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Application of Automatic Yarn Winder to Improve Productivity in Balinese Traditional Weaving Businesses

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Abstract

Weaving is a fabric craft made by combining threads crosswise and lengthwise. Before carrying out the weaving process, the winding thread process is usually carried out. However, one of the weaving artisans from Jembrana Regency still does the thread-winding process manually. Winding yarn with a manual tool takes quite a long time. The results of the yarn spools are not neat and cause physical complaints. Therefore, an automatic yarn winder innovation was created. Automated yarn winders can help weavers by providing convenience in the yarn winding process through the technology offered, namely the use of DC motors, Arduino nano, BTS7960 motor drivers, keypads, and LCDs. By providing these solutions and conveniences, cagcag weaving artisans can carry out the winding thread process more quickly, the results of thread rolls are tidier, and they can eliminate physical complaints they experience. Through the application of this tool, the productivity of traditional cagcag weaving artisans has increased.

Keywords: weaving; yarn winder; productivity.

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1. Introduction

Weaving is a fabric craft made by combining yarn transversely and lengthwise. Traditionally, woven fabric is a garment used to cover the body by both men and women [1]. According to the Jembrana Regency Profile [2], the leading commodity in the processing industry sector in the Jembrana area is weaving craftsmen, especially Traditional Cagcag Weaving. Cagcag weaving is a type of weaving typical of the Jembrana area whose manufacturing process is quite complicated. This weaving process uses tools made from wood and makes a "cag cag" sound during the weaving process. Therefore, the sound is the basis why Jembrana woven fabric is called Tenun Cagcag with the product results in the form of songket motif woven fabric. There are about 100 songket weaving craftsmen scattered throughout Jembrana with an average age of 40 years [3].

(a) (b)

Figure 1: (a) Manual Winding of Thread; (b) Weaving Process.

The process of making woven fabrics begins with the process of rolling the yarn. Some weaving craftsmen still do the yarn rolling process manually using a wheel that is rotated as in Figure 1 (a). The results of the yarn rolling will be grouped in large and small bobbins, where the bobbin is a place to roll the yarn in the form of a pipe or wooden stick with a length of 17 cm. The rolls on the bobbin are then used as the basis and motif of the woven fabric. The next process is manual weaving as shown in Figure 1 (b). The rolls of yarn on the resulting large bobbin will be stretched vertically and then small rolls will be inserted between the large rolls. The process of making one fabric product takes 10 to 20 days with a fabric length of 2 meters. The resulting woven products are songket motif woven fabrics in the form of kamben, saputan, udeng, and shawl which are traditional Balinese clothes. The selling price for one kamben is Rp. 700,000, one saputan is Rp. 600,000, one udeng is Rp. 200,000, and one shawl is Rp. 200,000.

Due to the large demand for woven fabric production in craftsmen, production efficiency is needed. Some traditional Balinese weaving craftsmen have problems in the production process, especially in thread rolling. The process of rolling yarn that is still done manually can slow down the time of rolling yarn and finishing woven fabrics, and experience physical complaints when rolling yarn for too long. With these problems, an innovation was made in the form of an automatic yarn rolling tool. The application of this innovation aims to speed up the process of rolling yarn and reduce physical complaints experienced by craftsmen when rolling yarn. With this tool, the craftsmen have convenience in the production process of woven fabrics, so as to produce more woven fabrics in a shorter time. Therefore, the productivity of weaving craftsmen has increased.

2. Materials and Methods

2.1. Literature Study

The literature study stage aims to find sources and types of data used in the application of automatic thread rolling tools in traditional Balinese weaving businesses. Sources of data in the application of automatic yarn rolling tools are obtained by collecting information along with supporting data in making tools. Information and supporting data are obtained from articles, journals, supporting books, and other sources of information. In addition to literature studies, data sources are also obtained from direct discussions with traditional Balinese weaving craftsmen. In the discussion, measurements of thread rolling time were also made on manual tools to support the process of analyzing the comparison of the results of manual and automatic thread rolling tools. The types of data used in the application of automatic yarn rolling tools are divided into two, namely primary and secondary data. Primary data includes data obtained from the measurement of thread rolling time on manual tools. Secondary data includes data obtained from journals and articles related to the specifications of supporting components in the manufacture of automatic thread rolling tools..

2.2. Tool Design

The design of the automatic yarn winding tool is designed in three-dimensional form using SketchUp 2019 software on a computer. The tool design results are shown in Figure 2.

Figure 2: Three-Dimensional Design of Automatic Thread Rolling Device.

2.3. Tool Making

Tool manufacturing is done with a pre-designed design. The tool frame is made of wood and aluminum. The electronic components as the main driver of this tool consist of a 730 rpm DC motor, BTS7960 motor driver, 4x4 keypad, 2x16 LCD, and arduino nano. The 730 rpm DC motor functions as the main driver of the automatic yarn winding tool, the BTS7960 motor driver functions to control the current and voltage of the DC motor rotation, the 4x4 keypad functions to adjust the motor rotation speed, the 2x16 LCD functions to display the motor rotation speed, and the arduino nano functions as a microcontroller that connects the input command from the keypad to the DC motor. The mechanical and electronic design of the automatic yarn winding device is shown in Figures 3 and 4.

Figure 3: Mechanical Design of Automatic Thread Winding Tool.

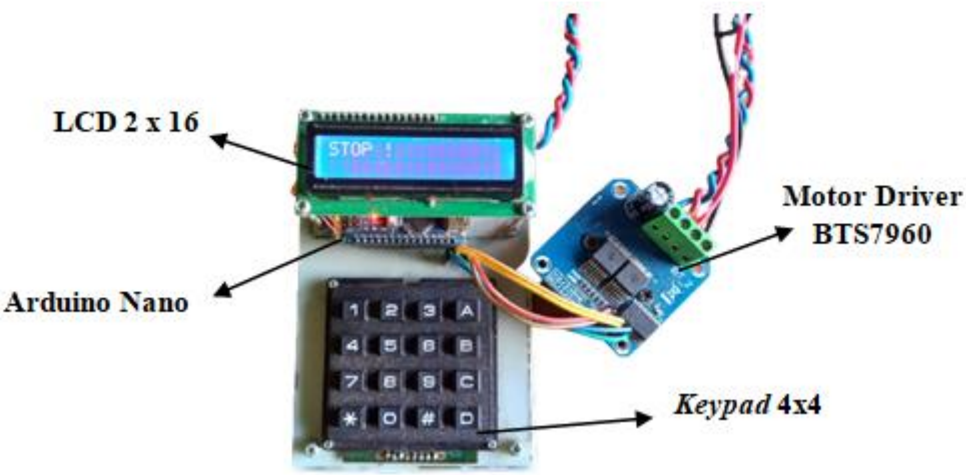


Figure 4: Electronics Design of an Automatic Thread Winder.

2.4. Tool Testing

At this stage, the function and performance of the tool are tested directly on the craftsmen. The purpose of this trial stage is to determine the success of the tool work in accordance with the initial plan. The success of the tool work is determined by the speed of the yarn rolling process using automatic tools and the reduction of physical complaints experienced by craftsmen when rolling yarn.

2.5. Implementation of Tools for Weaving Craftsmen

The final stage is the implementation of tools on traditional cagcag weaving craftsmen. At this stage, evaluation and monitoring were also carried out with the aim of analyzing the suitability of using the tools to the craftsmen. The results of evaluation and monitoring can be used as a benchmark for the sustainability of tool implementation in weaving craftsmen more broadly.

3. Results

3.1. Decrease Thread Winding Time

Automatic yarn rolling tools applied to Traditional Cagcag Weaving craftsmen are able to function properly and overcome the problems experienced by craftsmen. By using automatic yarn rolling tools, craftsmen are able to roll yarn in a shorter time with a decrease of 25% as in table 1. A faster yarn-winding process results in a greater number of rolls of yarn per bobbin. Craftsmen generally do the yarn winding process for 8 hours. By using an automatic yarn winding tool, the number of yarn rolls made over 8 hours has increased by 33% as shown in table 2.

Table 1: Comparison of Yarn Winding Time per-Bobbin.

Tools	Rolling Time (bobbin)			
	Small	**Percentage**	**Big**	**Percentage**
Manual	20 minutes	25%	40 minutes	25%
Automatic	15 minutes		30 minutes	

Table 2: Comparison of Yarn Winding Results for 8 Hours.

Tools	Time (hours)	Number of Rolls (*bobbin*)			
		Small	**Percentage**	**Big**	**Percentage**
Manual	8	24	33%	12	33%
Automatic	8	32		16	

3.2. Decrease in Physical Complaints

Apart from humans, work tools also have a very important role in the production process [4]. Work tools have a function to facilitate workers in carrying out an activity to be more effective and efficient. In this case, the use of thread rolling tools to support the woven fabric production process must also be considered properly. The application of these tools must meet ergonomic standards, where ergonomics is a study that discusses human aspects with their work environment [5]. The level of ergonomics can be analyzed with the calculation of REBA (Rapid Entire Body Assessment). This calculation can be used as a reference in analyzing the effect of postural loads on work that uses hands or other body parts. The following is a comparison of the level of ergonomics in the use of manual and automatic thread rolling tools by traditional Balinese weaving craftsmen.

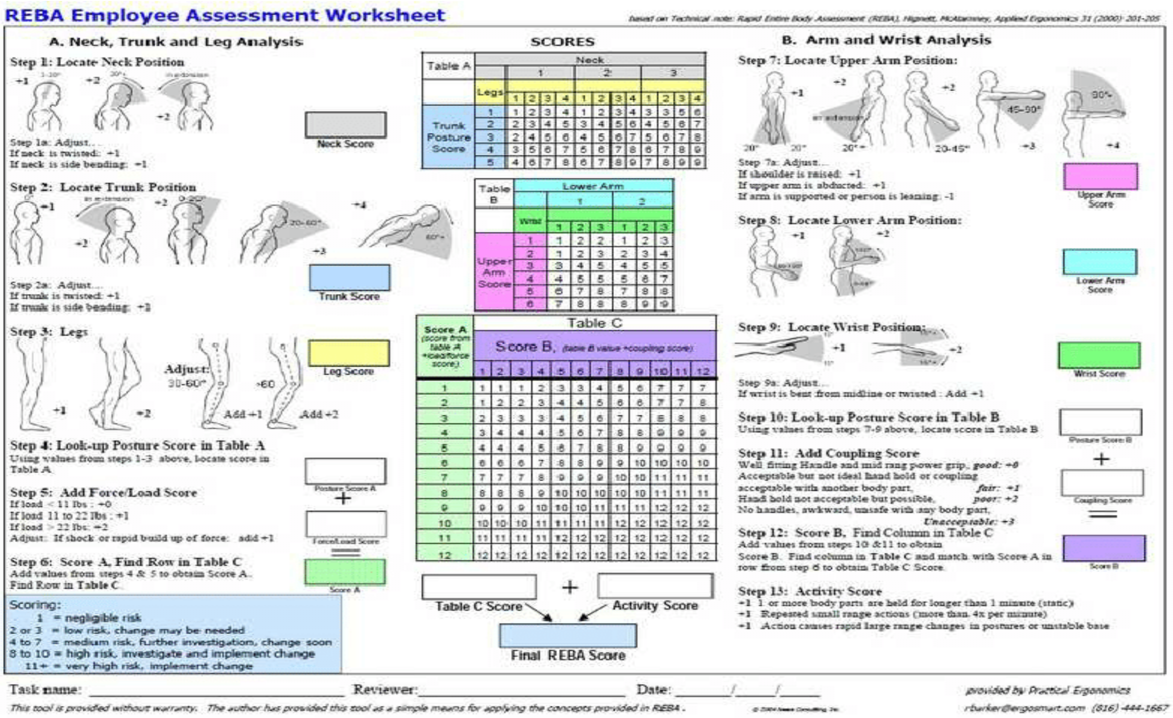


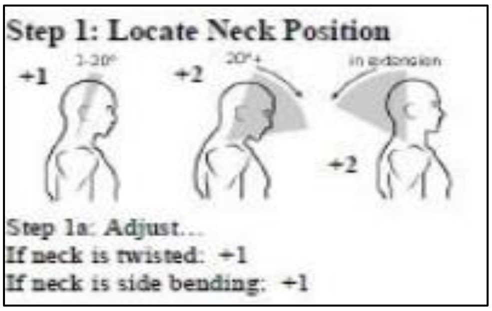
Figure 5: REBA Calculation Process [6].

a. REBA Calculation of The Use of Manual Thread Winder

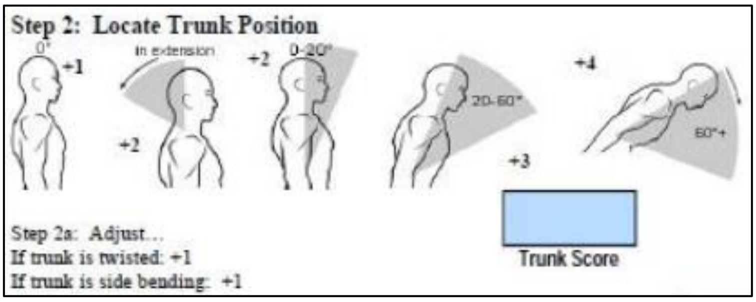
Figure 6: Manual Yarn Winding Process.

Figure 6 shows the process of rolling the yarn manually by traditional Balinese weaving craftsmen. The position of the craftsman in the process of rolling the yarn is slightly bent and both hands work to rotate the wheel as the main drive and organize the thread rolls so as not to fall apart. The results of the REBA calculation of the manual yarn winding process are as follows.

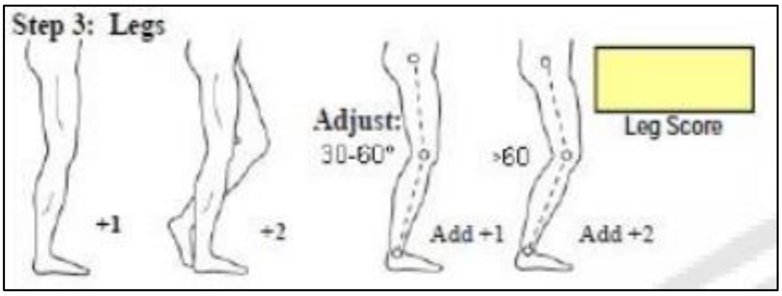
- **Neck, Trunk, and Leg Calculation Anlysis**



Neck Score = +2



Trunk Score = +3



Leg Score = +2

Table A		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Figure 8

In accordance with the results of the neck score, trunk score, and leg score calculations, the calculations in table A have a result of 5

Score A Calculation Result

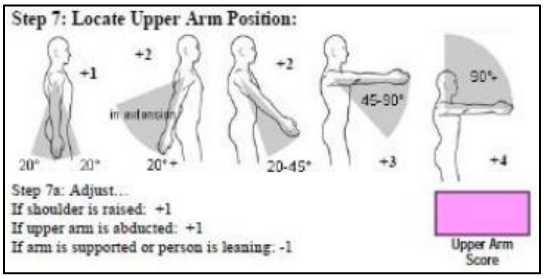
Since the weaver's workload is less than 5kg, Force/Load Score = +0

So Score A = Table A + Force/Load Score

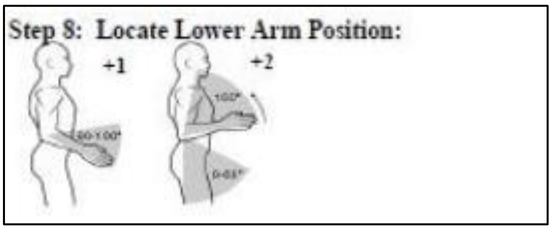
= 5 + 0

= 5

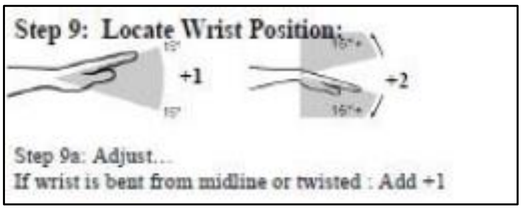
- **Arm and Wrist Calculation Analysis**



Upper Arm Score = +2



Lower Arm Score = +1



Wrist Score = +2

Table B	Lower Arm					
	1			2		
Wrist	1	2	3	1	2	3
Upper Arm Score 1	1	2	2	1	2	3
2	1	2	3	2	3	4
3	3	4	5	4	5	5
4	4	5	5	5	6	7
5	6	7	8	7	8	8
6	7	8	8	8	9	9

Figure 9

According to the calculation results of the arm and wrist, the results of Table B are 2

Score B Calculation Result

Because the handle in the yarn winding process is done well, the Coupling Score = +0

So Score B = Table B + Coupling Score

= 2 + 0

= 2

- **REBA Calculation Results**

Score A (score from table A +load/force score)	Table C: Score B, (table B value +coupling score)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Figure 10

Table Value C = 4

Since some limbs are in a fixed position for longer than 1 minute, Activity Score = +1.

REBA Score **=** Table C + Activity Score

= 4 + 1

= 5

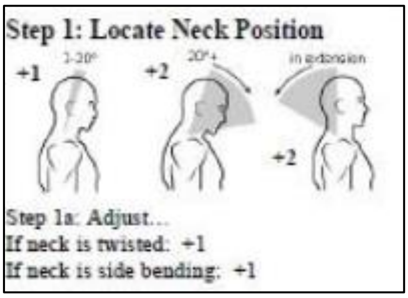
Based on the score and action category table [7], the REBA score of 5 has a moderate risk which means it requires further investigation of the tools used.

b. REBA Calculation of The Use of Automatic Yarn Winder

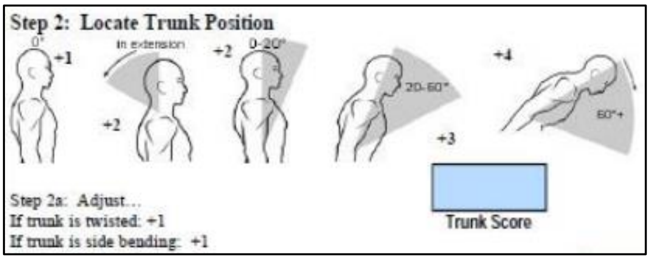
Figure 7: Automatic Thread Winding Process.

Figure 7 is an automatic yarn winding process, where the automation is in the main driving source of the yarn winding. By using this tool craftsmen no longer need to use the wheel as a driver of thread rolling, but already using a DC motor whose speed can be adjusted through the keypad. The position of the craftsmen in rolling the yarn also becomes more upright, so that the physical complaints that were initially experienced can be reduced. The following is the REBA calculation on the automatic yarn winding process.

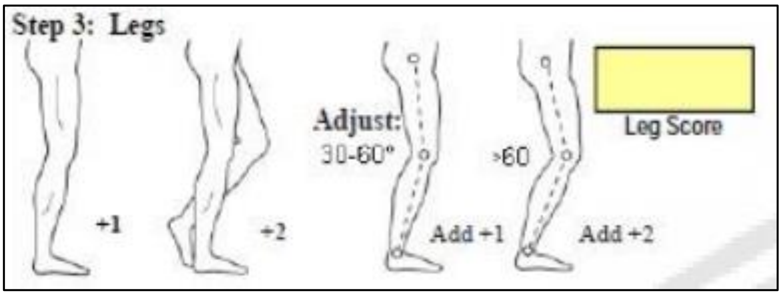
- **Neck, Trunk, and Leg Calculation Anlysis**



Neck Score = +1



Trunk Score = +2



Leg Score = +2

Table A	Neck												
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Figure 11

In accordance with the results of the neck score, trunk score, and leg score calculations, the calculations in table A have a result of 3

Score A Calculation Result

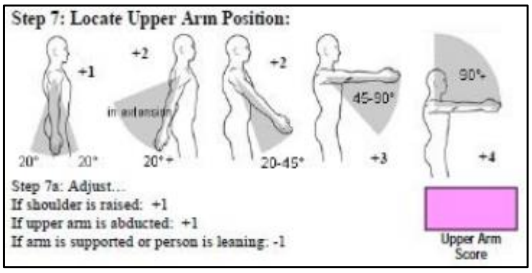
Since the weaver's workload is less than 5kg, Force/Load Score = +0

So Score A = Table A + Force/Load Score

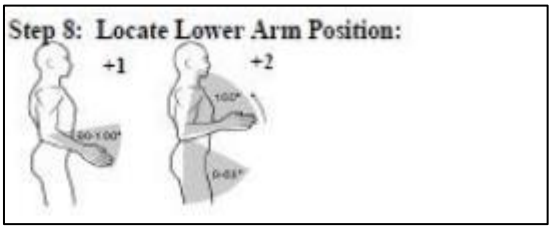
= 3 + 0

= 3

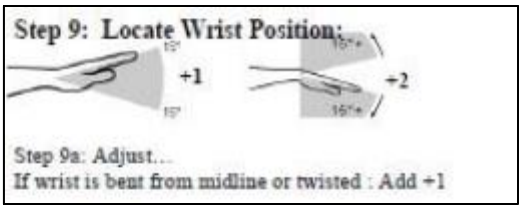
- **Arm and Wrist Calculation Analysis**



Upper Arm Score = +2



Lower Arm Score = +1



Wrist Score = +1

Table B		Lower Arm 1			Lower Arm 2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Figure 12

According to the calculation results of the arm and wrist, the results of Table B are 1

Score B Calculation Result

Because the handle in the yarn winding process is done well, the Coupling Score = +0

So Score B = Table B + Coupling Score

= 1 + 0

= 1

- **REBA Calculation Results**

Score A (score from table A +load/force score)	Table C											
	Score B, (table B value +coupling score)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Figure 13

Table Value C = 2

Since some limbs are in a fixed position for longer than 1 minute, Activity Score = +1.

REBA Score = Table C + Activity Score

= 2 + 1

= 3

Based on the score and action category table [7], REBA score 3 has a low risk which means changes may be needed to the tool.

By looking at the results of the REBA calculation, the automatic yarn winder has a more feasible ergonomic level compared to the manual yarn winder. Therefore, the use of an automatic yarn winder can reduce the physical complaints experienced by previous partners.

3.3. Income Increase

From the results of data processing before and after the application of automatic yarn rolling tools in traditional Balinese weaving craftsmen, data obtained a decrease in yarn rolling time by 25% and an increase in the acquisition of bobbin yarn by 33%. These results also affect the increase in woven fabric production every month. Before the use of automatic yarn rolling tools, craftsmen were only able to complete 3 weaving products of shawl and kamben types. After the use of automatic thread rolling tools, the number of woven products produced each month has increased by 2 products. Based on these results, the income of weaving craftsmen has increased by 82% as shown in Table 3.

Table 3: Increase in Income of Balinese Traditional Weaving Craftsmen in One Month.

Tools	Types of Weaving Products	Total	Price	Price Total	Income Increase
Manual	Shawl	2	Rp. 400.000	Rp. 1.100.000	82%
	Kamben	1	Rp. 700.000		
Automatic	Shawl	3	Rp. 600.000	Rp. 2.000.000	
	Kamben	2	Rp. 1.400.000		

4. Conclusion

Based on the results of the application of automatic thread rolling tools in one of the traditional cagcag weaving craftsmen in Jembrana, the following conclusions can be drawn:

1. The application of automatic yarn rolling tools can facilitate traditional Balinese weaving craftsmen in rolling yarn.
2. The use of this tool is able to shorten the yarn winding time with a difference in time before and after the application of the tool by 25% and increase the number of yarn bobbins by 33%.
3. By using this tool craftsmen can reduce physical complaints experienced with REBA 3 calculations that have low risk.
4. With the implementation of an automatic thread winder, the income of traditional Balinese weaving craftsmen has increased by 82% in one month.

Acknowledgements

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