Physical fatigue	Ladle-Kowi 15kg	31,08±6,10	4,29
	Ladle-Kowi 50kg	32,42±5,35	

Based on table 2, it can be reported that the transport activity and the pouring of molten steel using one-operator ladle-kowi and two-operator ladle-kowi, it was obtained a different mean value of fatigue.

The differences between the highest mean value of fatigue is on the fatigue from the aspects of with the difference value of 10.20%, then the difference of fatigue from the aspect of work motivation is at 5.98%, the difference of fatigue from the physical aspects of the work is at 4.29%. If seen from the aspect of the condition of fatigue in general, workers who use two-operator Ladle-kowi reached a lower fatigue level (3.77%) when compared to workers who use one-operator ladle-kowi.

This condition occurs due to the current use of two-operator ladle-kowi, it was carried out by two-operators and possible interactions occurred on a reciprocal basis; the coordination for pouring molten steel into molds ranging from speed, permanence and the volume of liquid steel poured into in the mold occurred.

This good interaction process affected the organization of work to become more comfortable so that the process of activities completion in the metal casting mold becomes lighter. Fatigue of the work activities can be minimized by the workers themselves. To know the difference of fatigue, the measurement data need to be continued further with statistical analysis.

Table 3: Test results of different data of General fatigue and the other 3 aspects (n=14)

Value	General fatigue a - General Fatigue b	General fatigue a - General Fatigue b	Motivation fatigue a - Motivation Fatigue b	Physical fatigue a - Physical Fatigue b
Z	-.904 ^a	-2.014 ^a	-.667 ^a	-.786 ^b
Asymp. Sig. (2-tailed)	.366	.044	.505	.432

Differences in mean values of general fatigue, fatigue on aspects of activity, fatigue in aspects of motivation and fatigue in the physical aspects need to do further analysis in the form of statistical tests to prove their different use of one-operator ladle-kowi with a two-operator ladle-kowi. On fatigue data, data normality test was applied earlier, and it found the value ($p < 0.05$), as a means to determine differences in the level of fatigue when using one-operator ladle-kowi with a two-operator ladle-kowi, the next step to be performed is the non-parametric test.

The results of different test of fatigue data based on Table 3, the data showed that, for general fatigue, physical fatigue and motivational fatigue reached a p values > 0.05 , which means that there is no difference between the use of one-operator ladle-kowi and two-operator ladle-kowi.

However, the data on activities fatigue of ($p < 0.05$) was found, which means that there is a difference between the fatigue in work activities the use of one-operator ladle-kowi with the use of two-operator ladle-kowi. It was temporarily inferred from the results of statistical analysis that it is only on fatigue of the activity aspects where it is experiencing a difference when workers used a one-operator ladle-kowi with a two-operator ladle-kowi, while the other aspects of fatigue is considered as not experiencing any difference.

Discussion

The characteristics of the subjects used in this study included the ages which has decreased from human muscle power i.e. within the ages of 30.88 ± 4.31 years of productive age with maximum muscle strength under 30 years, but because of the work of pouring molten steel into molds need long enough skilled and experience i.e. 19.02 ± 8.32 years, the ability of muscles considered to have conformed, workers also has skilled to process using a metal casting work facilities in the form of one-operator Ladle-kowi and two-operator ladle-kowi.

The need to work with a safe and comfortable attitude needs an attention to the natural rules in working in the activities of casting molten steel. The attitude of forced

labor, if left in a relatively long time, will lead to danger ergonomics. Labor movement looks unnatural, such as rotating along with the body withstanding the load. Unnatural and uncomfortable working attitude, coupled with a fairly heavy workload and done repeatedly can increase the risk of cumulative trauma disorders [15, 16].

In Figure 1 and 2, it can be seen that these labor activities are very dangerous, in addition to experiencing high-temperature exposure; workers ignore the use of personal protective equipment (PPE) that is required for the use. This condition occurs because the company simply urges so that consciousness constructed by workers still need to be pursued. Potential hazards or often be shot with the term *hazard*, can occur in the activities of pouring molten steel into molds which are exposed to splash and spill of the liquid steel, foot slipped and fell on a the pit of molds, inhaling the smell of molten metal mixture forming component materials, sipping *fly ash*, hand withstanding excessive burden, bodily complaints at L5/S1 occurred, a decrease in sharpness of vision.

This entire hazard is a result of unsafe action of workers in the metal casting industry. If a great value for the risk of injury in the workplace is found between 51%-70%, the actions that should be taken is to do improvement on work system in the near future [17]. Other conditions that need to be considered are the environmental conditions such as piles of materials such as iron plate, quartz sand and various mixtures to create prints on the production floor; all these participating the accounted potential of the unsafe of workers or the condition is often referred to as *unsafe condition*, at the end of the day will have an impact on health work as stated that the environmental conditions affect the health of workers [18].

Every new technology of design result certainly has their advantages and disadvantages, the advantages of ladle-kowi is that it is able to assist the activities of workers in the distribution of molten steel into a mold, however, only on function consideration in a work facility planning is not enough [19], another consideration is

required such as a maximum load of muscular force of workers hands, direct or indirect big impact (in the long term) of a product that has been used by workers.

Thus, up to now the standard operating procedures (SOP) has been created by the use of tools, needs an improvement, namely by considering work activities and work attitude during the tool use, as it was stated that the development of design tools for working facilities must be followed by the development of operational standards procedure based on the *human factor*. Humans used as a *center design* in every change, technology adoption needs to be balanced and adjusted to the size of the users' anthropometry. Human anthropometry measurement changes from one region to other region, especially with the different characteristics of the job.

In the era of the changing times, the design of the tool is already considered to be environmentally friendly, but not a lot of equipment has been tested to not disturb the human physiological factors [20]. If the design tool is based on users' working attitude, then use the results of the draft will impact the increase in labor productivity, for providing convenience on the main job and not the other way; it gives additional workload. The implementation of a holistic approach can be done as a problem solving of a technology design to do starting from product definition, troubleshooting analysis and follow-up and actively involving workers and *stakeholders* formed within one team [21, 22].

The process of casting molten steel using ladle-kowi with two operator's capacity the draft result better be adjusted to the comfortability and the safety of the users. The draft of work facilities should cover the humans' weakness and the limitation as an operator so that maximum result will be maximized. Humans are the number one priority of the design, while the workplace and the environment should come later [23].

Radiated heat directly in contact with the worker's body can cause a decrease in occupational health, burn the minimal skin tissue peripheral, increase the

cardiovascular system of the body, and increase the pulse of the work. Even as the eye can see molten steel directly for a long time and exceed the maximal degree of eye vision, it is possible for a decrease in visual acuity in both eyes to happen in a certain period of the year. There are differences in skin surface temperature received by workers when using one-operator Ladle-kowi and two-operator ladle-kowi. The exposure of the surface of skin temperature toward the increase in the rotation of Ladle-kowi in each period of the rotation of casting the molten steel into a mold underwent an increase with the *direct linear* line pattern and the "**strong**" correlation coefficient on one-operator Ladle-kowi and "**very strong**" correlation on two-operator ladle-kowi.

This gives a temporary conclusion that the longer the activity of pouring molten steel into the mold will have an impact on an increase in body temperature exposure of workers. An immediate improvement through redesigning of ladle-kowi and more natural nworking attitude is necessary in order to improve employee performance. Many designs that produce high productivity, superior quality product, but have yet to take into account the current use of the product, thus affecting the increase of the physically and mentally workload so quickly causing fatigue and can lead to accidents or occupational diseases[24].

Ladle-kowi design should consider the size of workers' anthropometry. The measurement of anthropometry in designing the working tool will affect the physiological responses of the body when lifting and carrying loads [25].

Work organizations on the operation of the ladle-kowi activities contribute to the high degree of skin surface temperature exposure at the end of the day will affect the work performance.

The utilization of ladle-kowi tools that are not accompanied by a standard guide for the activity of operation of the device may result in multiple activities so that the process of transportation and casting the molten steel into a mold to be very varied, thus Standard

Operating Procedure based on convenience and safety of users' work attitude is necessary.

The impact of uncomfortable and unsafe work attitude will be felt by workers in the form of a decrease in work performance, which is fatigue. Every job that relies on the muscle strength in a given period will experience a fatigue. Conditions needed to be taken care of are a graph of drastic reduction in fatigue and not expected in the near future.

A fatigue on the job is different with other jobs, the difference is determined by the characteristics of the condition and the type or category of the workloads do. In this study, it was reported that the highest average value of the fatigue difference is on the fatigue of the aspects of the activity (10.20%), then the difference of fatigue from the aspect of work motivation at 5.98%, a difference of fatigue from the physical aspects of the work of (4.29%) and fatigue in general (3.77%).

Activities of casting molten steel into a mold with a maximum of 13 minutes affect the maturity of the organization of work. In principle, the working time cannot be adjusted or extended, because if this is the case, the nature of the material properties of the content of the liquid steel will be changed so as to reduce the quality of the product. Another way to do is to evaluate the use and design of ladle-kowi and the improvement of work organization so that in-effective movements can be eliminated or minimized. Thus an improvement on work postures is necessary so that complaints from workers will decrease [26].

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Conclusion and Recommendation

There are differences in the level of exposure to skin surface temperature of employee between using one-operator ladle-kowi and using two-operator ladle-kowi. The level of exposure to the skin surface temperature when using one-operator Ladle-kowi is a lower (0,03°C) when compared with the use of the two-operator ladle-kowi.

There is a strong positive correlation between the exposure length when seen from the sheer number of activities of the casting metal transportation activities with the degree of exposure to the skin surface temperature. The mean score of general fatigue in workers when using one-operator Ladle-kowi is 97.25 ± 10.75 , consisting of activities fatigue by 32.67 ± 4.78 , motivational fatigue by 33.50 ± 5.58 and physical fatigue by 31.08 ± 6.10 , while the mean score in workers general fatigue when using Ladle-kowi with a capacity of 50 kg reached 93.58 ± 10.25 consisting of activities fatigue by 29.33 ± 2.00 , motivational fatigue by 31.83 ± 6.14 , and physical fatigue by 32.42 ± 5.35 . Only the fatigue on aspects of activity experienced the highest fatigue differences by 10.20% and $p < 0.05$ when using one-operator ladle-kowi than to using the two-operator ladle-kowi.

The use of two-operator Ladle-kowi when seen from general fatigue experienced by workers is 3.77% lower compared to the level of general fatigue during the use of one-operator ladle-kowi. An ganizational improvement is necessary when operating the one-operator ladle-kowi and the addition of heat radiation shield as a barrier for the two-operator ladle-kowi.

muskuloskeletal karyawan beberapa perusahaan kecil di Bali. Jurnal ergonomi Indonesia, 2(1,6):6-9.

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