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Enhancing the performance of V Rossi wheels for motorcycles through finite element analysis using Solidworks

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Abtract: Enhancing motorcycle wheel performance has significant implications for rider stability, maneuverability, and comfort. In this context, finite element analysis has emerged as a crucial method for understanding and enhancing wheel performance. This study aims to delve into the potential of utilizing Solidworks to elevate the performance of V Rossi motorcycle wheels. By blending contemporary engineering principles with advanced simulation technology, the research presents a structural analysis and response of V Rossi wheels to various load conditions. Through innovative design and the integration of Solidworks Simulation, the study seeks to provide profound insights into the motorcycle industry. Solidworks proficiently calculates strain and stress on motorcycle wheel rims, facilitating numeric computation and streamlined design processes. Additionally, Solidworks adeptly handles scaling and meshing while accurately determining the strain and stress required for the wheel rims. The V Rossi wheels are ideally suited for contemporary usage with the ever-evolving modern landscape and the current millennial era.

Keywords : V Rossi wheel; Motorcycle; Finite element analysis; Solidworks; Wheel performance; Stress; Strain

1. Introduction

Within the motorcycle industry, the enhancement of wheel performance has emerged as a principal concern for manufacturers and engineers [1]–[3]. Wheels serve as the direct intermediary between the motorcycle and the road and play a critical role in the vehicle's stability, maneuverability, and the rider's comfort [4], [5]. With the advancement of technology and a deeper understanding of materials engineering and simulation, finite element analysis has evolved into an indispensable tool for comprehending and augmenting the performance of motorcycle wheels [6].

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Wheels are among the most crucial elements influencing the overall performance of a motorcycle [7], [8]. Wheel performance enhancements impact rider safety and influence riding comfort, maneuverability, and fuel efficiency [9], [10]. In this framework, finite element analysis has emerged as a significant instrument in designing and developing contemporary motorcycle wheels [11]. This method enables engineers to precisely model and forecast the structural response of wheels under diverse load conditions, encompassing bending stresses, torque forces, and lateral loads.

The V Rossi wheels, renowned for their exceptional quality and illustrious track record in racing events, present a compelling subject for investigation [12]. Enhancing the performance of V Rossi wheels promises a competitive edge in the racing domain. It holds potential applications in conventional motorcycles, enriching the riding experience for everyday users [13]. Solidworks emerges as a remarkably effective tool for conducting finite element analysis on wheel designs in this scenario. It provides an extensive suite of features and capabilities, enabling engineers to accurately model the wheel's complex geometry, simulate diverse loads and operational conditions, and precisely analyze structural responses [14], [15]. By incorporating Solidworks into the design process, manufacturers can achieve significant time and cost efficiencies while ensuring the superior quality and performance of the resulting wheels [16].

In this investigation, we aim to probe the capacity of Solidworks to enhance the performance of the V Rossi wheels for motorcycle applications. Our objective is to amalgamate cutting-edge engineering principles with leading-edge simulation solutions, aspiring to contribute to the motorcycle industry's evolution and enrich our understanding of wheel efficacy under diverse operational conditions. Our research into V Rossi wheels strives to forge designs that are visually captivating and robust, maintaining a minimalist aesthetic that aligns with the rapid dynamics of the current millennial era, thus positioning V Rossi wheels as an exemplary choice. We have formulated several research inquiries to steer the realization of these objectives.

1. How can employing finite element analysis through Solidworks enhance the V Rossi wheel's performance for motorcycles?
2. In what ways do the structural characteristics of the V Rossi wheels adapt in response to diverse loading conditions, such as sharp turns, high velocities, and resistance to wear?
3. How does integrating Solidworks Simulation into the V Rossi wheel design process expedite design iterations and optimize overall performance?

By addressing the research questions mentioned above, it is anticipated that profound insights will be gleaned, fulfilling the research objectives concerning the potential application of finite element analysis in augmenting the performance of V Rossi motorcycle wheels.

2. Methods

The wheel is a crucial vehicle component, serving as the driving force after the engine [17]. Consequently, it is imperative to have both aesthetically appealing and robust wheels while meeting standardized requirements. In this study focusing on the design of V Rossi wheels, Solidworks was employed to craft a 3D representation of the V Rossi wheels, alongside utilizing the Finite Element Analysis Method for their analysis [18], [19]. The framework of the wheels was constructed using Solidworks software due to its provision of many functions such as planar sketches, 3D sketches, 3D modeling, extrusion, and others. Dimensional drafts were created using Solidworks drafting tools.

2.1 Design of V Rossi alloy wheels

Solidworks serves as the primary tool in crafting the design of the V Rossi wheels, whether in two or three dimensions.

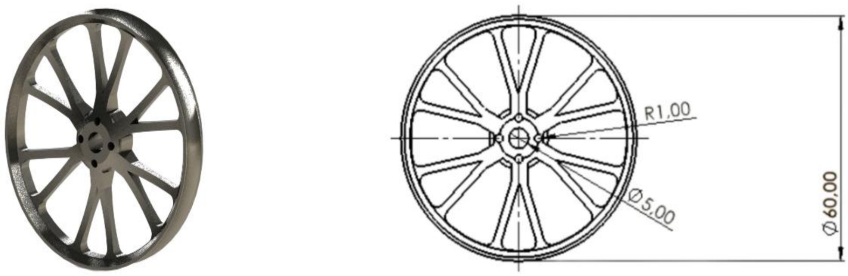


Figure 1: Model dari Velg V Rossi

2.2 Material specifications of V Rossi alloy wheels

The components employed in studying the V Rossi wheels, designed via Solidworks software, encompass two materials for comparative analysis: the 1060 Alloy and Alloy Steel [20]. These materials exhibit distinct mechanical properties, as delineated in Table 1.

Table 1: Material dari Velg V Rossi

Property	1060 Alloy	Alloy Steel	Units
Elastic Modulus	69000	210000	N/mm^2
Poisson's Ratio	0.33	0.28	N/A
Shear Modulus	27000	79000	N/mm^2
Mass Density	2700	7700	kg/m^3
Tensile Strength	68.9356	723.8256	N/mm^2
Yield Strength	27.5742	620.422	N/mm^2
Thermal Expansion	2.4e-05	1.3e-05	/K
Thermal Conductivity	200	50	W/(m · K)
Specific Heat	900	460	J/(kg · K)

2.3 Meshing

Employing the "create mesh" feature facilitated determining the number of nodes, elements, and their sizes within the V Rossi wheel [21]. The mesh analysis on the V Rossi wheel design yielded data indicating a Solid Mesh element type with element dimensions of 0.864082 mm and a tolerance of 0.0432041. The study revealed a total of 95.052 nodes and 54.980 elements.

Table 2: Mesh details on V Rossi wheels

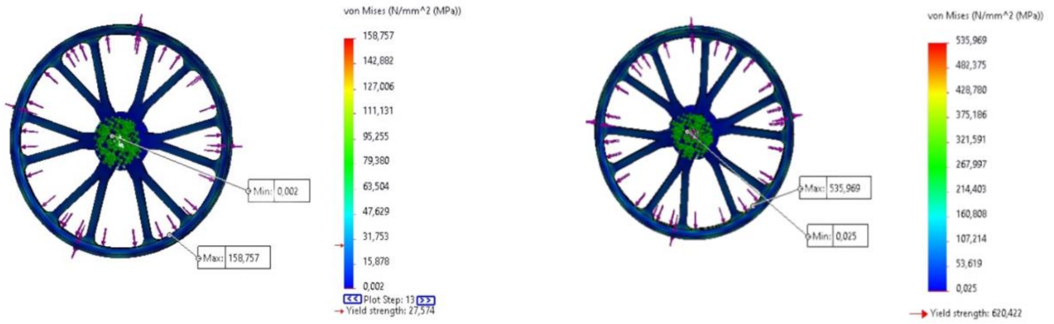
Details	Value
Mesh type	Solid Mesh
Mesher Used	Standard mesh
Automatic Transition	Off
Include Mesh Auto Loops	Off
Jacobian points for High-quality mesh	16 Points
Element Size	0.864082 mm
Tolerance	0.0432041 mm
Mesh Quality	High
Total Nodes	95052
Total Elements	54980
Maximum Aspect Ratio	16.526
% of elements with Aspect Ratio < 3	96.3
% of elements with Aspect Ratio> 10	0.0291
Time to complete mesh(hh;mm;ss)	00:00:10

3. Results and discussion

Upon completion of the V Rossi wheel frame design, simulation analysis was conducted on the frame section using two materials, namely 1060 Alloy and Alloy Steel, to establish a comparison. The simulation spanned from 0 to 10 seconds with a load of 700 Newtons. The analyses included Von-Misses Stress, Displacement, Strain, and Safety Factors.

3.1 Von-Misses stress

The stress analysis outcomes, conducted under a load of 700 N, involved two materials: firstly, the 1060 Alloy revealed a minimum value of 0.002 N/mm^2(MPa) and a maximum value of 158.757 N/mm^2(MPa); subsequently, the Alloy Steel exhibited a minimum value of 0.025 N/mm^2(MPa) and a maximum value of 535.969 N/mm^2(MPa), as depicted in Figure 2.

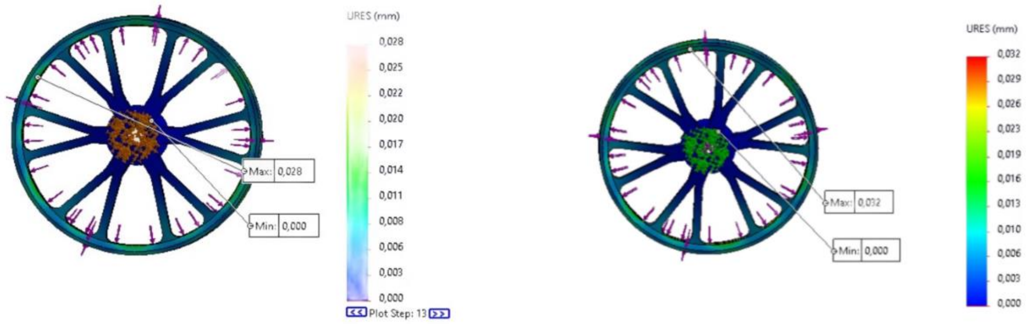


(a) (b)

Figure 2: Von Misses (a. 1060 Alloy, b. Alloy Steel)

3.2 Analysis displacement plot

Upon scrutinizing the displacement plot analysis, juxtaposing two materials, the initial material, 1060 Alloy, exhibited a minimum value of 0.00 mm and a maximum value of 0.028 mm, while for the Alloy Steel, the corresponding figures were a minimum of 0.00 mm and a maximum of 0.032 mm, as illustrated in Figure 3, portraying the outcome of the displacement plot.

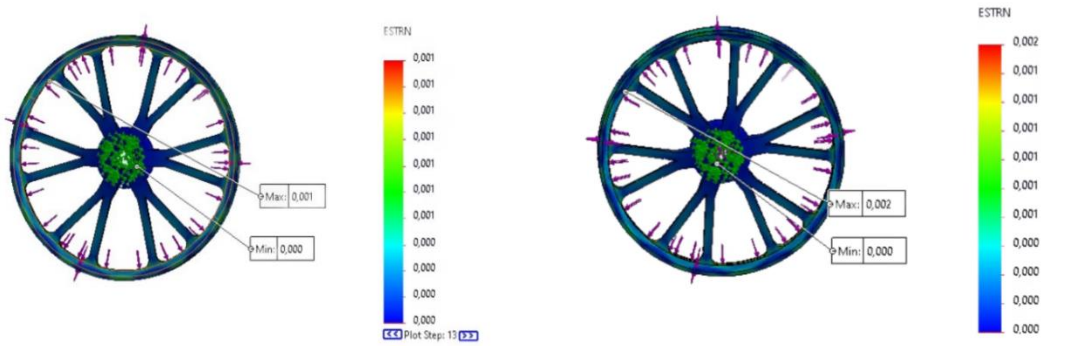


(a) (b)

Figure 3: Displacement (a. 1060 Alloy, b. Alloy Steel)

3.3 Strain analysis

This strain analysis applies a load of 700 N with a twofold comparison between two materials. For the initial material, 1060 Alloy, the values obtained range from a minimum of 0.00 to a maximum of 0.001. Conversely, for the second material, Alloy Steel, the minimum and maximum values are 0.000 and 0.002, respectively, as depicted in Figure 4, representing the outcomes of the strain analysis.

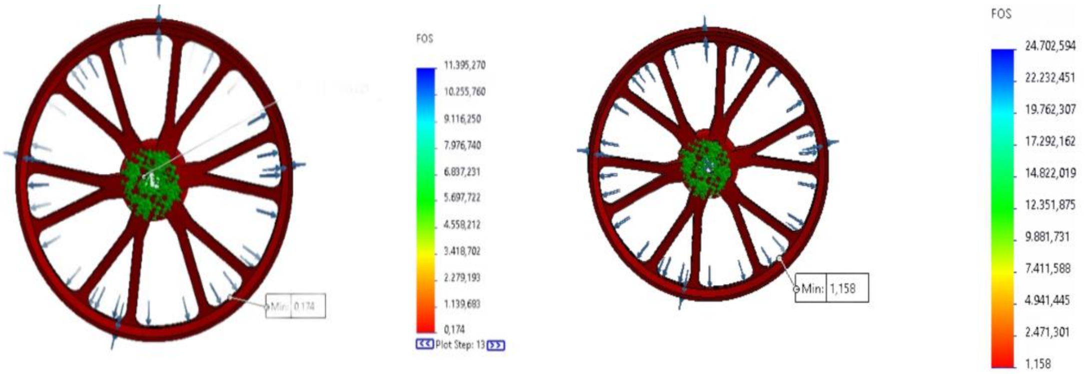


(a) (b)

Figure 4: Strain (a. 1060 Alloy, b. Alloy Steel)

3.4 Safety factor analysis

The safety factor analysis, conducted under a load of 700 N, yields a minimum value of 0.174 for the 1060 Alloy material and a minimum value of 1.158 for Alloy Steel material. These results are depicted in Figure 5 below, showcasing the outcomes of the safety factor analysis.



(a) (b)

Figure 5: Safety Factor (a. 1060 Alloy, b. Alloy Steel)

The analysis results aimed at investigating Von Misses stress, strain, displacement plot, and safety factor for two different materials, namely 1060 Alloy and Alloy Steel, subjected to identical loads of 700 Newtons and similar velocities. The comparison indicates the superiority of Alloy Steel over 1060 Alloys across various parameters, including Von Misses stress, strain, displacement plot, and safety factor. Alloy Steel demonstrates superior performance and suitability compared to 1060 Alloy. Evidence supporting Alloy Steel's superiority lies in the safety factor analysis, where Alloy Steel achieves a minimum value of 1.158, whereas 1060 Alloy registers at a minimum of 0.174. Consequently, Alloy Steel emerges as the more viable option for utilization. Noteworthy distinctions between this study and the reference article encompass divergent designs, disparate structural durability, and variation in material selection.

4. Conclusion

This study underscores the significance of enhancing wheel performance within the motorcycle industry, specifically focusing on rider stability, maneuverability, and comfort. Finite element analysis, particularly utilizing the Solidworks software, has proven to be an exceedingly effective tool in comprehending and enhancing wheel performance. By incorporating Solidworks into the design process, manufacturers can produce wheels of superior quality and performance while simultaneously saving time and costs. Additionally, this research highlights the potential for enhancing the performance of V Rossi wheels, which is pertinent in racing and everyday motorcycle use. The analysis results indicate that Alloy Steel material offers superior performance compared to 1060 Alloy, particularly concerning Von Misses stress, displacement, strain, and safety factors. Consequently, integrating Solidworks into the design of V Rossi wheels can significantly contribute to the motorcycle industry.

5. Limitations and Future Work

While this research offers profound insights into using Solidworks to enhance motorcycle wheel performance, certain limitations warrant attention. Firstly, the scope of this study is confined to finite element analysis using Solidworks, concentrating on the performance of V Rossi wheels. Moreover, the discussion on materials is limited to two types, namely 1060 Alloy and Alloy Steel. Furthermore, this study overlooks other factors influencing wheel performance, such as environmental conditions or rider variables. Future research should broaden the analytical scope by considering various different factors impacting wheel performance, including material variations, road conditions, and environmental factors. Additionally, the study could delve deeper into analyzing the influence of wheel geometry design on overall performance. Exploring new technologies and more sophisticated analytical methods could also enhance the precision and accuracy of the analysis. Consequently, future research endeavors could furnish a more comprehensive understanding of motorcycle wheel performance and offer robust guidelines for developing more innovative and superior designs.

Author contribution

Fathony Arifin: Conceptualization, Investigation, Data Curation and Writing - Original Draft. Farid R. Vafazov: Writing - Review & Editing, Formal analysisand Resources

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Conflict of interest statement

The authors declare no conflict of interest in this research and publication.

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