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# Evaluation of the environmental impact of material selection and design in the hanger press machine manufacturing process

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**Abstract**

This study evaluates the material selection and environmental impact in the manufacturing process of hanger press machine. Using the Life Cycle Assessment (LCA) tool eco-indicator to evaluate the environmental impact of producing clothes-hanging machines. Two different press tool designs were analyzed, each using other materials for punch and die. The results indicated that the press tool design 2 with SKD11 punch and die was suitable for long-term use but emitted the highest $CO_2$ emissions at 102.33 kg $CO_2$. In contrast, the press tool design 1 with S45C punch and die was suitable for short-term use but emits the lowest $CO_2$ emissions at 69.72 kg $CO_2$. The results indicates that press tool design 1 with S45C for products requiring elbow angles and temporary service life, while design 2 with SKD11 is optimal for longer-lasting products with elbow angles.

**Keywords:**
Material, design, press tool, sustainable manufacturing.

## 1 Introduction

The selection of materials used during the manufacturing process and the design used also affect the environment. This is because the production of products consumes energy and produces waste, including carbon dioxide, which negatively impacts the environment. Products resulting from machining processes, such as press tools, can use sustainable manufacturing processes.

Presses, also known as presses, are essential in the metal making process, especially in the efficient and high-quality production of large quantities of products [1]. It is equipped with punch and die parts for various purposes, such as in the bending process [2]. The design of the press machine is tailored to specific requirements, such as forming plates with a thickness of three millimeters or bending with lines of up to 300 millimeters [3] [4].

Clothes hangers are an example of a press tool product. In sustainable manufacturing, the issue of the influence of material selection and design on the environment is very complex. The use of ST 37 and ST 42 materials in press parts can have different environmental effects [5]. As seen in the use of stainless steel and iron in the production of exhaust pipes, Life Cycle Assessments (LCAs) are essential for evaluating the environmental impact of production activities and material selection [6]. In the design of press tools, use composite materials, which have environmental benefits such as lower density and easier formability [7]. Sustainable manufacturing practices such as lightweight and green manufacturing are essential in the textile industry. They can be applied to the production of press equipment for clothes hangers because they can reduce waste and become a more sustainable production process [8].

In the manufacturing industry, several studies have studied the use of sustainable press equipment. The study covers potential technologies for wood-based forming tools and key technologies for sustainable machine tool design [9], [10]. Environmental design principles and tools such as life cycle evaluation and design for the environment are essential for sustainable production [11]. In this discussion, we will assess the sustainability of advanced machining technologies such as cryogenic machining and fluid delivery for high-pressure pulse metal working. Sustainable press tools can help improve sustainability in the manufacturing industry and reduce their environmental impact. These studies collectively underscore this potential [12].

Studies have investigated the use of LCA in a variety of design contexts, such as the development of LCA tools for the initial design stages, which focuses on train modernization and foundations of building design and discusses important parts of press tools, including design considerations and material selection [13], [14], [15]. These studies collectively underscore the importance of LCA in design and its possible integration into various tools and processes; they also highlight the need to make a difference based on LCA expertise and data entry responsibilities [15].

For the manufacturing industry, LCA is an important tool, especially for circular business models [16]. As shown in the process of making plywood in China, this helps to identify environmental impacts and hotspots [17]. These studies collectively highlight the importance of LCA in evaluating and improving the environmental sustainability of manufacturing processes, as well as in assessing the impact of additive manufacturing on the environment [18], [19].

The impact of selected and designed materials on the environment during the manufacturing process has been studied in several studies. In sustainable construction, the use of recyclable and innovative materials, along with local skills, is essential. The method for selecting these materials is based on the product's environmental impact, cost, and quality [20], [21], [22], [23], [24]. Combining manufacturing processes and material selection with suppliers to reduce costs and environmental impact [25]. Additive manufacturing can save material and energy resources, increasing its environmental impact. These studies collectively underscore how important it is to use a holistic approach when selecting and designing materials with consideration of environmental impact, cost, and product quality [26].

The author wants to research how the design and material approaches in the manufacturing process of press tools for clothing hanging products have an impact on the environment. Because there has been no previous research on the impact of material selection and design of the press tool manufacturing process on the environment during the sustainable manufacturing process.

## 2 Research Methods

This study uses press tool designs with differences in material and function. The determination of these materials and functions is based on the expected shape of the final product. The process of collecting design data uses 3d design software.

This product is made of steel material measuring 2 × 20 × 200 with a radius of 10 mm at each end, as shown in Fig. 1.

Fig. 2 shows how this product is implemented. The elbow side is hung at the end of the door and used as a hanger for clothes and other light items. The radius at the end of the product helps the user avoid injury from sharp metals.

This study uses the LCA method. LCA is a method used to measure the environmental impact of a product or process, from the extraction of raw materials to disposal. It involves four stages:

objectives and scope, lifecycle inventory, lifecycle impact assessment, and interpretation [27]. The simplest LCA tool available on the market today is eco-it. The eco-it or eco-indicator tool is a simple tool for eco-design tool. The eco-indicator methodology includes [28]:

1. Calculating the impact of LCA on human health, ecosystem quality, and resources
2. To consider these three types of damage, the damage is calculated through a complex process that includes modeling and transportation, exposure, and consequences on a European or global scale.
3. Simulating the impact of land use on species diversity and calculating resource loss as the "surplus energy" required for extraction.

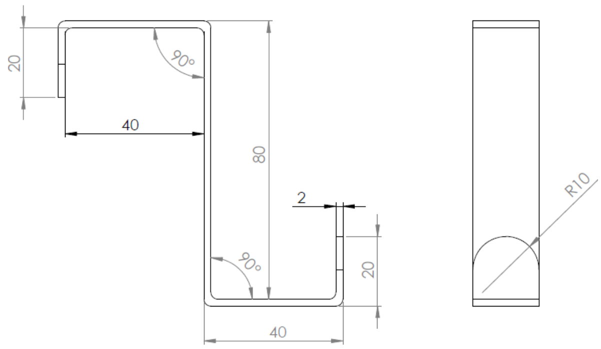



Fig. 1. End products of clothes hangers.


Fig. 2. Product implementation.

## 3 Results and Discussion

This study uses two press tool designs. The design, structure, and function of each press tool are different.

The design of press tool 1, shown in Fig. 3, has dimensions of 185 × 404 × 420 and a total volume of 8.82 × 106 mm$^3$, with a maximum weight of 68.06 kg.

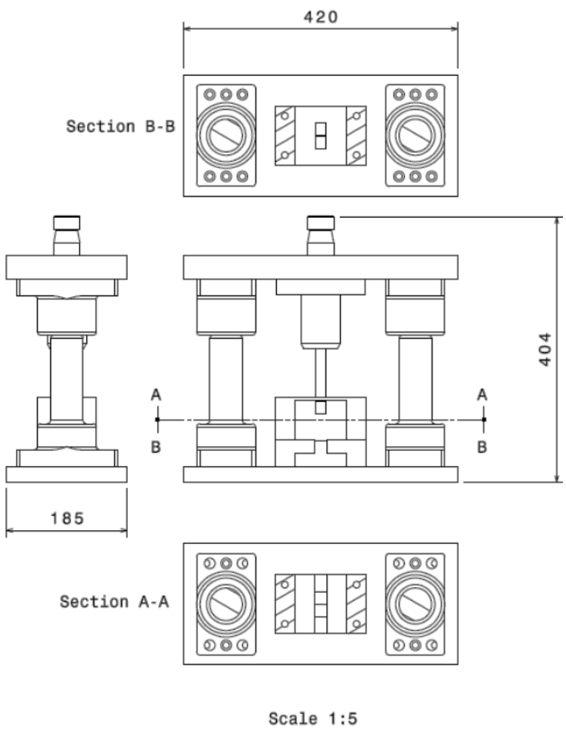



Fig. 3. Press tool design 1.

The design of press tool 2, shown in Fig. 4, has dimensions of 176 × 386 × 343, a total volume of 8,198 × 106 mm$^3$, and a maximum weight of 52.39 kg.

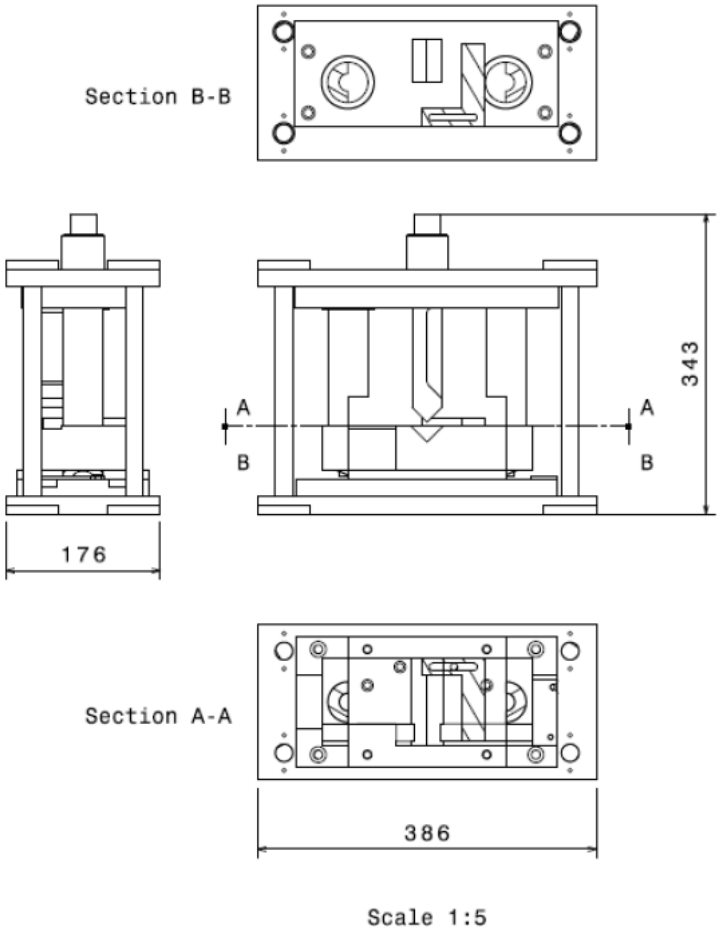



Fig. 4. Press tool design 2.

A shank, pillar guide, guide bush, top plate, punch holder, punch bending, stripper bending, die holder, die bending, and bottom plate are among the parts of printing machine 1's design, as seen in Fig. 5.

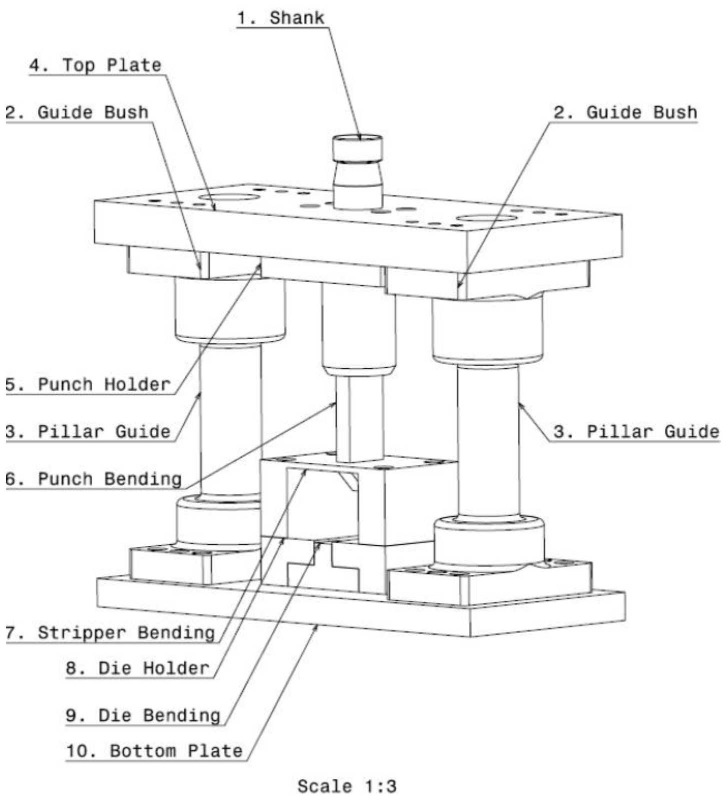
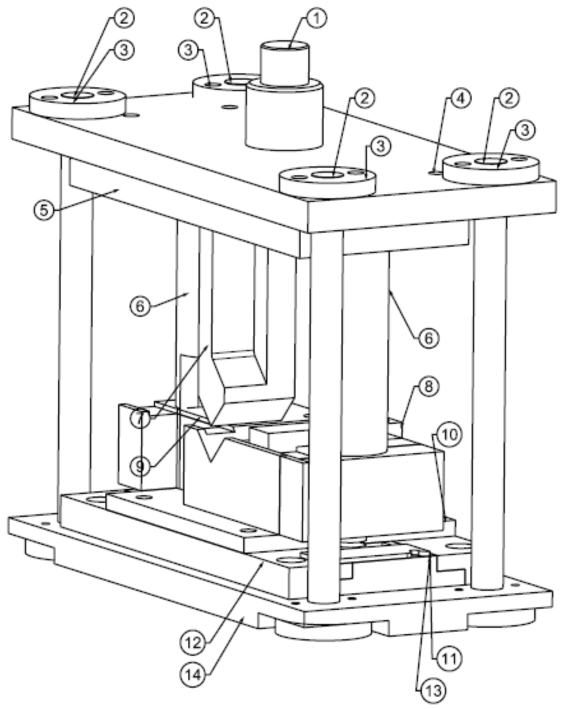



Fig. 5. Components of press tool design 1.

As seen in Fig. 6, the design elements of press tool 2 are much the same; however, punch blanking and die blanking are new additions. The blanking die serves as the foundation for the blanking process, while the blanking punch cuts the plate to create a radius at the end of the plate. Punch blanking, punch bending, die bending, and die blanking are the key elements of this design, as illustrated in Fig. 5 and Fig. 6. Materials like S45C and SKD11 are frequently utilized for this crucial part. SKD11 is superior to S45C for long-term use because to its increased hardness. [29]. into an elbow but is unable to produce a radius like design 2, which is crucial to avoiding scrapes that could cause harm [30].

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|---|---|---|---|---|---|---|---|---|
| | | 1 | | 14 | Bottom Plate | St 37 | 22x178x388 | A3-03 |
| | | 1 | | 13 | Die Blanking | S45C | 22x102x300 | A3-02 |
| | | 1 | | 12 | Holder Die Blanking | St 37 | 22x47x300 | A3-05 |
| | | 1 | | 11 | Stopper Blanking | St 37 | 3x33x77 | A4-09 |
| | | 1 | | 10 | Stripper Blanking | St 37 | 12x152x202 | A4-08 |
| | | 1 | | 9 | Die Bending | S45C | 52x102x242 | A3-04 |
| | | 1 | | 8 | Stopper Bending | St 37 | 15x73x97 | A4-07 |
| | | 1 | | 7 | Punch Bending | S45C | 52x52x157 | A4-06 |
| | | 2 | | 6 | Punch Blanking | S45C | Φ27x217 | A4-05 |
| | | 1 | | 5 | Punch Holder | St 37 | 26x122x302 | A4-04 |
| | | 1 | | 4 | Top Plate | St 37 | 22x178x388 | A3-01 |
| | | 4 | | 3 | Guide Bush | As Brass | Φ62x32 | A4-03 |
| | | 4 | | 2 | Pillar Guide | St 37 | Φ62x292 | A4-02 |
| | | 1 | | 1 | Shank | St 37 | Φ50x82 | A4-01 |

Fig. 6. Components of the press tool design 2.

Table 1 indicates that ordering time, energy consumption, and $CO_2$ emissions all increased when ordering time declined. Fig. 5 and Fig. 6 illustrate the relationship between material utilization and component quantity.

Table 1. Comparison of the total impact of each phase

| Press tool | Machining time (min) | Energy consumption (kWh) | Mass (kg) | $CO_2$ emission (kg $CO_2$) |
|---|---|---|---|---|
| Press tool 1 design with S45C punch and die material | 18.59 | 139.44 | 68.06 | 69.72 |
| Press tool 1 design with SKD11 punch and die material | 20.02 | 150.13 | 67.98 | 75.06 |
| Press tool 2 design with S45C punch and die material | 23.69 | 177.66 | 52.39 | 88.83 |
| Press tool 2 design with SKD11 punch and die material | 27.29 | 204.67 | 52.05 | 102.33 |

According to Fig. 7, the press tool 1 design with punch and die material S45C has a machining time of 18.59 minutes, a mass of 68.06 kg, a $CO_2$ emission of 69.72 kg, and an energy consumption of 139.44 kWh. Press tool 2 with punch and die material SKD11 has a machining time of 20.02 minutes, 150.13 kWh of energy consumption, 67.98 kg of mass, and 69.72 kg of $CO_2$ emissions, weighs 52.05 kg, takes 27.29 minutes to machine, uses 204.67 kWh of energy, and emits 102.33 kg of $CO_2$.

When compared to other designs, the press tool 2 design with SKD11 punch and die material has the lightest mass, the largest energy consumption, and the highest $CO_2$ emissions. It also has the longest machining time.

This is due to the greater number of components used to meet the capacity requirements of the garment hanger product manufacturing process. In addition, the use of SKD11 material, which is usually lighter than S45C material but is quite strong, which is indicated by its length: on the contrary, press tool 1 design with S45C punch and die material has faster machining time, lowest energy consumption, heaviest mass, and lowest $CO_2$ emissions. It is suitable for short-term use with a smaller risk of environmental pollution, but it is still not enough to fulfill the function of the product.

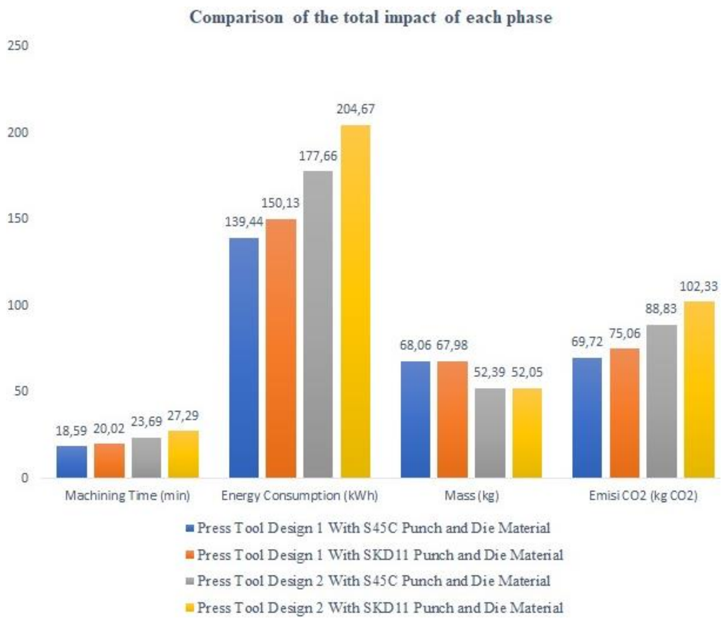


Fig. 7. Comparison of the total impact of each phase.

## 4 Conclusion

Evaluation of the environmental impact of the materials selected and design selection during the process of making a hanger press machine are concluded as:

1. Press tool design 1, using S45C for the punch and die, had the fastest machining time, lowest energy consumption, and lowest $CO_2$ emissions, but does not meet product capability requirements if the angle is not an elbow. In contrast, press tool design 2, made from SKD11, is suitable for long-term use, meets product capability requirements, has the lightest mass, and the longest machining time.
2. The study showed that press tool 1 (C45C) was better for products with elbow angles and temporary service life, meanwhile press tool 1 (SKD11) was better for products with elbow angles and longer service life.
3. The result showed that press tool 2 (C45C) was for products with a certain radius and temporary service life, meanwhile press tool 2 (SKD11) was for products with a certain radius and longer service life.
4. The findings may assist consumers in selecting the appropriate press tool based on their needs and environmental considerations.

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