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Implementation of Ergonomic Biomechanics on Harvest Management by Combined Harverter Machine

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ABSTRACT

Biomechanics is performed to minimize fatigue and risk of muscle bone loss, in repetitive working conditions. So in the placement and operation of the controller must be ergonomic so that the operation in the most efficient besides, to get the inclination (slope). The hand position angle relative to the horizontal so that the maximal force can be applied, then the condition must meet the condition of each muscle. The objective of the study is to apply ergonomic biomechanics to harvest management of combined harverter machines. The data collection is done directly to the user of a combined harverter machine to know the working condition, the collection/measurement, the dimension of the human body. Further data weight and the height of the operator will be processed to analyze the posture at work. The direct measurements of muscle strength before the redesign of the magnitude of the moment in each segment of the operator body are as follows: The moment of the forearm, the operator A = 11.366 Nm, operator B = 13.769 Nm, operator C = 11.287 Nm and operator D = 11,675 Nm and the magnitude of the moment at the upper arm, on the operator that is operator A = 22.610 N.m, operator B = 27.004 N.m, operator C = 19.845 N.m and operator D = 21.429 N.m.3. The magnitude of the moment on the back, on the operator before redesign the operator A = 69.029 N.m, operator B = 76.587 N.m, operator C = 66.334 N.m and operator D = 70.127 N.m.

Key Words: *Biomekanika, Ergonomics, Combine harvester.*

1. INTRODUCTION

Human engineering or often referred to as ergonomics is defined as the design of "man-machine interface" so that workers and machines (or other production) can function more effectively and efficiently as an integrated human machine system. This discipline will try to bring towards the process of designing machines that not only have more sophisticated production capabilities, but also pay attention to aspects that are related to the abilities and limitations of humans who operate the machine. The main purpose is the creation of effectiveness and work efficiency that can be achieved optimally. Biomechanics is performed to minimize fatigue and the risk of muscle bone loss, in repetitive working conditions. So in the placement and operation of the controller must be ergonomic so that the operation in the most efficient, besides, to get the inclination (slope). The hand position angle is relative to horizontal so that the maximal force can be applied, then the condition must meet the condition of each muscle. Simplification of a biomechanical model based on the bone joint system is to predict the load on the vertebrae to lift the work piece. And direct measurement of muscle strength. Various risks can occur when the balance between the combine harverter machines with the user is not met or not realized by the worker in doing the activity repeatedly or not adjusted with the portion of the body, this will impact to the workers, who will experience fatigue and endure the damage to the muscle bone. This study aims for the application of ergonomic biomechanics on the management of crops to combine harverter machine.

2. METHODOLOGY

Research was a series of steps or steps that were done in a planned and continuous and systematic in order to get the answers from a problem. In conducting the research was required a methodology in accordance with the research to minimize errors and the research flow was easy to understand and implemented. Therefore every stage must be passed carefully.

In collecting data, very important principles and theories were used that were related to statistics. Knowledge of these statistics was necessary both in the initial preparation of measurements and at the time of data processing. The data collection was done directly to the user of combined harverter machine to know the working condition, the collection / measurement and the dimension of the human body. Furthermore anthropometry data would be processed into an anthropometry table, which would be

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used for anthropometric analysis about the design of work facilities at the work station. Body weight and height data would be processed to analyze posture at work.

The next stage was done biomechanics analysis by applying Newton's law principle that a force would cause reaction force with same magnitude but opposite direction. The model that was used was the arm model, which was useful to know the size of the style.

System Level I :

- Triceps muscle pulled the ulna to move the elbow.
- Quadriceps muscle pulled the tibia through the patella to move the knee..

$$F = \frac{R \ . \ .L}{r} \qquad (1)$$

System Level II :

- Muscle Biceps pulled the radius to lift the elbow,
- Brachial muscle pulled the ulna to lift the elbow,
- Deltoid muscle pulled the humerus to shrug.

$$F = \frac{(r+R) \ .L}{r} \qquad (2)$$

Direct measurement of muscle strength, by using formul:

$W = m \ . \ g \ . \cos \theta$ (3)

Analisa Gaya : $\Sigma F = 0$

$F1 - W1 - W2 = 0$

$F1 = W1 + W2$ (4)

Analisa Momen : $\Sigma M = 0$

$M1 - W1 \times d2 \times \text{Cos } \theta - W2 \times d1 \times \text{Cos } \theta = 0$

$M1 = W1 \times d2 \times \text{Cos } \theta - W2 \times d1 \times \text{Cos } \theta$ (5)

3. RESULTS

In this study, the calculations performed are the calculation of force analysis and moment analysis. Data retrieval before reddest of 4 operators includes height, weight, inclination angle on the forearm, upper arm and on back and load are lifted by the operator. And more details in the table below:

Table 1. Data Measurement Of Body Segments Operator

Operator	High Body (Cm)	Weight Body (Cm)	Arms Down (Angle)	Upper Arms (Angle)	Back (Angle)	Weigh Material
A	167	55	37.5	35	45	3.5
B	168	60	35	33	45	4
C	145	44.5	25	28	15	2.5
D	147	45	20	30	15	3

Segment Calculation, In this research, the data retrieval from the activity that is done before redesign is conducted by 4 operators, then from the data is taken the length, weight and center of mass of each segment at the position of each operator. The results of segment calculations can be seen in the table:

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Table 2. Calculation Of Body Segment Segments A

Operator A High Body = 167 Cm Weigh Body = 55 Kg

No.	Segment Name	(%) Height Body	Body Segment Length (d2)	(%) Weight Body	Segmentt Weight	(%) Mass Centre	Mass Centre (d1)	Measurement of Mass Center
1	Forearm	26.5	44.26	2.3	1.265	41	18.14	from the elbow
2	Upper arm	17.4	29.06	2.8	1.540	48	13.95	from the shoulders
3	Back	28.8	48.10	58.4	32.120	46	22.12	from the hips
4	Thigh	24.3	40.58	1	0.550	41	16.64	from the hips
5	Calf	23.6	39.41	4.3	2.365	44	17.34	of the knee

Table 3. Calculation Of Body Segment Segments B

Operator B High Body = 168 Cm Weigh Body = 60 Kg

No.	Segment Name	(%) Height Body	Body Segment Length (d2)	(%) Weight Body	Segmentt Weight	(%) Mass Centre	Mass Centre (d1)	Measurement of Mass Center
1	Forearm	26.5	44.52	2.3	1.380	41	18.25	from the elbow
2	Upper arm	17.4	29.23	2.8	1.680	48	14.03	from the shoulders
3	Back	28.8	48.38	58.4	35.040	46	22.26	from the hips
4	Thigh	24.3	40.82	1	0.600	41	16.74	from the hips
5	Calf	23.6	39.65	4.3	2.580	44	17.45	of the knee

Table 4. Calculation Of Body Segment Segments C

Operator C High Body = 145 Cm Weigh Body = 44.5 Kg

No.	Segment Name	(%) Height Body	Body Segment Length (d2)	(%) Weight Body	Segmentt Weight	(%) Mass Centre	Mass Centre (d1)	Measurement of Mass Center
1	Forearm	26.5	38.43	2.3	1.024	41	15.75	from the elbow
2	Upper arm	17.4	25.23	2.8	1.246	48	12.11	from the shoulders
3	Back	28.8	41.76	58.4	25.988	46	19.21	from the hips
4	Thigh	24.3	35.24	1	0.445	41	14.45	from the hips
5	Calf	23.6	34.22	4.3	1.914	44	15.06	of the knee

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Table 5. Calculation Of Body Segment Segments D

Operator D High Body = 147 Cm Weight Body = 45 Kg

No.	Segment Name	(%) Height Body	Body Segment Length (d2)	(%) Weight Body	Segmentt Weight	(%) Mass Centre	Mass Centre (d1)	Measurement of Mass Center
1	Forearm	26.5	38.96	2.3	1.035	41	15.97	from the elbow
2	Upper arm	17.4	25.58	2.8	1.260	48	12.28	from the shoulders
3	Back	28.8	42.34	58.4	26.280	46	19.47	from the hips
4	Thigh	24.3	35.72	1	0.450	41	14.65	from the hips
5	Calf	23.6	34.69	4.3	1.935	44	15.26	of the knee

Calculation of Moment, Calculation of moment before redesign, Analyze moment of each position is observed only to at waist only and divided to 3 segments, that is:

1. Segment I is operator bottom arm,

2. Segment II that is top of operator,

3. Segment III that is back or neck to waist.

Analysis of segment I is on the operator's lower arm.

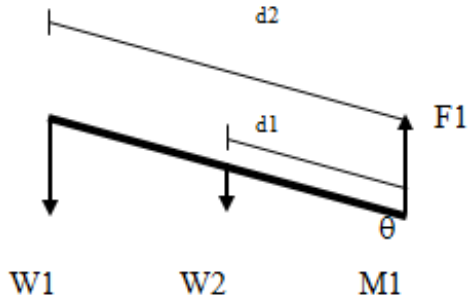

Figure 1. Style Components On The Below Long

Table 6. Result Of Segmental Calculations I. Arrows

Operators	W1 (N)	W2 (N)	d1	d2	A (level)
A	27.1999	12.65	0.1814	0.4426	37.5
B	32.1048	13.8	0.1825	0.4452	35
C	22.197	10.235	0.1575	0.3843	25
D	27.636	10.35	0.1597	0.3896	20

The results of the calculation of style analysis and moment analysis as in the table below:

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Table 7. Analysis Of Styles And Analysis Of Moments On The Below Line

No.	Operators	Gaya Analysis (F2) (N)	Moment Analysis (M2) (N.m)
1	A	39.8499	11.366
2	B	45.9048	13.769
3	C	32.432	11.287
4	D	37.986	11.675

So the magnitude of the moment on the forearm, the operator before redesain the operator A = 11.366 N.m, operator B = 13.769 N.m, operator C = 11.287 N.m and operator D = 11.675 N.m.

Segment II analysis on the operator's upper arm.

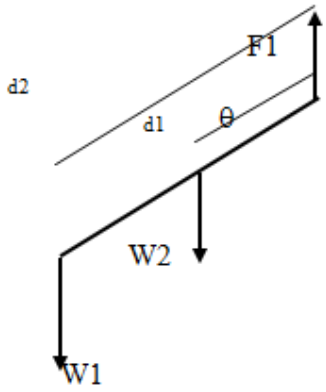

Figure 2. Style Components On The Arm

Table 8. Results Of Segment Ii. Upper Arm

Operators	F1	W2 (N)	d1	d2	M1	a (level)
A	39.8499	15.40	0.1395	0.2906	11.366	35
B	45.9048	16.80	0.1403	0.2923	13.769	33
C	32.432	12.46	0.1211	0.2523	11.287	28
D	37.986	12.60	0.1228	0.2558	11.675	30

The results of the calculation of style analysis and moment analysis as in the table below:

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Table 9. Analysis of Style and Moment Analysis On The Arm

No.	Operators	Gaya Analysis (F2) (N)	Moment Analysis (M2) (N.m)
1	A	55.25	22.610
2	B	62.70	27.004
3	C	44.89	19.845
4	D	50.59	21.429

The result of the calculation of force analysis and moment analysis is as in the table below: So the magnitude of the moment on the upper arm, the operator before redesign the operator A = 22.610 N.m, operator B = 27.004 N.m, operator C = 19.845 N.m and operator D = 21.429 N.m.

Analysis of segment III is on operator backs

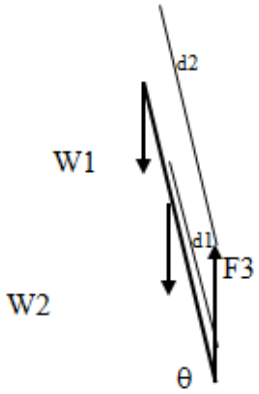

Figura 3. **Components of the Style on the Back**

Table 10. Data Segment Iii. Back

Operators	F2 (N)	W2 (N)	d1	d2	A (level)
A	55.25	321.2	0.221242	0.48096	45
B	62.70	350.4	0.222566	0.48384	45
C	44.89	259.88	0.192096	0.4176	15
D	50.59	262.8	0.194746	0.42336	15

The results of the calculation of style analysis and moment analysis as in the table below:

Table 11. Analysis Of Styles And Moment Analysis On Back

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No.	Operators	Gaya Analysis (F3) (N)	Momen Analysis (M3) (N.m)
1	A	376.45	69.029
2	B	413.10	76.587
3	C	304.77	66.334
4	D	313.39	70.127

So the magnitude of the moment on the back, on the operator before redesign the operator A = 69.029 N.m, operator B = 76.587 N.m, operator C = 66.334 N.m and operator D = 70.127 N.m.

4. CONCLUSION

Direct measurements of muscle strength before redesign of the magnitude of the moment in each segment of the operatic body are as follows:

1. The magnitude of the moment on the forearm, the operator A = 11.366 Nm, operator B = 13.769 Nm, the operator C = 11,287 Nm and operator D = 11,675 Nm

2. The magnitude of the moment on the upper arm, on the operator that is operator A = 22.610 N.m, operator B = 27.004 N.m, operator C = 19.845 N.m and operator D = 21.429 N.m.3. The magnitude of the moment on the back, on the operator before redesign the operator A = 69.029 N.m, operator B = 76.587 N.m, operator C = 66.334 N.m and operator D = 70.127 N.m.

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