Design of Chicken Feed Mixer Machine Model to Increase Work Productivity

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Keywords: Mixing Machine, Subjective Complaints, Workload and Work Productivity.

Abstract: Feed is the largest single variable cost in a vertically integrated industrial animal factory. U.S. Department of Agriculture have estimated that feed costs account for 60-64 percent of the total cost of producing poultry and eggs, 47 percent for pork, and 17 percent for beef. Feed requirements (in dry weight) for each chicken is 3-5% of their body weight. In animal feed consumption is influenced by various factors, namely energy levels, amino acid balance, feed fineness, animal activity, body weight, growth speed and environmental temperature. The increasing price of animal feed in recent years has caused many farmers to mix their own feed to make animal feed. At present the process of mixing animal feed is still stirred by hand, causing an increase in workload and subjective complaints of pain in the back, arms and hands when stirring and the time in the mixing process. This causes the work productivity on animal feed to be low. Efforts to overcome these problems, carried out research with the same subject design that is designing a model of animal feed mixing machines to help speed up the work process of mixing feed to speed up work time and increase work productivity. The Mixer Machine model is designed according to the needs of chicken farmers and subjective complaints data are recorded with a fatigue questionnaire, workload is measured based on work pulse and work time is measured during work and work productivity is measured from the ratio of inputs (work pulse) to output (Amount of kg of animal feed load stirred) multiplied by work time (hours).The results showed that the use of the Mixing Machine Model for the stirring process of animal feed can facilitate chicken breeders in the process of mixing animal feed so that the animal feed mixture is more evenly compared to mixing using the previous manual method, reducing the subjective complaints of pain in the limbs when stirring decreases by 20 %, reduce the workload of workers by 48% and increase work productivity by 84%.

1 INTRODUCTION

Feed is that the largest single variable cost during a vertically integrated industrial animal factory. U.S. Department of Agriculture have estimated that feed costs account for 60-64 percent of the whole cost of manufacturing poultry and eggs, 47 percent for pork, and 17 percent for beef (Dennis Olson,2006). The feed that's given isn't only intended to beat hunger or as a stomach filler but must be really useful for the requirements of life, forming new cells, replacing damaged cells and for producing (Setiawan, Tony and Arsa Tanius,2005). the necessity for feed (in dry weight) for every chicken is 3-5% of weight. The consumption of animal feed is influenced by various factors, namely energy state, aminoalkanoic acid balance, feed fineness, livestock activity, weight, rate of growth and ambient temperature. the extent of difference in consumption is additionally influenced by several factors, including: weight, age, feed digestibility, feed quality and palatability. Palatability is that the level of preference shown by livestock to consume a given feed ingredient at a specific time. Good quality food features a higher consumption level than inferiority food in order that if the feed quality is comparatively an equivalent, the consumption level isn't different (Parakkasi, A, 1998). the method of blending animal feed is currently done by hand to stir the animal feed consisting of fifty kg of corn, 50 kg of bran, 50 kg of concentrate and 50 kg of minerals. The animal feed that has been placed during a large container is then stirred by the worker with both hands stirring slowly until the animal feed is evenly mixed. The stirring process is administered by standing and bending for a mean of 63 minutes to stir 200 kg of animal feed. This work process causes the typical pulse of workers to extend, sweating plenty, and increased pain within the

Suarbawa, I. and Mulawarman, A.
Design of Chicken Feed Mixer Machine Model to Increase Work Productivity.
DOI: 10.5220/0010967700003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 1485-1490
ISBN: 978-989-758-615-6; ISSN: 2975-8246

limbs after work, like pain within the back, neck, legs, upper arms, forearms, and hands. Increased pulse at work and complaints after work cause work productivity to be low (Manuaba, A, 2000). Work posture that aren't physiological are often caused by the characteristics of task demands, work tools, work stations, and work Posture that are incompatible with the skills and limitations of workers (Kroemer and Grandjean, 2000; Manuaba, A, 2000). Non-physiological work posture that's administered for years can cause bone deformities in workers (Kroemer and Grandjean, 2000).

In an attempt to beat this problem, a machine for mixing animal feed with a gasoline motor drive was designed with a drum capacity of 200 kg. The working mechanism of this animal feed mixer is that the rotation produced from the gasoline motor shaft to rotate the stirrer shaft within the stirring drum until the animal feed is evenly mixed. The rotation of the driving motor is sustained with the belt rotation and uses a pulley in order that the rotation of the stirring shaft is smoother. the utilization of a mixing machine for animal feed that replaces human labour within the mixing process will increase work productivity and reduce workloads and subjective complaints from workers. By designing the assembly process it's ready to save the necessity for raw materials and processes, in order that overall costs are often saved within the manufacturing industry Rusdiyantoro, 2011). Ergonomic redesign of kit will reduce muscle complaints and worker fatigue (Kroemer and Grandjean, 2000).

2 METHODS

2.1 Research Design

This research is a one-short case study with a pre and post test design of the design group carried out observational to the crafters in the process of stirring the animal feed (Suarbawa, at all, 2016). The chart can be described as picture1.

R → P0 → PI

Figure 1: Research Design.

Information:
R = Random sample.
P0= the result of the pretest experimental unit.
PI = the result of the posttest experimental unit.

The research stages in the design of an animal feed mixer is to examine the current manual stirring process (stirring with a shovel) compared to the stirring process with the help of a mixer on working time, workload, skeletal muscle complaints, fatigue and work productivity.

2.2 Research Variable

The variables to be measured during this study include: (1) workload as measured by the heart beat of rice before and after work; (2) complaints of fatigue and skeletal muscles before and after work; (3) work productivity after work by comparing work pulse (beats per minute) with the amount of products produced (kg) during working time (minutes). The measurement of variables number (1) to number (3) is that the information data of the initial condition and therefore the final condition which is then compared to work out the comparison before using the mixer machine and after using the mixer machine.

2.3 Data Analysis

The design data of the mixer machine are calculated supported the necessity for a load capacity of 100 Kg, then an electrical motor, a shaft and a stirrer tank, and an ergonomic machine holder construction are planned. Test data before using mixer a machine and after using mixer a machine include data on working time/ a length of labour, a workload, subjective complaints, and work productivity which can then be analyzed descriptively to get conclusions.

3 RESULT AND DISCUSSION

3.1 Subject Characteristics

The mean age of the themes was 33.21 ± 1.56 years and therefore the age range was 28 - 34 years. This age range remains included within the working age bracket. This age range still includes the workforce consistent with the Central Statistics Agency (BPS). The regulation for the workforce that applies in Indonesia is 15 to 64 years old. The mean age of the themes of this study, when viewed from muscle strength, has decreased because the recommended optimum muscle strength for work is between 20 and 30 years (Corlett, Nigel, 2005). The mean body mass index (BMI) during this study was 20.21 ± 0.04 kg/m2. The meaning of this BMI value is that workers are during a normal nutritional status. the traditional BMI of Indonesians ranges from 18.5 - 25 kg/m2

(Almatzier, S, 2001). BMI is an indicator of body fat, if the BMI is below 18.5 kg/m2 it's said to be very thin (underweight) while above 25.0 kg/m2 is claimed to be obese (overweight) because of excessive fat accumulation. The mean work experience of the themes during this study was 5.23 ± 1.45 years. The meaning of this experience mean is that the topic has been skilled and ready to adapt to his job. Work experience in formal sector jobs is usually considered to be ready to improve one's employability (Robbins, Stephen P and Timothy A. Judge. 2008).

Table 1: Subject Characteristics.

Description	n	Min	Max	Mean	SD
Age (year)	4	28.00	34.00	33.21	1.56
Height (cm)	4	158.21	168.00	167.22	2.15
Weight (kg)	4	55.40	73.60	62.14	6.98
BMI (kg/m^2)	4	20.26	21.56	20.21	0.04
Work experience (year)	4	4.50	6.30	5.23	1.35

3.2 Manually Stirring Mixture of Animal Feed

Previously, the process of stirring animal feed was done manually with a working stance, standing bent with both hands holding a shovel to stir. The length of work in the stirring process for 200 kg of animal feed mixture was carried out for an average of 64 minutes. A work posture that slows down repeatedly for a long time is a non-physiological work posture. Work posture that are not physiological can be caused by the characteristics of task demands, work tools, work stations, and work Posture that are incompatible with the abilities and limitations of the workers (Manuaba, A, 2000). Non-physiological work posture that is carried out for years can cause bone deformities in workers (Corlett, Nigel, 2005). Kimberly (2011) stated that there needs to be a change in the work system to reduce the level of worker fatigue. Roles, et al., 2009 made a study on a work model based on ergonomic principles, and found that the work model was able to reduce fatigue by 17.71% (Rolles P., Manuaba, A., Adiputra, N., Pangkahila, A, 2012). Torik, et al, 2009 also stated that designing an ergonomic work system can reduce the level of worker fatigue. The working posture and working conditions of the craftsmen are as shown in Figure 2.

Figure 2: Manual Stirring of Animal Feed Mixture.

3.3 Work Environment

The mean air temperature was 30.01 ± 1.11 (^{0}C), the mean ball temperature was 31.22 ± 1.03 (^{0}C), the mean ratio was 64.23 ± 1.31%, the typical WBGT index was 29.84 ± 0.49 (0C). the edge value for the category of heavy work with WBGT of 30.5 (^{0}C) is that the setting of working time per hour is merely allowed to succeed in 25%, while the edge value for the category of moderate workload with WBGT reaches 29 (^{0}C) is allowed for setting the working time of fifty - 75% per hour. The lighting intensity is 332.21 ± 6.23 lux, this intensity value is within the safe category consistent with the choice of the Indonesian Minister of Health. No. 405 of 2002 concerning the wants and procedures for implementing the health of the economic work environment, where manual work requires a minimum candlepower of 100 lux. Lighting that's not enough or below the specified threshold will cause work fatigue because the shortage of sunshine intensity within the workplace leads to decreased eye vision and work fatigue (Bridger, R.S, 2005). The typical noise intensity reaches 76.43 ± 3.51 dBA. Workplace noise remains within normal limits when it's below 85 dBA (Tarwaka, 2010). and therefore the air velocity is 0.85 ± 0.21 m / s. it's recommended that indoor air movement isn't quite 0.2 m / s in order that air movement doesn't have an adverse impact on workers, whereas for work environments exposed to heat a better wind speed is required (Corlett, Nigel, 2005).

Table 2: Work Environment.

Description	n	Min	Max	Mean	SD
Air Temparature (^{0}C)	10	30.10	32.90	30.01	1.11
Ball Temparature (^{0}C)	10	28.80	33.00	31.22	1.03
Humidity ($^{\%}$)	10	63.90	69.60	64.23	1.31
WBGT (^{0}C)	10	27.16	28.01	27.64	2.26
Illumination Intensity (lux)	10	380.20	3901.40	385.33	4.23
Noise Intensity (dBA)	10	74.31	82.32	76.43	3.51
Air Speed (m/det)	10	0.65	0.70	0.85	0.21

3.4 Design of Animal Feed Mixer Machine

This animal feed mixer machine is meant with a gasoline motor drive. the facility on the motor shaft which is provided with a belt attached to the pulley with a ratio of 1: 3. The rotation of the stirrer is meant at 3600 rpm. The capacity of the mixer drum is 100 Kg. This machine is operated by one person with a standing work posture. The way the machine works is extremely easy, namely: 1). Put the animal feed ingredients which will surrender into the mixer drum, 2). activate the mixer for about quarter-hour until the animal feed is evenly mixed, 3). Remove the animal feed mixture from the drum.

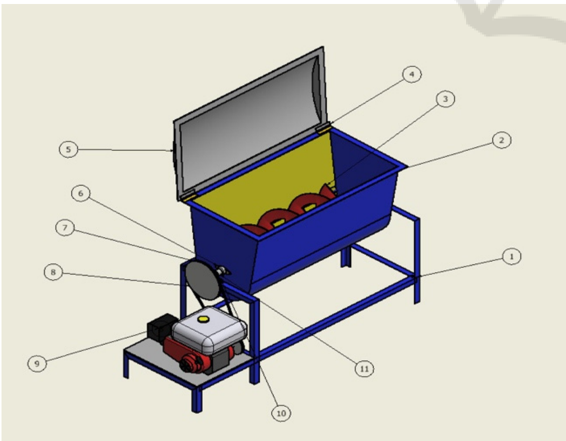

Figure 3. Design Engine Component.

Table 3: Engine Component.

No.	Engine Component	Caption
1	Machine frame	Iron Elbow 40 mm x 40 mm x 4 mm
2	Mixing drum	Steel plate 1,2 mm
3	mixer	Iron steel
4	Hinge	Iron steel 12 x 3 mm
5	Cover	Steel plate 1,2 mm
6	Bearing Holder	Iron steel Ø40 mm
7	Pully	Ratio pully 1: 3
8	V-belt	1,5 mm x 80 mm
9	Gasoline motor	5,5 hP
10	Pollow block	50 mm
11	Shaft	Iron steel Ø40 mm

Figure 4: The Result of Design Mixer Machine.

3.5 Workload, Musculoskeletal Complaints, Fatigue, and Productivity

Measurement of workload is done by measuring the work rate per minute using the 10 pulse method. Work pulse is measured every 60 minutes. The 10 pulse method is a method by palpation of the radial artery of the left hand, which is calculated as the length of time it takes from the first pulse to the eleventh pulse, the result is in seconds (Adiputra, 2002). Workload was measured in the period I research (P0), namely the manual stirring process research and in the second period study (PI), the stirring process using a mixer machine.

Musculoskeletal complaints are disorders of the skeletal muscle system caused by work tools and conditions of the subject, organization, environment. The discrepancy of these factors affects the work posture when doing work that is recorded using the Nordic Body Map. The complaint value of the musculoskeletal disorder system is determined based on the difference between the mean value of complaints before work and the mean value of complaints after work. The assessment criteria were not sick, slightly sick, sick and very sick. Musculoskeletal disorder were measured in the Period I (P0) study, namely the manual stirring process research and in the II Period (PI) study, the stirring process using a mixer.

Fatigue in general is a condition that is reflected in the symptoms of psychological changes in the form of slackness in motor and respiratory activity, a feeling of pain, heaviness in the eyeballs, weakening of motivation, decreased activity which will be influenced by physical and mental activity (Bridger, R.S, 2005). Fatigue was recorded with 30 items of fatigue level which was modified with four Likert scales and consisted of three categories, namely fatigue for activity (1−10), fatigue for motivation (11−20) and physical fatigue (21−30). Fatigue was measured in the period I (P0) study, namely the manual stirring process and in the second period (PI) study, the stirring process using a stirrer machine.

Work productivity is the ratio between the amount of output (mixture of animal feed in units of Kg) and the input (average working pulse in units of dpm) in a period of time (length of work in minutes), calculated based on the following formula (Manuaba, 2000). Productivity was measured in the period I research (P0), namely the manual stirring process research and in the second period study (PI), the stirring process using a mixer. The results of measuring workload, musculoskeletal complaints, fatigue and productivity in the first period (P0) study, namely the manual stirring process research and the second period research (PI), namely the stirring process using a mixer, are presented in Table 4.

Table 4: Measurement Results of Workload, Musculoskeletal Disorder, Fatigue and Productivity (Period I).

Description	Period I (P0)			
	Min	Max	Mean	SD
Resting Pulse (denyut/menit)	64,21	70,2	72,56	2,05
Work Pulse (denyut/menit)	18,39	23,42	20,21	2,45
Different Score Musculoskeletal Disorder Before and After Work	10	15	12,1	3
Different Score fatigue Before and After Work	5	10	7,2	2,1
Productions (Kg)			100	
Times of mixer (menit)	41	48	43	1,2
Work Productivity	0,178	0,265	0,230	0,03

Table 5: Measurement Results of Workload, Musculoskeletal Disorder, Fatigue and Productivity (Period II).

Description	Period II (PI)			
	Min	Max	Mean	SD
Resting Pulse (denyut/menit)	62,02	70,02	71,4	2,61
Work Pulse (denyut/menit)	8,4	12,8	10,61	2,04
Different Score Musculoskeletal Disorder Before and After Work	2,31	10,25	6,31	0,72
Different Score fatigue Before and After Work	2,33	7	4,7	0,8
Productions (Kg)			100	
Times of mixer (menit)	12	16	13,5	0,4
Work Productivity	0,977	1,984	1,396	0,01

Table 4 and 5 shows that the use of an animal feed mixer machine in the process of stirring the animal feed mixture reduces the workload of workers by 48%. The average work pulse rate of workers in the P0 study (stirring manually) was 92.58 bpm including the light workload category (pulse 75-100), while the average work pulse rate of workers in the P1 study (stirring with a stirring machine) was obtained a mean work pulse amounted to 74.25 bpm, including the category of very light workload (pulse 65-75) (Corlett, Nigel, 2005).

The results of measuring the musculoskeletal complaint score showed that the use of an animal feed mixer in the process of stirring the animal feed mixture reduced musculoskeletal complaints by 48%. The mean score of musculoskeletal complaints in the P0 (Manual stirring) study was 12.1, while the mean score of workers' musculoskeletal complaints in the P1 study (stirring with a stirring machine) was 6.31. The results of the measurement of the fatigue score showed that the use of a mixer for animal feed in the stirring process of the animal feed mixture reduced fatigue by 35%. The mean score of fatigue in the P0 study (stirring manually) was 7.2, while the mean score of worker fatigue in the P1 study (stirring with a stirring machine) was 4.7. The result of productivity measurement shows that the use of a mixer for animal feed in the process of stirring the animal feed mixture increases productivity by 84%. The average productivity in the P0 study (stirring manually) was 0.230, while the average productivity of workers in the P1 study (stirring with a stirring machine) was 1.396. A decrease in musculoskeletal complaint scores, fatigue and an increase in work productivity indicate that ergonomic interventions in work systems can reduce musculoskeletal complaints scores due to physiological work posture (Adiputra, N, 2002), reduce fatigue scores (Suma'mur PK, 2013), and increase productivity (Bridger, R.S, 2005).

4 CONCLUSIONS

Based on the results of the discussion of the design of a mixture of animal feed mixer, it was found that the use of a mixer in the process of mixing animal feed can reduce workload by 48%, reduce the score of musculoskeletal complaints by 48%, reduce fatigue scores by 35% and increase work productivity by 84%. Therefore, in the process of mixing animal feed, an ergonomic animal feed mixer can be used.

ACKNOWLEDGEMENTS

The authors would like to thank the department of research and community service center Bali State Polytechnic and the Ministry of Education and Culture of Indonesia for the financing of this research.

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