engineering proceedings

MDPI

Proceeding Paper

Design of Ergonomic Red Brick Molder with Axiomatic Design and Ulrich & Eppinger Method †

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† Presented at the 9th Mechanical Engineering, Science and Technology International Conference (MEST 2025), Samarinda, Indonesia, 11–12 December 2025.

Abstract

In the small and medium industries producing red bricks in Indonesia, the production process still uses traditional tools. At the workstation, operators in bent postures, which increases the potential for musculoskeletal disorders (MSDs) to occur and requires corrective actions at the workstation. This research aims to reduce the risk of unhealthy operator work postures by designing red-brick molding tools that are more ergonomic and efficient, thereby speeding up the production process. The research uses the axiomatic design method and integrates it with the Ulrich and Eppinger's product design and development stages. At the product concept development stage, five alternative design solutions were generated, and the second solution was determined as the selected concept. The solution was design and tested virtually. The research results show that the REBA method test score is one, which means that the red-brick molding work using this tool carries a negligible level of risk and does not require corrective action. Based on the designed specifications, this tool can reduce molding time by 92.5% compared to the molding time of traditional tools.

Keywords: REBA method; axiomatic design; product design and development; Redbrick production

1. Introduction

Red brick is one of the most commonly used building materials in the construction of building walls, produced in the form of rectangular prisms that are either solid or hollow [1]. Redbrick are chosen because they have strong durability at an affordable cost. Red bricks are generally made of clay, which is molded and fired at high temperatures [2]. Red bricks are easy to find in Indonesia, one example being SMI in the red brick manufacturing center of Central Java, Indonesia. This red brick cottage industry still relies on a manual production process utilizing traditional equipment. The bricks are generally made of pure clay that is mixed thoroughly with water, molded using wooden molds, dried for several days, and burned in a brick kiln at high temperatures between 900 °C and 1000 °C [2].

In these SMIs, the entire production process is still done manually. For instance, at a molding workstation, the operator's work posture is not ergonomic, which can lead to complaints of MSDs [3]. MSDs are conditions characterized by symptoms that affect the muscles, nerves, tendons, ligaments, cartilage, and the spinal cord [4]. MSDs can cause

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Academic Editors: Rusandi Noor, Sigiet Haryo Pranoto, Arbansyah, Sarjito, Waluyo Adi Siswanto, Agus Dwi Anggono and Taghfirul Azhima Yoga Siswa

Published: 14 August 2026

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pain and discomfort in the muscles, thereby reducing operator productivity at work [5]. MSD complaints arise from improper material handling activities [6].

To confirm the researchers' assumptions, it is necessary to assess the working postures of operator at the molding workstation. This assessment was carried out using the Rapid Upper Limb Assessment (REBA) method. The REBA method is used to evaluate posture, use of force, type of movement, repetition, and coupling. The REBA method is applied in small pottery-making industries [7]. The resulting REBA score determines the corrective action required at the workstation. One such action is to designing a red-brick molder that is more ergonomic and efficient. In designing this tool, the researchers use the axiomatic design method and integrate it with the design and product development stages defined by Ulrich and Eppinger. Axiomatic design is a design method that uses two basic axioms: the pottery-making-dependent Axiom and the Information Axiom [8,9]. Meanwhile, product design and development is a cycle of continuous improvement over time with repeated feedback and input from members of the development team, executives, sales and marketing departments, and the production team [10]. This activity must go through several phases, specifically planning (phase 0), concept development (phase 1), system-level design (phase 2), detail design (phase 3), testing and refinement (phase 4), and production ramp-up (phase 5) [11].

Various studies on axiomatic design have been carried out by previous researchers [8]. On the other hand, several studies have also been carried out in Indonesia [12] to be developed using integration of axiomatic design method with house of quality or called axiomatic house of quality (AHOQ). In However, most of these analyses focused on product design using the axiomatic design method exclusively. In line with this information, this study examines the design of a red-brick molder by integrating the axiomatic design method into the design and development stages of Ulrich and Eppinger's products, which has never been done before. This research will produce a design proposal for a red brick molder. The proposed design of the red brick press is expected to reduce the risk of MSD complaints and increase operator productivity.

2. Material and Methods

2.1. Object of Research

The research location is the SMI Red brick worksite, which is located in Sukoharjo Regency, Indonesia. This research was conducted over 6 months, from October 2021 to March 2022. The subject of this research is the operator of a red brick molding workstation, while the object of the study is the ergonomics of the molding process, assessed based on the work posture and efficiency of the operator.

2.2. Methodology and Techniques

This study uses evaluative research methods. Evaluative research is part of applied research. The term evaluative refers to the nature of an activity. In this case, an important part of the evaluation is the existence of an expected goal or condition, and then that goal is assessed by conducting an evaluation [12]. This research was conducted by applying the design and product development stages proposed by Ulrich and Eppinger. The stages or phases are planning, concept development, system-level design, detail design, testing and refinement, and production ramp-up. The scheme of the combination of the principles of the solution is based on the mapping of the combination of the principles of the solution in the form of a morphological chart [13].

The planning phase consisted of several steps, namely problem identification, a literature study, a field study, data collection, and data processing. The collected data included the work posture of the molding operator, the cycle time of the molding process, and

customer needs. These data were obtained through observations and interviews with 15 resource persons who worked as molding workstation operators in the red brick center of Waru Village. The anthropometric data of Indonesians were collected from the research results of the Indonesian Ergonomics Association https://antropometriindonesia.org/index.php/detail/artikel/4/10/data_ant (accessed in 1 May 2022). The operator's work posture data processing utilized the REBA method. The REBA method assesses work postures for various risks of muscle, joint, and nerve disorders due to work tasks, specifically Work-Related Musculoskeletal Disorders (WMSDs) [14]. According to [15], the body segments measured by the REBA method are divided into two groups: group A (trunk, neck, and legs) and group B (upper arms, lower arms, and wrists). Meanwhile, the molding cycle time was processed into the normal time and standard time of the molding process.

The concept development phase began with the identification of customer needs obtained from interviews., followed by the synthesis of the axiomatic design method. According to Suh (1995), axiomatic design consists of four domains that must be mapped: the customer domain, containing customer attributes (CAs); the functional domain, containing functional requirements (FRs); the physical domain, containing design parameters (DPs), and the process domain, containing contains process variables (PVs) [8]. In this study, the synthesis of the axiomatic design method started with the identification of CAs and ended with mapping CAs to FRs and DPs [9]. Then, the target specifications, concept generation, and concept selection were determined [16].

The system-level design stage formed the product architecture, while the detailed design stage was analyzed using a bill of materials (BOM) to make the tool. The testing and refinement stage was carried out through virtual testing using CATIA V5-6R2020 software to find out how ergonomic and efficient the design of the selected red brick molder was. The CATIA assembly software was chosen because it can create CAD design products; furthermore, this application is also able to identify the relationships between the design products and humans through posture analysis simulations [17], similarly to the analysis software SolidWork Premium 2016 [18]. he testing was carried out by calculating the REBA score from the simulation using a virtual red-brick molder and analyzing the time efficiency of the molding process based on the specifications of the designed tool. The final result of this stage is the final specification of the red brick molder.

3. Result and Discussion

3.1. Phase 0—Planning

Initial Condition. This SMI had only one worker, who was assisted by the owner in the production process. The red brick molding process itself was carried out by a 42-year-old worker. Field observation revealed that the traditional red brick molding workstation comprised several processes, namely: (1) positioning the mold on the floor, (2) picking up and placing the dough, and (3) leveling the dough. The mold had a mass of 1 kg and was made of stainless steel. It featured five mold holes and one handle located on the right side of the tool.

Operator Work Posture Assessment. The assessment of work posture using the REBA method was carried out during the molding process using traditional tools. Three processes were analyzed at the red-brick molding workstation, namely: (a) a work posture for positioning the molding press, (b) a work posture for taking and placing the dough, and (c) a working posture for flattening the dough. The three working postures exhibited angles across certain body segments as shown in Table 1 below.

Table 1. Analysis of working posture angles.

Body Segments	Work Posture (°)		
	Process (a)	Process (b)	Process (c)
Trunk	116.84	106.75	47.68
Neck	17.82	24.34	3.78
Legs	3.93	20.71	160.21
Upper Arms	111.14	109.52	81.38
Lower Arms	14.61	28.12	36.93
Wrists	14.76	8.34	50.71

Figure 1 shows three processes at the red brick molding workstation, namely: (a) the working posture of positioning the molding tool, (b) the working posture for taking and placing the dough, and (c) the working posture for flattening the dough.



Figure 1. Working postures at molding workstation (**a**) process of positioning the printing tool, (**b**) process taking and placing the dough, (**c**) process of flattening the dough.

Assessment of work posture using the REBA method produced a work posture score (a) of 8, work posture (b) of 11, and work posture (c) of 7. The three REBA scores indicate that improvements are needed to minimize the REBA score to and reduce WMSDs, namely by designing a more ergonomic red-brick molder.

Molding Time Calculation. The measurement of working time at the molding workstation using traditional tools was carried out 10 times. The resulting cycle time data is shown in Table 2 below.

Table 2. Molding process cycle time using traditional tools.

Cycles	Time (Minute)		Cycles	Time (Minute)	
1	00:01:12	1.20	5	00:01:39	1.65
2	00:01:22	1.37	7	00:01:26	1.43
3	00:01:24	1.40	8	00:01:55	1.92
4	00:01:22	1.37	9	00:01:34	1.57
5	00:01:39	1.65	10	00:01:22	1.37
			Total Cycle Time		**1.50**

From the results of interviews with the molding workstation operator at red brick SMI, it was found that operators were given 15 min of rest and personal needs. he molding operation was conducted for 2 h (or 120 min) per working day. Based on the results of the calculation of normal time and standard time above, it was determined that an operator of a red brick print workstation could perform one molding process with a normal time of 1.5 min or 90 s, and a standard time of 1.6875 min or 101.25 s.

Anthropometric Data. Anthropometric data is very useful in the world of design, especially for objects used by humans. The specific anthropometric dimensions used in the design of the red brick molder are shown in Table 3 below.

Table 3. Anthropometric dimensions of the red brick molder.

No.	Notation	Dimension	Principle	Percentile	Value (cm)
1	D4	Elbow height	Design for Range	5th s.d 95th	92.48–112.67
2	D2	Eye height	Design for Average	50th	167.39
3	D17	Shoulder width	Design for Extreme	95th	51.12
4	D29	Hand Width	Design for Extreme	95th	15.91

3.2. Phase 1—Concept Development

Identify Customer Needs. Customer needs were obtained from interviews conducted with the owners of red brick SMEs and the operators of the red-brick molding process around the Waru Village area, Sukoharjo Regency. 15 respondents from 10 SMIs expressed several opinions regarding the need for red-brick molder, which are categorized in Table 4 below.

Table 4. Customer needs.

No.	Customer Needs
1	Good mold result
2	One mold, many results
3	Using machine
4	Easy to disassemble
5	Fast mold process
6	Safe to use
7	Light
8	Do not make the body sore
9	Do not cause quick fatigue
10	Do not make it dirty
11	The molder can be customized by the operator
12	Easy to use
13	Easy to move
14	Durable
15	Energy-saving
16	Strong
17	Easy to maintain

Axiomatic Design. The synthesis of the axiomatic design method started by grouping the needs into customer attributes (CAs), which were recollected from customer needs data, REBA evaluation results, and anthropometric data. The obtained CAs were effectiveness (CA1), efficiency (CA2), ergonomics (CA3), flexibility (CA4), and reliability (CA5). These five CAs were then mapped into FRs and DPs, as shown in Table 5 below.

Target Specification. The target specification were determined based on the design parameters obtained from the mapping of the FR synthesis process into DP. Each design parameter was translated into metrics and units by considering the marginal and ideal values. The resulting target specifications are as in Table 6 below.

Table 5. Mapping CAs to FRs and DPs.

Customer Attribute	FR		DP	
	Code	**Function**	**Code**	**Parameters**
Effectiveness (CA1)	FR1	Produces a rectangular prism brick shape	DP1	Mold
	FR1.1	Prevents dough from falling off the mold	DP1.1	Aluminum Mold Material
	FR1.2	Adds a brand logo embossment to the molded dough	DP1.2	Stamp
	FR1.3	Prevents the dough from being crushed by other dough	DP1.3	Proximity Sensor
Efficiency (CA2)	FR2	Speeds up the raw time of the molding process	DP2	Machine/Mechanical
	FR2.1	Uses machines with linear movements	DP2.1	Linear Actuator
	FR2.2	Eliminates the stages of removing the dough by hand repeatedly inefficiently	DP2.2	Hopper
	FR2.3	Smooths the dough to fill the mold evenly	DP2.3	Spatula
	FR2.4	Helps the dough fall to the molding floor	DP2.4	Dough Pusher
Ergonomic (CA3)	FR3	Makes tools according to the size and posture of the human body	DP3	Anthropometry and working posture
	FR3.1	Forms a support tool for standing working posture with a two-foot pedestal	DP3.1	Frame
	FR3.2	The steering shape of the tool corresponds to the height of the human elbow within the range of intermediate and upper percentiles, enough for all human percentiles and comfortable to grip	DP3.2	Handlebar
	FR3.3	Makes tool operation so it does not cause neck extensions or flexion of more than 20 degrees	DP3.3	Mold Position Parameters
	FR3.4	Minimizes energy when operating the appliance by reducing its friction force	DP3.4	Ball Bearing
	FR3.5	Minimizes tool mass	DP3.5	Hollow Frame
Flexibility (CA4)	FR4	Increases tool mobility	DP4	Wheel
	FR4.1	Uses portable resources	DP4.1	Battery
	FR4.2	Manages tool productivity with programs according to operator ability	DP4.2	PLC
	FR4.3	Operates the molding process by hand	DP4.3	Switch/Button
	FR4.4	Facilitates the movement of tools according to the direction of control	DP4.4	Swivel Wheel
Reliability (CA5)	FR5	Creates a strong frame	DP5	Black Hollow Iron
	FR5.1	Strong hopper withstands dough volume	DP5.1	Iron Plate
	FR5.2	Prevents water from entering the electrical department	DP5.2	Electrical Box
	FR5.3	Prevents rust in iron components	DP5.3	Iron Paint
	FR5.4	Prevents impact on dough thrusters	DP5.4	Tension Spring
	FR5.5	Makes it easier to maintain tools through a modular, detachable design	DP5.5	Fastener
	FR5.6	Keeps the linear movement of the actuator stable	DP5.6	Linear Track

Table 6. Target specification.

No.	Metric	Units	Marginal Value	Ideal Value
1	Aluminum Thickness	mm	>1.5	≤1.5
2	Range Minimum Proximity Sensor	cm	>10	≤10
3	Mold Process Standard Time	minute	>1635	<1635
4	Stroke Linear Actuator	mm	<50	≥50
5	Shaft Movement Speed	mm/s	≤100	>100
6	Volume Hopper	liter	>200	≤200
7	Number of Mold Holes	Unit	>5	5
8	Mold Hole Size	cm	>25 × 13 × 5	25 × 12.5 × 4
9	Minimum Height of Handlebar	cm	>92.48	92
10	Handlebar Maximum Height	cm	<112.67	113
11	Handlebar Minimum Width	cm	<51.12	52
12	Minimum Handgrip Width	cm	<15.91	16
13	Handgrip Diameter	mm	>40	22
14	Mold Position Parameter Height	cm	>167	≤167
15	Maximum Tool Mass	kg	>50	≤50
16	Hollow Steel Frame Thickness	mm	>2	1.6
17	Number of Digital Input/Output PLC	Unit	<10	20
18	PLC Input Voltage	Volt	>24	24
19	Battery Voltage Supply	Volt	>24	24
20	Black Hollow Iron Size	mm	<20 × 20	40 × 20
21	Hopper Iron Plate Thickness	mm	<1	1
22	Compressor Air Pressure	psi	<40	50–100

Figure 2 is a morphological chart that contains a list or summary of the changes in form and variations in function used to find out how the shape of a product is designed.

Concept Generation. Based on the morphological chart above, five alternative design solutions were successfully generated.

Concept Selection. The selection of design concepts or solutions was carried out in two stages, namely, concept screening and concept scoring. The results of the concept screening are shown in Table 7 below.

Table 7. Concept screening.

Selection Criteria	Solution				
	1 (Reference)	**2**	**3**	**4**	**5**
Effectiveness	0	+	+	-	+
Efficiency	0	+	-	-	-
Ergonomic	0	+	-	+	0
Flexibility	0	0	-	+	+
Reliability	0	+	-	+	-
Sum (+)	0	4	1	3	2
Sum (0)	5	1	0	0	1
Sum (−)	0	0	4	2	2
Net Score	0	4	−3	1	0
Rank	4	1	5	2	3
Continue	Comb.	Yes	No	Yes	Comb.

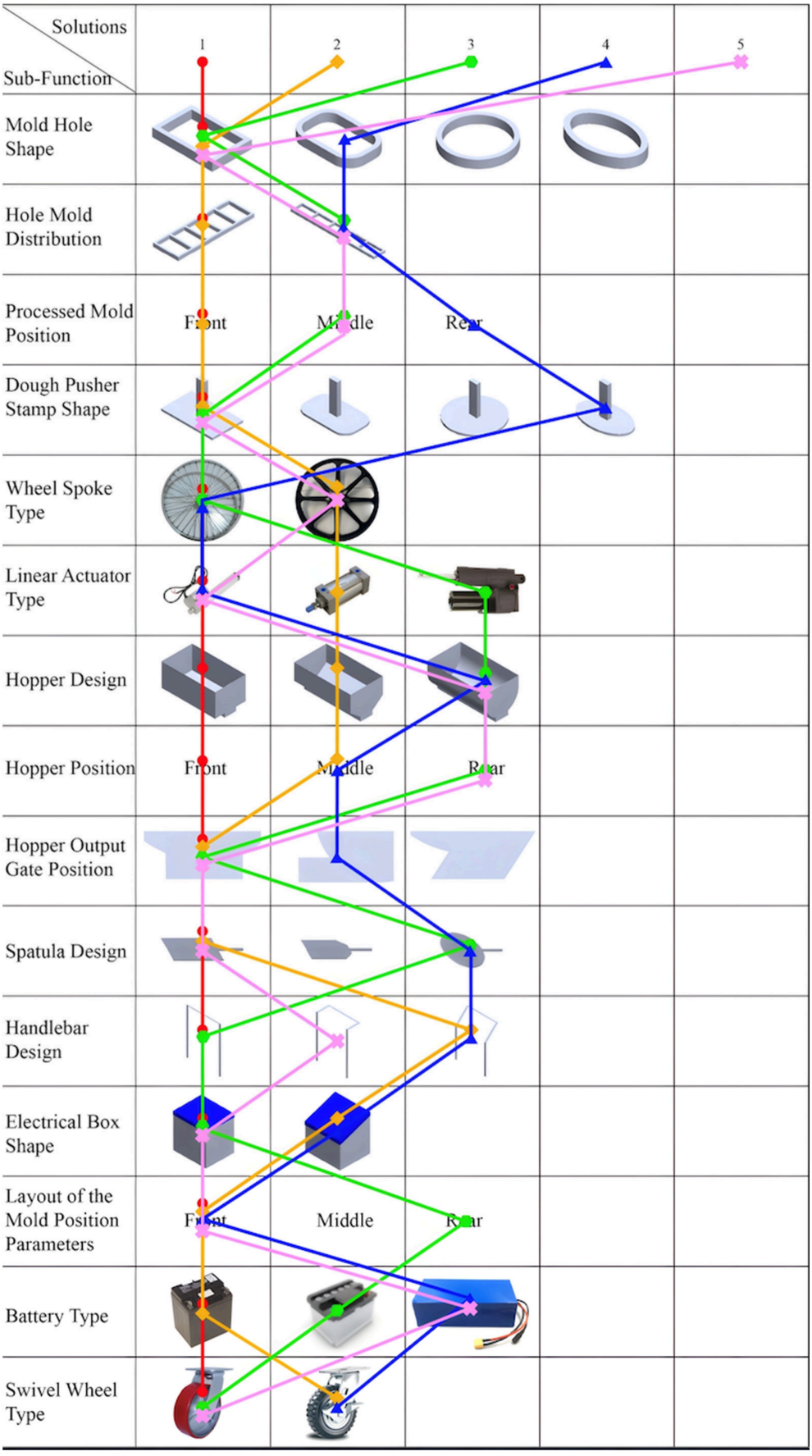


Figure 2. Morphological chart.

Based on the concept selection results in Table 7, the solutions that qualified for the concept scoring process were solutions 2, 4, as well as a combination of solutions 1 and 5. The combination of solutions was done by substituting the solution criteria 1 and 5, by choosing the better one. Consequently, the combination of solutions 1 and 5 obtained a Net Score of 2 for each criterion being: Effectiveness (+), Efficiency (0), Ergonomics (0), Flexibility (+), and Reliability (0).

Next is the concept scoring process was conducted, utilizing predetermined weights for each selection criterion: Effectiveness 10%, Efficiency 30%, Ergonomics 30%, Flexibility 20%, and Reliability 10%. The concept scoring process is shown in Table 8 below.

Table 8. Concept scoring.

Selection Criteria	Weight	Solution					
		2		4		Comb. 1,5	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Effectiveness	10%	5	0.5	1	0.1	4	0.4
Efficiency	30%	5	1.5	1	0.3	4	1.2
Ergonomic	30%	4	1.2	5	1.5	3	0.9
Flexibility	20%	3	0.6	5	1	4	0.8
Reliability	10%	5	0.5	4	0.4	3	0.3
Total Score			4.3		3.3		3.6
Rank			1		3		2
Continue			Develop		No		No

Based on the results of concept scoring in Table 8 solution 2 obtained the highest total score, which is 4.3. Thus, is solution 2 as selected as the design concept to be developed. The virtual design of design solution 2 is shown in Figure 3 below.

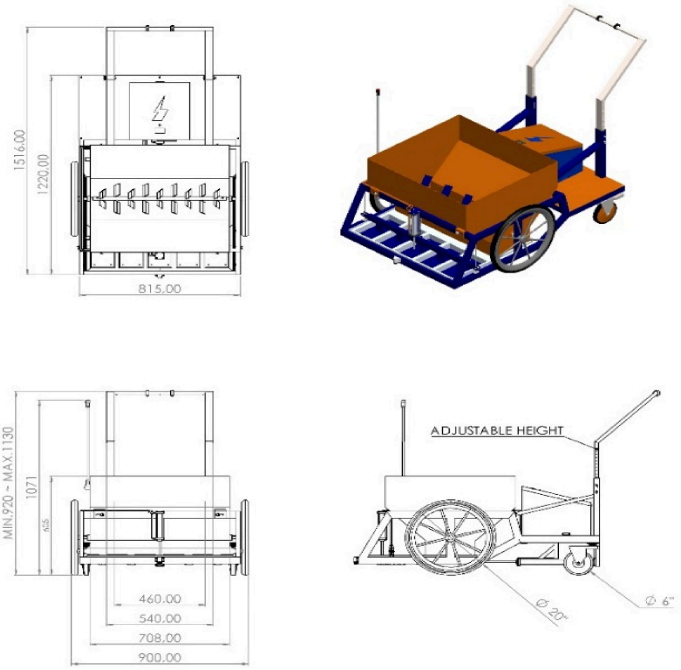


Figure 3. Selected concept virtual design.

3.3. Phase 2—System Level Design

The red-brick molder was designed based on a semi-automatic principle by utilizing a control system called programmable logic control (PLC) system. Meanwhile, the molding press drive system uses a linear actuator with a pneumatic principle called a pneumatic cylinder. The comprehensive subsystem architecture of the designed red brick molder is shown in Figure 4 below.

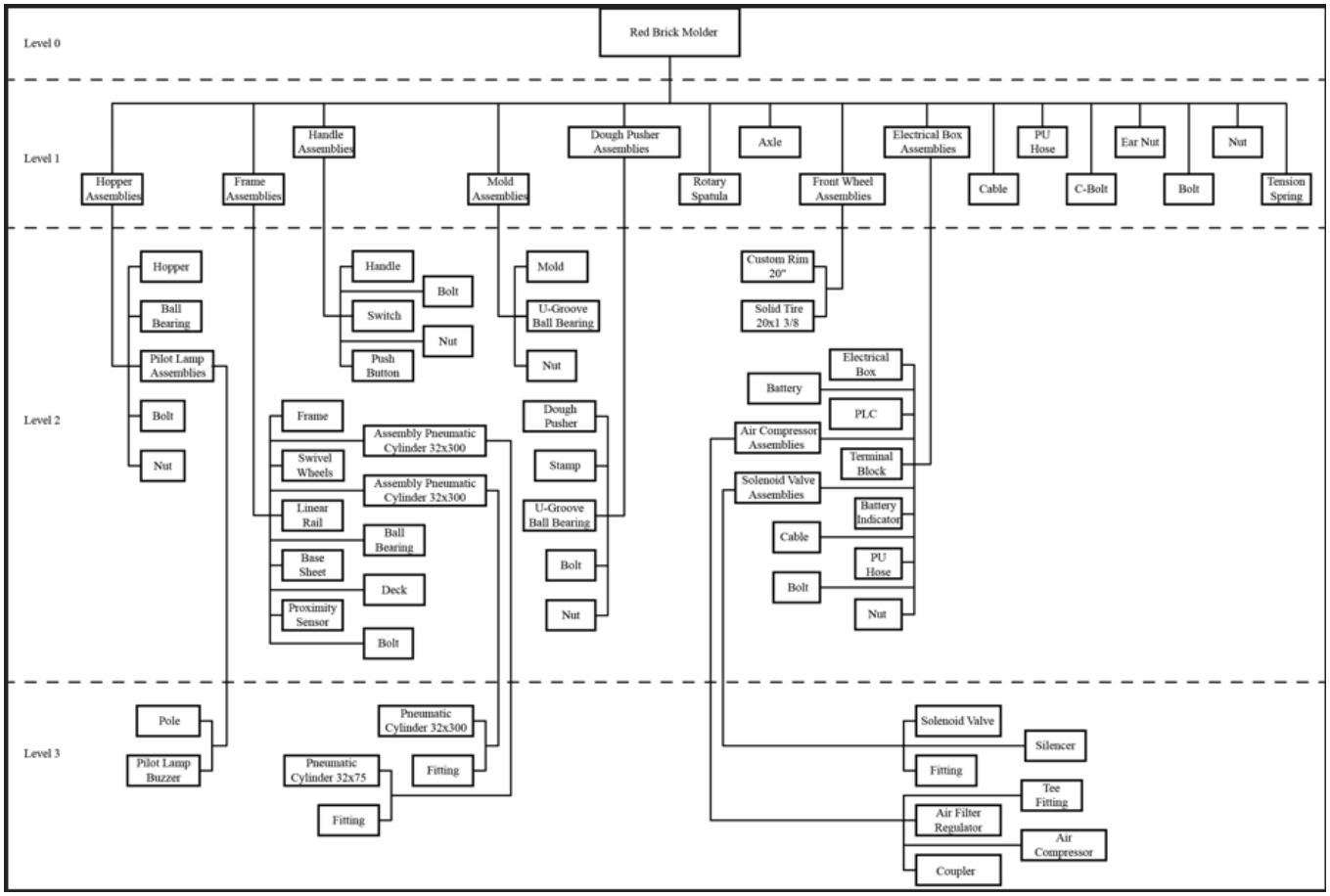


Figure 4. Red rick molder architecture.

3.4. Phase 3—Detail Design

The designed red-brick molder composes several components. Developed in accordance with the product architecture from the system-level design phase, the components of the red-brick molder are shown in Table 9 below.

Table 9. Bill of material.

No.	Description	Qty	Dec.
1	Red-Brick Molder	1	Assembled
2	Hopper Assemblies	1	Assembled
3	Frame Assemblies	1	Assembled
4	Handel Assemblies	1	Assembled
5	Mold Assemblies	1	Assembled
6	Dough Pusher Assembly	1	Assembled
7	Rotary Spatula	1	Made
8	Axle	1	Made
9	Front Wheel Assembly	2	Assembled

Table 9. *Cont.*

No.	Description	Qty	Dec.
10	Assembly Electrical Box	1	Assembled
11	Cable	1	Purchased
12	PU hose	4	Purchased
13	C-Bolt	2	Purchased
14	Ear Nuts	4	Purchased
15	Bolt	16	Purchased
16	Nut	9	Purchased
17	Tension Spring	1	Purchased
18	Hopper	1	Made
19	Ball Bearing	2	Purchased
20	Assembly Pilot Lamp Buzzer	1	Assembled
21	Bolt	1	Purchased
22	Nut	1	Purchased
23	Frames	1	Made
24	Pneumatic Cylinder Assembly 32 × 300	1	Assembled
25	Pneumatic Cylinder Assembly 32 × 75	1	Assembled
26	Swivel Wheel	2	Purchased
27	Linear Rail	2	Made
28	Ball Bearing	2	Purchased
29	Base Sheet	1	Made
30	Deck	1	Made
31	Proximity Sensor	1	Purchased
32	Bolt	48	Purchased
33	Handle	1	Made
34	Switch	1	Purchased
35	Push Button	1	Purchased
36	Bolt	2	Purchased
37	Nut	2	Purchased
38	Mold	1	Made
39	U-Groove Ball Bearing	8	Purchased
40	Nut	8	Purchased
41	Dough Pusher	1	Made
42	Stamp	5	Made
43	U-Groove Ball Bearing	2	Purchased
44	Bolt	2	Purchased
45	Nut	2	Purchased
46	Custom Rims 20″	2	Made
47	Dead Tire 20 × 1 3/8	2	Purchased
48	Electrical Box	1	Made
49	Battery	2	Purchased
50	PLC	1	Purchased
51	Air Compressor Assembly	1	Assembled
52	Solenoid Valve Assembly	2	Assembled
53	Terminal Block	2	Purchased
54	Battery Indicator	1	Purchased
55	Cable	1	Purchased
56	PU hose	3	Purchased
57	Screw	2	Purchased
58	Bolt	8	Purchased
59	Nut	8	Purchased
60	Pole	1	Purchased
61	Pilot Lamp Buzzer	1	Purchased
62	Pneumatic Cylinder 32 × 300	1	Purchased
63	1/8. fittings	2	Purchased

https://doi.org/10.3390/engproc2026137028

Table 9. *Cont.*

No.	Description	Qty	Dec.
64	Pneumatic Cylinder 32 × 75	1	Purchased
65	1/8. fittings	2	Purchased
66	Air Compressor	1	Purchased
67	Air Filter Regulator	1	Purchased
68	Coupler	1	Purchased
69	Tee Fittings	1	Purchased
70	Solenoid Valve 5/2	2	Purchased
71	Fittings	6	Purchased
72	Silencer	2	Purchased

3.5. Phase 4—Testing and Refinement

Testing. Testing is carried out virtually using CATIA software, which aims to simulate the work postures using the designed tool, so that it can be seen whether the design has been able to improve the work posture of the manual red-brick molding process. The test results using CATIA are shown in Figure 5 below.

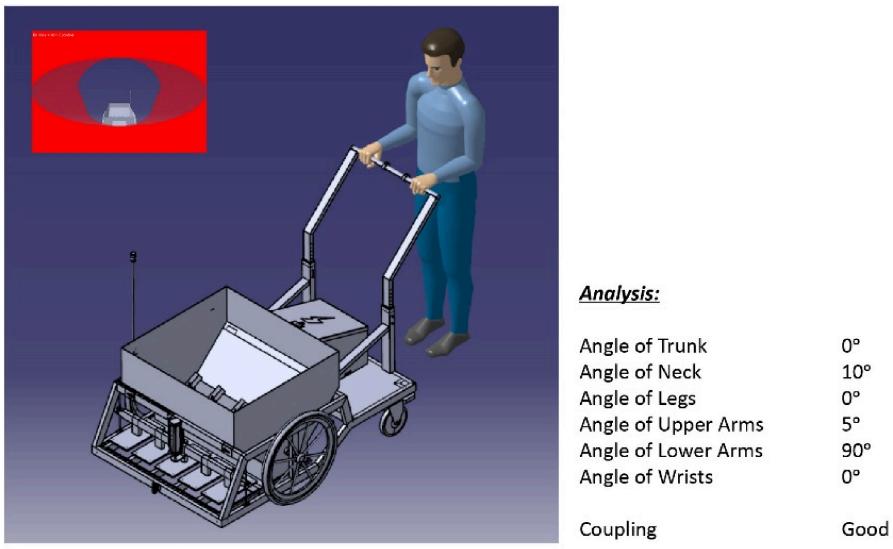


Figure 5. Virtual design test.

Assessment of work posture using the REBA method based on the test results data, resulting in a score of 1. That means that red-brick molding work using the designed tool has a negligible level of risk and does not require corrective action. Therefore, it can be concluded that the design of the red-brick molder has been able to reduce the level of WMSD's risk and the design does not require repair or refinement.

The design of a red-brick molder that uses a linear actuator with pneumatic principles can produce an average shaft speed of 433 mm/s with an average compressor air pressure of 65 psi. For one molding process, the linear actuator performs a double-acting stroke where a total stroke of 750 mm is required. For subsequent molding, the tool needs to be moved a minimum of 270 mm within 5 s. Based on the calculations, the standard time of 7.57 s was obtained. Thus, the designed brick molder can reduce molding time- by 92.5% compared to the standard molding time using the currently available tools.

Final Specification. Based on the alternative design of the selected red-brick molder, the final design specifications are obtained as shown in Table 10 below.

Table 10. Final specification.

No.	Metric	Units	Value
1	Aluminum Thickness	mm	1.2
2	Range Minimum Proximity Sensor	cm	7
3	Mold Process Standard Time	minute	0.016 s/d 0.31
4	Stroke Linear Actuator	mm	75 and 300
5	Shaft Movement Speed	mm/s	40 s/d 800
6	Volume Hopper	liter	140
7	Number of Mold Holes	Unit	5
8	Mold Hole Size	cm	25 × 12.5 × 4
9	Minimum Height of Handlebar	cm	92
10	Handlebar Maximum Height	cm	113
11	Handlebar Minimum Width	cm	52
12	Minimum Handgrip Width	cm	16
13	Handgrip Diameter	mm	22
14	Mold Position Parameter Height	cm	107.5
15	Maximum Tool Mass	kg	50
16	Hollow Steel Frame Thickness	mm	1.6
17	Number of Digital Input/Output PLC	Unit	20
18	PLC Input Voltage	Volt	24
19	Battery Voltage Supply	Volt	24
20	Black Hollow Iron Size	mm	40 × 20
21	Hopper Iron Plate Thickness	mm	1
22	Compressor Air Pressure	psi	50–80

This research has an important role because it can increase operator productivity at work by improving work posture and shortening working time. Comparing the specifications of the existing tools and the proposed design, it was found that the design of the proposed red-brick molder has several advantages that the existing tools do not have. The differences in these specifications include the use of semi-automatic principles in the proposed design, which utilizes PLC and pneumatic-powered linear actuators. Meanwhile, the existing tools still use conventional principles. The design proposals are take into account the needs of workers and the ergonomic conditions of workers. The REBA score between the tools that currently exist and those that are proposed is significantly different, where the average score of the tools currently available is 8.67, while the proposed score is 1. In addition, the comparison of working time between the tools currently available and the proposed design also has a significant difference, where the proposed design produces a standard molding time of 7.57 s or 0.126 min. Thus, it can reduce molding time by 92.5% compared to existing tools, which is 101.25 s or 1.6875 min. Research [19] on fishing aids using the Ulrich and Eppinger method, with the mission of developing fishing aid products that can be made by local industry, selected one variant concept with some specifications, namely: (1) tool dimensions of 500 mm × 150 mm × 225 mm; (2) a drive system with low electric power by using a large reducer rotation. In addition, [20] research on corn seed planting equipment aims to simplify and speed up the planting process, in which a mechanical system is used to throw corn seeds and to reduce the weight of corn seed planting equipment, a combination of galvanized material (500 g), PVC pipe (100 g), plastic (25 g), and metal (75 g) is used. This means that the proposed design of the red-brick molding machine can be better than the existing one because there is no need for corrective action on work posture and can save molding time. Research [21] a brick mold tool which is in a form of trolley, so that workers do not need to lift a brick mold that weighs 24 kg. To carry the brick molds, workers only need to push the trolley to the drying area. Meanwhile, using the Gravity Hammer system, the production capacity increased by an average of

2000 bricks per day. Research for redesign of work equipment was conducted by [22] for the fish smoking process and also [23] for leather shoe making, while research by [24] was in the form of a tempeh punching tool that refers to worker anthropometric data which is able to reduce working time from 1.03 h/unit to 0.52 h/unit.

4. Conclusions

Based on the results and discussion above, several conclusions can be drawn, namely, this research has succeeded in designing and testing a more ergonomic and efficient red-brick molder with the axiomatic design method which is integrated with the Ulrich and Eppinger product design and development approach. The results showed that the design of the tool can improve the working posture of the molding workstation operator with a REBA rating score of 1. In addition, the design of the tool can also reduce molding time-by 92.5% compared to traditional tools. These findings can improve understanding of product design and development system using the axiomatic design method, as well as understanding of designing products with ergonomic working postures.

Author Contributions: Conceptualization, methodology, writing—original draft preparation I.P.; validation, formal analysis, resources, data curation M.F.R.; writing—review and editing, visualization, supervision, M.N.A.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Universitas Muhammadiyah Surakarta grant number PID-2097–2022 and the APC was funded by Universitas Muhammadiyah Surakarta.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of Universitas Muhammadiyah Surakarta.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to the presence of personal information.

Conflicts of Interest: The authors declare no conflict of interest.

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