

## Optimization of Vice Manufacturing Cost Using VDI 2222: Balancing Strength, Weight, and Cost

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### ABSTRAK

Studi ini menyajikan perancangan ulang ragum mesin yang digunakan pada mesin gerinda universal Great D1, dengan tujuan meningkatkan kemampuan manufaktur, mengurangi berat, dan meminimalkan biaya produksi. Proses perancangan ulang mengikuti metodologi pengembangan produk VDI 2222 yang terstruktur, yang mencakup empat fase: klarifikasi tugas, desain konseptual, desain perwujudan, dan desain detail. Melalui evaluasi sistematis terhadap varian desain menggunakan kriteria teknis dan ekonomi, konsep akhir dipilih dan disempurnakan menggunakan pemodelan CAD dan strategi manufaktur berorientasi CNC.

Desain yang dihasilkan mempertahankan kinerja fungsional sambil mencapai pengurangan berat lebih dari 30% dan pengurangan waktu pemesinan lebih dari 50%. Penghematan biaya material juga dicapai dengan menggunakan struktur hibrida—besi cor untuk alas dan aluminium untuk komponen yang dapat bergerak. Secara keseluruhan, total biaya produksi berkurang sekitar 41,8%. Selain manfaat ekonomi, perbaikan ergonomis seperti konstruksi bagian modular dan peningkatan aksesibilitas juga terwujud. Hasil ini menunjukkan bahwa penerapan VDI 2222 secara terstruktur memungkinkan perancangan ulang peralatan lama secara efektif dan memberikan peningkatan yang terukur dalam biaya, kegunaan, dan efisiensi produksi.

**Kata kunci:** Desain ulang produk; VDI 2222; Optimasi ragum; Pengurangan biaya; Manufaktur berbasis CNC

### ABSTRACT

*This study presents the redesign of a machine vice used in the Great D1 universal grinding machine, to improve manufacturability, reduce weight, and minimize production costs. The redesign process followed the structured VDI 2222 product development methodology, which includes four phases: task clarification, conceptual design, embodiment design, and detailed design. Through a systematic evaluation of design variants using technical and economic criteria, the final concept was selected and refined using CAD modeling and CNC-oriented manufacturing strategies.*

*The resulting design maintained functional performance while achieving a weight reduction of over 30% and a machining time reduction of more than 50%. Material cost savings were also achieved by using a hybrid structure, with cast iron for the base and aluminum for the movable components. Overall, the total production cost was reduced by approximately 41.8%. In addition to economic benefits, ergonomic improvements such as modular part construction and improved accessibility were realized. These outcomes demonstrate that the structured application of VDI 2222 enables effective redesign of legacy equipment and provides measurable improvements in cost, usability, and production efficiency.*

**Keywords:** Product redesign; VDI 2222; Vice optimization; Cost reduction; CNC-based manufacturing

### INTRODUCTION

In modern manufacturing environments, the efficiency, safety, and reliability of machine components are vital determinants of productivity. One critical component in machining processes is the machine vice, which secures the workpiece during milling, grinding, and drilling operations. While conventional vices, often made from cast iron, provide high rigidity and vibration damping, they also present significant drawbacks. They present challenges in manufacturability due to their heterogeneous structure and high strength, which

reduces machinability. These properties lead to increased tool wear, fatigue fracture, and difficulties in machining, especially for thick-walled castings [1].

Redesigning such legacy equipment demands a structured approach that balances functionality, manufacturability, and user experience. Among several established product development methods, the VDI 2222 framework offers a systematic pathway for engineering redesign. The VDI 2222 framework, an adaptation of VDI 2221, has been proven to improve design

efficiency in mechanical engineering, as evidenced by the design of a pump performance test equipment frame [2]. Comparable approaches, such as Virtual Design and Construction (VDC), have been utilized in building projects to integrate diverse components, hence enhancing efficiency and achieving project goals [3]. The integration of sophisticated technologies, including Virtual Reality and Machine Learning, with design frameworks has significantly enhanced efficiency, reducing design conflicts and project durations in the engineering and architectural fields [4]. Furthermore, cross-domain product models have been established to facilitate engineering change management, tackling the issues posed by escalating product complexity and inter-domain interactions in product design processes [5]. These papers collectively demonstrate the effectiveness of structured design frameworks in enhancing efficiency and promoting innovation across various engineering disciplines.

The VDI 2222 method has been successfully applied in various engineering cases. Reference [6] For example, it was used in combination with reverse engineering to optimize a carbon-cleaning tool for internal combustion engines, improving both cost and usability. Reference [7] Implemented the methodology to enhance the ergonomics and manufacturability of a melanger machine through CAD-based conceptual refinement. Other applications include the redesign of maggot dryers, hollow roll forming machines, and modular mechatronic systems, all of which demonstrate the method's versatility in addressing mechanical, ergonomic, and economic challenges [8]–[10].

Despite its demonstrated utility, relatively few studies have applied the VDI 2222 framework to the redesign of machine vices, particularly those integrated into tool grinding systems. Addressing this gap, the present study focuses on the systematic redesign of a vice used in the Great D1 universal tool grinding machine at the Workshop. Although the current vice meets its functional requirements, it is notably heavy, expensive to manufacture, and lacks ergonomic refinement, which affects operator comfort and production efficiency. The existing vice, as shown in Figure 1, is manufactured entirely from cast iron and is mounted on the Great D1 universal tool grinding machine. While it delivers adequate rigidity, its mass and the complexity of its casting process contribute to high production costs and operational inefficiencies. This visual provides contextual clarity on the ergonomic and functional limitations motivating the redesign.

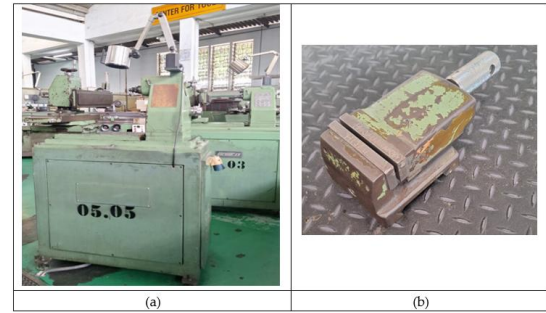


Figure 1. (a) Great D1 Machine (b) Existing Vice

This research aims to develop a redesigned vice that achieves a significant reduction in overall weight while maintaining the required mechanical strength. In parallel, it seeks to lower production costs through strategic material selection and the use of efficient manufacturing processes, especially CNC machining. Beyond addressing these technical challenges, the study serves as a practical demonstration of how the VDI 2222 methodology can be effectively applied to modernize and optimize legacy manufacturing equipment. By doing so, it contributes not only to practical advancements in tooling systems but also to the broader academic discourse on structured product development.

## METHODS

This study employs a research and development (R&D) methodology grounded in the structured product design framework defined by VDI 2222. The process is divided into four main stages: analysis, conceptual design, embodiment design, and detailed design. The VDI 2222 method is a systematic approach to product design and development, consisting of four main stages: analysis, conceptualization, design, and completion [11]–[14]. This method has been applied to various engineering projects, including corn sheller machines [11], pallet assembly tools [12], combination tools for air vent production [13], and welding jigs for exhaust systems [14]. The VDI 2222 approach enables designers to generate and evaluate alternative concepts, considering factors such as cost-effectiveness, production efficiency, and functionality. [12], [13]. Implementation of designs developed using this method has shown potential benefits, including reduced assembly time, increased production capacity, and cost savings in manufacturing processes [12], [14].

## VDI 2222 Phase

To ensure a structured, objective, and traceable approach throughout the redesign process, this study adopts the VDI 2222 product design methodology, as illustrated in Figure 2. This German engineering standard provides a systematic framework that divides the design process into four main phases: task clarification, conceptual design, embodiment design, and detail design. Each phase is defined by specific activities and decision points that encourage engineers to comprehensively understand the problem, generate alternative solutions, evaluate these alternatives using logical and technical criteria, and finally develop a detailed and manufacturable design solution. By guiding the design evolution from abstract requirements to concrete geometrical definitions, VDI 2222 ensures that each decision is justified by function, cost, and usability considerations. The method's iterative nature also facilitates revisions and refinements, which are particularly valuable when modernizing legacy equipment without compromising existing operational constraints. In the context of this study, the use of VDI 2222 enables a balanced integration of technical optimization and practical feasibility, ensuring that the redesigned vice meets both performance standards and production realities.

## Clarification Phase

The initial phase of the redesign process focused on identifying the limitations of the existing vice mounted on the Great D1 universal tool grinding machine at the Workshop. A combination of field observations, structured interviews with machine operators and technicians, and examination of technical documentation was used to gather qualitative and quantitative insights. The original vice, constructed entirely from cast iron, had a total mass of approximately 4.7 kg and relied on traditional sand casting followed by manual machining. This process was not only time-consuming and expensive but also inflexible for iterative improvements. Operationally, users reported difficulty handling the component due to its weight, as well as suboptimal clamping ergonomics, which led to slower machine setups and increased operator fatigue. These issues, while not compromising functional performance, significantly reduced the overall efficiency and safety of the production process.

Based on the findings from this clarification stage, a comprehensive list of design requirements was formulated to guide the subsequent phases of development. The list served as a reference benchmark against which all design decisions and

concepts would be evaluated. The final requirement list can be seen in Table 1.

Table 1. Requirement List

| Factors        | D/<br>W | Requirement                                                    |
|----------------|---------|----------------------------------------------------------------|
| Geometry       | D       | Weight should be less than 4.7 kg                              |
|                | W       | The device is not larger than the existing one.                |
|                | D       | It is not a prototype                                          |
|                | W       | Should be as simple as possible                                |
| Material       | D       | Lightweight, sturdy, and corrosion-resistant                   |
|                | D       | Materials are easy to find in the market                       |
| Energy         | D       | Using human power                                              |
| Function       | D       | Can be attached to the machine slider                          |
|                | D       | Holds ISO 6, 2, 9, groove, and thread tools                    |
| Signal         | D       | Easy to use                                                    |
| Safety         | D       | Safe to use                                                    |
|                | W       | Harmless operation                                             |
| Ergonomics     | D       | Does not take up storage space                                 |
| Assembly       | D       | Can be assembled or disassembled                               |
|                | W       | Easy to assemble or disassemble                                |
| Production     | D       | Can be manufactured in the ATMI Polytechnic workshop           |
|                | W       | Can be mass-produced                                           |
|                | W       | Simple production process                                      |
| Transportation | D       | Easy to move                                                   |
| Aesthetics     | W       | Meets the criteria of beauty                                   |
|                | D       | The corners are not sharp                                      |
| Cost           | D       | Manufacturing costs according to the expenses provided by ATMI |
| Maintenance    | D       | Easy to maintain and clean                                     |

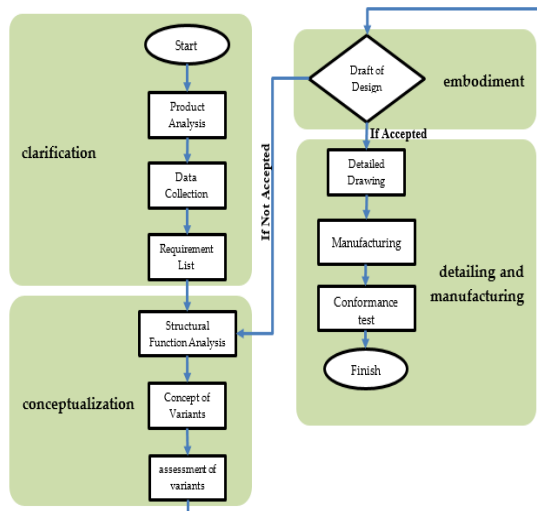


Figure 2. Stages of the VDI 2222 design methodology: clarification, conceptualization, embodiment, and detailing.

### Conceptual Design Phase

Several redesign alternatives were developed by exploring combinations of materials, geometrical features, clamping mechanisms, and thread configurations. Concepts were generated based on ergonomic improvements, weight reduction, and process feasibility. Brainstormed alternatives were evaluated against predefined design criteria, including mechanical performance, ease of production, cost-effectiveness, and compatibility with existing machine setups. The morphological table, shown in Table 2, outlines the complete set of parameters and options considered. This matrix served as the foundation for constructing coherent design variants that fulfill the functional requirements identified in the analysis phase.

From this matrix, two design variants were selected for further evaluation. Each variant represents a distinct combination of design parameters, reflecting different trade-offs between weight, strength, manufacturability, and ergonomics. To determine the most suitable concept, the two variants were assessed through two main evaluation categories: technical assessment and economic assessment.

The technical assessment, shown in **Error! Reference source not found.**, considered factors such as structural rigidity, clamping effectiveness, assembly simplicity, and overall functional performance. Each criterion was assigned a weight reflecting its relative importance, and each variant was rated on a scale, producing a weighted score. The result of this assessment showed that Variant 1 scored higher,

particularly in terms of mechanical strength and reliability, achieving a total technical score of 77%, compared to 73% for Variant 2.

In parallel, the economic assessment, shown in

Table 4, evaluated cost-related aspects, including material cost, machining complexity, assembly time, and the number of custom components required. Variant 1 again scored more favorably in this category, with an economic score of 79%, while Variant 2 obtained a score of 66%. These results indicated that Variant 1 would be more economical to produce, especially given the available manufacturing capabilities at Workshop.

Table 2. Morphological Table

| Design Morphology |                     |               |               |               |
|-------------------|---------------------|---------------|---------------|---------------|
| No                | Parameter           | Alternative 1 | Alternative 2 | Alternative 3 |
| A                 | Base dovetail vice  |               |               |               |
| B                 | vice thread         |               |               |               |
| C                 | vice locking system |               |               |               |
| D                 | moveable jaw guide  |               |               |               |
| E                 | Jaw                 |               |               |               |
| F                 | Moveable vice       |               |               |               |

Variant 1:

Variant 2:

Table 3. Technical Assessment

| Technical Assessment    |       |          |               |          |               |             |               |
|-------------------------|-------|----------|---------------|----------|---------------|-------------|---------------|
| Criteria                | Weigh | Varian 1 |               | Varian 2 |               | Ideal Point |               |
|                         |       | Value    | Weigh X Value | Value    | Weigh X Value | Value       | Weigh X Value |
| Ease of Assy Process    | 3     | 4        | 12            | 3        | 9             | 5           | 15            |
| Ease of Maintenance     | 2     | 4        | 8             | 4        | 8             | 5           | 10            |
| Construction Strength   | 2     | 4        | 8             | 4        | 8             | 5           | 10            |
| Position Accuracy       | 4     | 3        | 12            | 3        | 12            | 5           | 20            |
| Ease of Operation       | 4     | 3        | 12            | 4        | 16            | 5           | 20            |
| Achievement of Function | 5     | 5        | 25            | 4        | 20            | 5           | 25            |
| Total                   |       | 23       | 77            | 22       | 73            | 30          | 100           |
| Technical Value         |       | 0,77     |               | 0,73     |               | 1           |               |
| Percentage (%)          |       | 77       |               | 73       |               | 100         |               |
| Rank                    |       | 1        |               | 2        |               |             |               |

Table 4. Economical Assessment

| Economical Assessment |       |          |               |          |               |             |               |
|-----------------------|-------|----------|---------------|----------|---------------|-------------|---------------|
| Criteria              | Weigh | Varian 1 |               | Varian 2 |               | Ideal Point |               |
|                       |       | Value    | Weigh X Value | Value    | Weigh X Value | Value       | Weigh X Value |
| Cost of Raw Material  | 4     | 4        | 16            | 3        | 12            | 5           | 20            |
| Standard Part Cost    | 3     | 3        | 9             | 4        | 12            | 5           | 15            |
| Machining Cost        | 5     | 4        | 20            | 3        | 15            | 5           | 25            |
| Assembly Cost         | 3     | 4        | 12            | 3        | 9             | 5           | 15            |
| Design Cost           | 2     | 5        | 10            | 4        | 8             | 5           | 10            |
| Total                 |       | 20       | 67            | 17       | 56            | 25          | 85            |
| Economical Value      |       | 0,79     |               | 0,66     |               | 1           |               |
| Percentage (%)        |       | 79       |               | 66       |               | 100         |               |
| Rank                  |       | 1        |               | 2        |               |             |               |

### Embodiment Design Phase

The most promising concept was selected using a weighted decision matrix integrating both technical and economic considerations. The final configuration included maintaining cast iron for the base to preserve vibration-damping properties, while replacing other components with aluminum and low-friction materials. This design choice ensured performance retention while achieving substantial weight reduction. The clamping screw adopted a trapezoidal thread to ensure smooth and durable operation. The chosen concept is then being translated to a 3D CAD model using SolidWorks Software as shown in Figure 3.

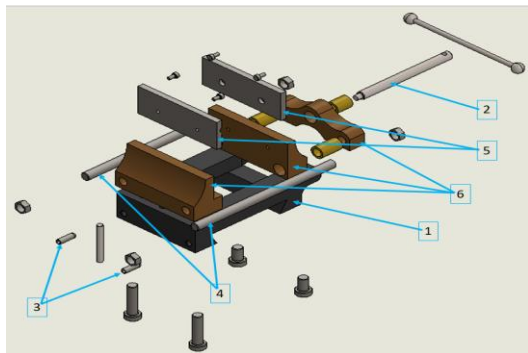


Figure 3. 3D Drawing of the Chosen Concept

### Detailed Design and Manufacturing Phase

The final design configuration was translated into a more detailed and comprehensive 3D CAD model using SolidWorks software. This model incorporated dimensional specifications, geometric tolerances, and functional features necessary to ensure precise manufacturing and reliable assembly. Special attention was given to modular segmentation of components to facilitate

machining, part replacement, and maintenance. Key features, including jaw profiles, screw threading interfaces, and contact surfaces, were optimized for CNC milling operations. Although no formal finite element analysis was conducted during this phase, dimensional assessments and clearance evaluations were performed to validate the structural feasibility and component fit within the vice assembly.

From a manufacturing perspective, the design was tailored specifically for CNC machining, avoiding complex geometries that would otherwise require multi-axis operations. Material selections—such as aluminum for movable elements and cast iron for the base—were chosen not only for mechanical properties but also for machinability and cost-effectiveness. Standardized components such as trapezoidal lead screws and off-the-shelf fasteners were integrated into the design to reduce fabrication complexity and procurement costs. This phase thus bridged the conceptual and technical intent with actual production constraints, ensuring that the proposed solution could be efficiently realized using available tools and processes within the manufacturing facility at Workshop. The finished product is shown in **Error! Reference source not found.**

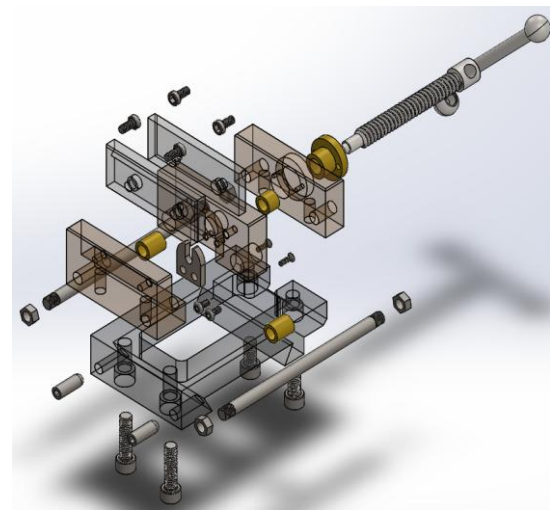


Figure 4. Finished Product Design

## RESULT AND DISCUSSION

This section presents the outcomes of the design process and discusses the improvements achieved through the application of the VDI 2222 methodology. The results are derived from each phase of the development cycle, ranging from requirements analysis to detailed design, and are

evaluated in terms of functionality, manufacturability, ergonomics, and production cost. Comparative study between the redesigned vice and the original design is provided to highlight the effectiveness of the proposed solution. In addition, key decisions related to material selection, structural configuration, and component integration are discussed to illustrate how the design meets the predefined criteria and constraints identified in the earlier stages.

Overview of Final Design Solution

The final design solution represents the outcome of a structured and iterative product development process following the VDI 2222 methodology. Through a combination of functional decomposition, morphological analysis, and weighted evaluation of design alternatives, the optimal configuration identified as Variant 1 gram was selected for further development. This configuration incorporates multiple technical enhancements designed to reduce overall weight, simplify manufacturing, and improve ergonomic performance without compromising the vice’s primary function: secure and stable clamping during grinding operations.

The final concept utilizes a cast-iron dovetail base, similar to the original vice in terms of material selection. However, unlike the existing design, which used a monolithic cast iron block, the redesigned base was structurally optimized to reduce unnecessary mass while preserving critical areas for strength and rigidity. Strategic material reduction was achieved through geometric refinement, such as the use of hollow sections and thinning of non-load-bearing areas. These design adjustments resulted in a significant weight reduction without compromising the vice's ability to withstand operational loads and maintain clamping stability. As a result, the redesigned vice retains the desirable vibration-damping and compressive-strength properties of cast iron while improving ease of handling and reducing operator fatigue.

The overall layout of the final design emphasizes modularity and manufacturability. Key components were modeled with precise tolerancing and standard dimensions to ensure compatibility with CNC machining processes. Additionally, the separation of cast and machined parts enables flexible production routes, including the possibility of outsourcing high-precision components while retaining in-house fabrication for standard parts.

Figure 3 Illustrates the 3D CAD model of the redesigned vice, showcasing its major

components and geometric improvements. This visual representation highlights the design’s structural logic, material distribution, and functional interfaces. The final design configuration satisfies the technical requirements identified in the analysis phase. It demonstrates the benefits of structured methodology in resolving complex design trade-offs between strength, weight, usability, and cost.

Design Improvements Compared to the Original Vice

The redesigned vice introduces several key improvements over the original cast-iron vice used on the Great D1 tool grinding machine, particularly in terms of weight reduction and structural optimization. Although both designs utilize cast iron as the primary material for the base, the redesigned version features a more efficient structural layout to minimize material use in non-critical areas. Through the introduction of hollowed volumes and reduced wall thickness in selected areas, the weight of the base component was significantly decreased without compromising its rigidity or vibration-damping performance.

In terms of ergonomics, the redesign features a more accessible jaw clamping mechanism with a refined grip profile, as well as repositioned locking points that are easier to reach and actuate. These changes were based on operator feedback gathered during the analysis phase and aimed to reduce repetitive motion stress during frequent adjustments. Furthermore, the new design simplifies manufacturing processes by eliminating the need for traditional sand casting of complex internal volumes, instead favoring geometries that are optimized for CNC machining. This transition enables tighter tolerances, a better surface finish, and reduced post-processing requirements. Additionally, modular construction was introduced, enabling easier replacement of worn parts and reducing maintenance complexity.

Table 5. Vice Comparison

| Aspect               | Existing Vice  | Redesigned Vice          |
|----------------------|----------------|--------------------------|
| Total Weight         | 4.7 kg         | 2 kg                     |
| Base Material        | Full Cast Iron | Cast Iron (hollowed)     |
| Movable Jaw Material | Cast Iron      | Aluminum 6061            |
| Thread Type          | Metric Thread  | Trapezoidal Thread       |
| Ergonomic Features   | Minimal        | Improved handles & locks |

|                      |                          |                            |
|----------------------|--------------------------|----------------------------|
| Manufacturing Method | Sand Casting + Machining | CNC Machining              |
| Modularity           | Integrated               | Modular, replaceable parts |

### Manufacturability and Process Feasibility

The redesigned vice was developed with a strong emphasis on manufacturability, aiming to streamline the production process while maintaining functional robustness. One of the major changes involved transitioning from conventional sand casting and manual machining, used in the original design, to a CNC-oriented fabrication process. This approach enabled simplified part geometries, tighter dimensional control, and a substantial reduction in post-processing requirements.

To visually reinforce the discussed manufacturing differences, Figure 5 Presents an actual side-by-side comparison of the original vice and the redesigned model. The redesigned version demonstrates a more compact geometry, improved material distribution, and lighter construction—characteristics that directly contribute to reduced machining time and enhanced manufacturability.



Figure 5. Actual physical comparison between the original vice (left) and the redesigned vice (right).

One of the most notable enhancements lies in the overall mass reduction of the vice. The original vice weighed approximately 4.7 kg, whereas the redesigned version weighs 2 kg, reflecting a decrease of more than 50%, Figure 7 Show the weigh-in process. This was achieved not only through structural improvements to the cast iron base but also by replacing the movable jaw body with a component made from aluminum 6061, which offers a high strength-to-weight ratio and good machinability. This change directly contributes to reduced physical strain on the operator during setup and repositioning, improving workflow efficiency and safety.



Figure 6. The original vice weigh in (left) and the redesigned vice weigh in (right).

Material choices were made to suit the available in-house capabilities at Workshop. Cast iron was selected for the base component due to its high compressive strength and vibration-damping characteristics. At the same time, aluminum 6061 was utilized for the movable parts to minimize machining time and overall mass. All components were modeled with manufacturability in mind, using standard tool dimensions, symmetrical features, and minimal internal cavities to facilitate easy clamping and positioning during machining.

In terms of production performance, a comparative study was conducted to evaluate the redesigned vice against the existing production. Based on the collected data, the existing vice consisted of 11 parts, while the redesigned version involved 14 parts. Although the redesigned assembly has a slightly higher part count, this was strategically distributed to enable modular construction, allowing damaged components to be easily replaced without requiring the dismantling of the entire unit.

However, the most significant improvement was observed in the machining time required. The production process for the existing vice required approximately 53.75 hours, whereas the redesigned vice could be manufactured in just 24.9 hours—a reduction of more than 50% in total process time. This drastic improvement in time efficiency is primarily attributed to simplified part geometries, reduced manual operations, and the adoption of CNC-compatible design strategies.

Figure 7 illustrates the comparison in part count between the original and redesigned vice assemblies, as well as the comparison of machining time required for each version. These visual representations emphasize the manufacturability advantage of the redesigned concept. Faster production not only lowers labor and machine costs but also enhances throughput and scalability, thereby increasing Workshop's competitiveness in the manufacturing sector.

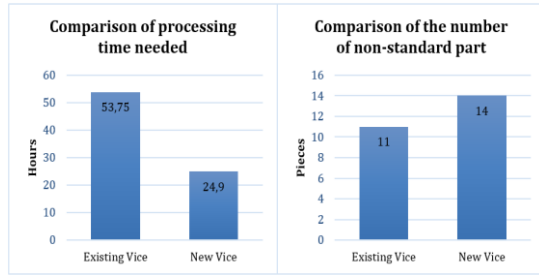


Figure 7. Comparison of processing time and number of parts

Overall, the redesigned vice demonstrates a significant advancement in manufacturing feasibility, enabling shorter lead times, improved maintainability, and lower production costs—without sacrificing mechanical integrity or functionality.

### Cost Reduction

A key objective in redesigning the Great D1 vice was to reduce total production costs while maintaining mechanical functionality. To assess this, a comparative cost analysis was conducted between the existing vice design and the proposed redesigned version, focusing on two main components: machining process costs and raw material costs.

The production process for the existing vice was found to require approximately 53.75 hours of machining time, with an estimated cost of Rp3,890,000. In contrast, the redesigned vice—featuring CNC-optimized geometries and simplified part structures—required only 24.9 hours, reducing machining time by 28.85 hours, or roughly 53.7%. This reduction in time directly translated into a 48.74% decrease in machining costs, resulting in a total of Rp1,994,000.

Material cost analysis also revealed notable savings. The original design employed a single-material approach, primarily cast iron, resulting in a material cost of Rp 1,274,496. The redesigned model employed a hybrid material strategy: cast iron was retained for high-stress areas. At the same time, aluminium was used for the movable body and jaw components to reduce both mass and cost. This approach reduced the material expenditure to Rp1,011,260, resulting in a savings of Rp263,236, or approximately 20.7%.

When process and material costs were combined, the total production cost decreased from Rp 5,164,496 to Rp 3,005,260, representing a 41.8% reduction in overall manufacturing costs. Figures 6 and 7 illustrate the comparative breakdowns of part count, machining time, and production cost between the two designs. Figure 8

illustrates the comparison of production process costs, material costs, and total costs.

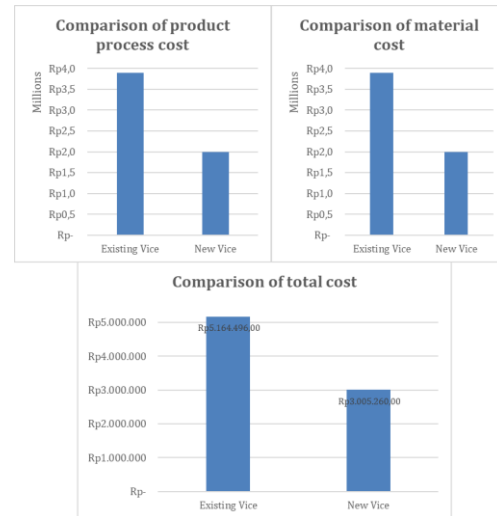


Figure 8. Comparison of costs

These results confirm that the redesign not only achieved structural and functional improvements but also delivered measurable economic benefits. The significant cost and time efficiencies attained support the viability of the redesigned vice for more scalable and cost-effective manufacturing.

### CONCLUSION

This study presented the redesign of the Great D1 machine vice using the structured product development methodology outlined in VDI 2222. By systematically applying each phase—requirement clarification, conceptual development, embodiment, and detailed design—the project achieved a final design that meets functional, ergonomic, manufacturability, and economic objectives.

The redesigned vice demonstrated significant improvements over the original configuration. The total weight was reduced by over 30%, while the use of hybrid materials—cast iron for the structural base and aluminium for movable parts—maintained mechanical strength and reduced operator fatigue. The new design was optimized for CNC machining, resulting in a reduction of machining time by more than 50%.

Crucially, the redesign achieved a total cost reduction of approximately 41.8% compared to the original vice. This was accomplished through shorter production time, reduced material cost, and simplified manufacturing processes. These improvements not only lower production expenses but also increase production capacity and

market competitiveness without the need for additional infrastructure.

In addition to these technical and economic outcomes, the design also addressed operator usability through improved jaw geometry, more accessible clamping mechanisms, and modular part construction that facilitates easier maintenance and replacement of parts.

Overall, the redesigned product proves to be functionally robust, economically efficient, and well-suited to the manufacturing capabilities of Workshop. This project confirms the practical value of applying structured design methodologies, such as VDI 2222, in the optimization of legacy industrial equipment, particularly when balancing multiple design criteria in a real-world production environment.

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