Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

DESIGN OPTIMIZATION OF A MOTORBIKE SWING ARM USING GENERATIVE DESIGN

Aryan Raval[*1], Amit Dangodara[*2], Manav Mandiwala[*3],Vishal Dagra[*4], Sunny patel[*5]Smit Brahmkshatriya[*6]

[1,2,3,4,5,6] Automobile engineering, LD college of engineering, Ahmedabad

ABSTRACT

This study delves into design optimization process using generative design as the optimization method. The objective of this study is to achieve a refined swing arm design which goes through mass reduction while withstanding the forces that could be acting upon in real world load cases. For this particular study generative design capabilities of Autodesk Fusion 360 are employed, which creates numerous iterations of possible design which might serve as inspiration for the final design by using user defined loads and geometrical as well as dimensional constraints.

Keywords: Swing-arm, Generative design, Design optimization, Mass minimization, mass reduction

I. INTRODUCTION

The introduction should be typed in Times New with font size 10. In this section highlight the importance of topic, making general statements about the topic and Presenting an overview on current research on the subject. The simplest way is to replace(copy-paste) the content with your own material. Your introduction should clearly identify the subject area of interest. A swing-arm is a component of a motorbike which connects the structural frame of the bike to its rear wheel. It is critical to the maneuverability of the said vehicle. The length of a swing arm determines the turning radius as well as over all rigidity of the bike. After the frame and the engine, it is highest weighing rigid structural component of a motorbike and thus weight reduction observed in swing arm could go a long way in reducing the overall weight of a bike while making it more agile. Aim of this study is to consider various design possibilities and compare them with each other by employing the capabilities of generative design and using a real-world swing arm as a case study. As discussed above, the design of swing arm has wide range of effects on the dynamics and performance of the vehicle, some of the factors affected by the swing arm are:

1.Suspension geometry: The shock absorber and dampers or the rear suspension system elements of a vehicle are mounted directly on the swing arm, which enables a sing arm to dictate the total suspension travel and over all suspension geometry.

2.Wheelbase: The wheelbase of two-wheeler is the distance between the centers of front and rear wheels. The front wheel and its corresponding length to the swing arm is constrained by the design of the vehicular frame, which does not allow much room for change. On the other hand the distance between the frame and the rear wheel is strictly dependent on the length of the swing arm, thus making it a critical component dictating the vehicular dynamics like turning radius and rigidity of the vehicle.

3.Weight distribution: The gross weight of swing arm could prove detrimental in determining the Cg (center of gravity) of the vehicle and a well-designed swing arm with minimum weight could go a long way in getting a desirable weight distribution over the vehicle.

This study delves into application of generative design which could withstand all the working load cases and at the same time manage to reduce overall mass of the component. Generative design is a design process where initial constraints such as preserved geometries, obstacle geometries, material, manufacturing methods and load cases are provided which leads to computer algorithms producing huge set of possible solutions and their respective iterations. The designs produced based on inputparameters serve as an inspiration for the designer and stress and structural analysis of the same are carried out to confirm the viability of the designs.

 ©IJSRED:All Rights are Reserved

Figure 1. A motorbike swingarm

II. METHODOLOGY

Objective

The objective of this study is to achieve an optimum design for a swing arm while going through maximum weight reduction and not yielding under working condition load cases.

Research methodology

For this particular study, the swing arm of "Kayo 250" dirtbike has been taken into consideration. The swing arm of said motorbike has been accurately modelled according to the original dimensions and constraints.

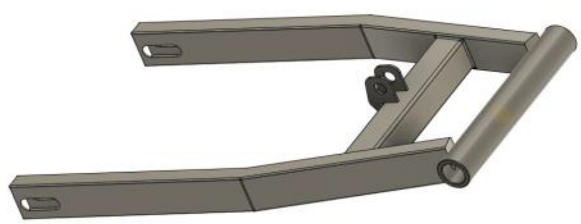


Figure 2: Original swing arm

The overall length of the swingarm in question is 560 mm. Which would be the distance between the frame and the center of the rear wheel. The maximum with of the swingarm, where the wheel would be housed is 287 mm. Along with these parameters there is also a mounting point for the monoshock suspension system attached to the swing arm which takes the load and provides the necessary suspension travel.

Table 1: Geometric constraints

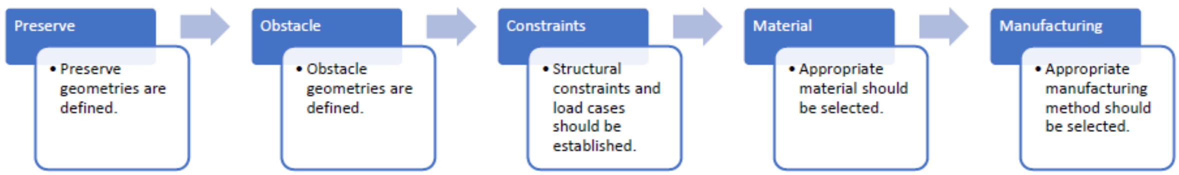
Sr no.	Geometrical constraints
1.	Frame-arm connection
2.	Suspension mounting
3.	Arm-wheel connection
4.	Wheel clerance

 ©IJSRED:All Rights are Reserved

Generative design

For employing the generative design into any design work flow, certain criteria should be met. First, all the dimensional criteria in terms of preserve geometries should be well defined. After establishing the preserve geometries, obstacle geometries should be constructed to stop the generative design from adding mass where clearance criteria are not met. Once both the obstacle geometries and preserve geometries are established, forces and constraints could be applied. Here forces should be comparable to the real world working conditions and the constraints should emulate their real world counter parts as closely as possible for most optimized design.

Figure 3. Generative design flow

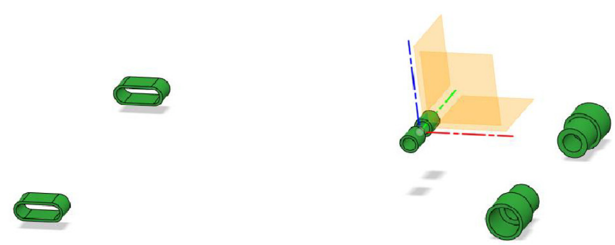


III. MODELING AND ANALYSIS

Preserve Geometries

Preserve geometries are the shapes that are critical for the design to function, therefore they are usually most chosen to be the most basic shapes which could define the dimensional constraints and meet all the necessary clearances. The preserve geometries defined below meet the dimensional constraints as well as clearance constraints established by the original swing arm.

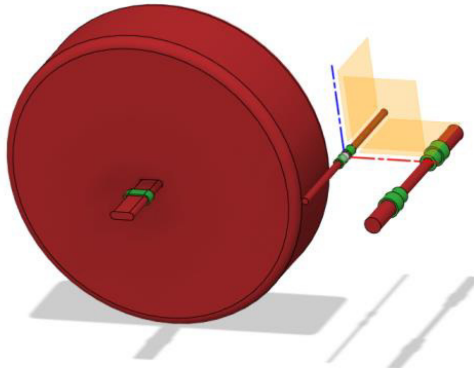
Figure 3. Preserve geometries



Obstacle geometries

Obstacle geometries are basically the sections of the design space where you any material or mass will render the component dysfunctional. Other than that, obstacle geometries could also be used as clearance space to access preserve geometries as well as clearance for bolts and shafts.

Figure 4. Obstacle geometries



Material and manufacturing process selection

Material selection is one of the most important part of design process followed by selection of manufacturing processes. Both of this criteria are deeply intertwined with each other and are critical to the structural and mechanical properties of a component. With generative design, the manufacturing process usually narrows down to additive manufacturing and other unconventional manufacturing methods as the geometries produced by generative design are harder or impossible to produce using conventional means of manufacturing. For this study, additive manufacturing is selected as the manufacturing method and wide arrays of materials from "Fusion 360 additive material library" are selected and further compared with each other.

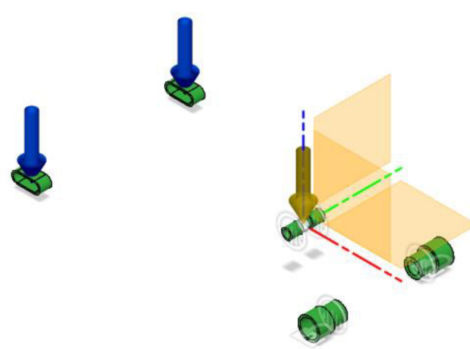
Load cases and constraints

To emulate real life loading conditions as simply as possible, two load cases are considered for this study.

- Load case 1: Upward force acting on the rear wheel coupled with bearing loads on suspension mounts as well as frame-swingarm connection. With the frame connection acting as "fixed".
- Load case 2: downward force acting on the rear wheel coupled with bearing loads on suspension mounts as well as frame-swingarm connection. With wheel connection acting as "fixed".

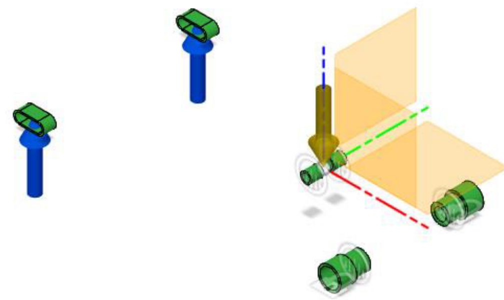
Model and Material which are used is presented in this section. Table and model should be in prescribed format.

Figure 5. Load case 1



 ©IJSRED:All Rights are Reserved

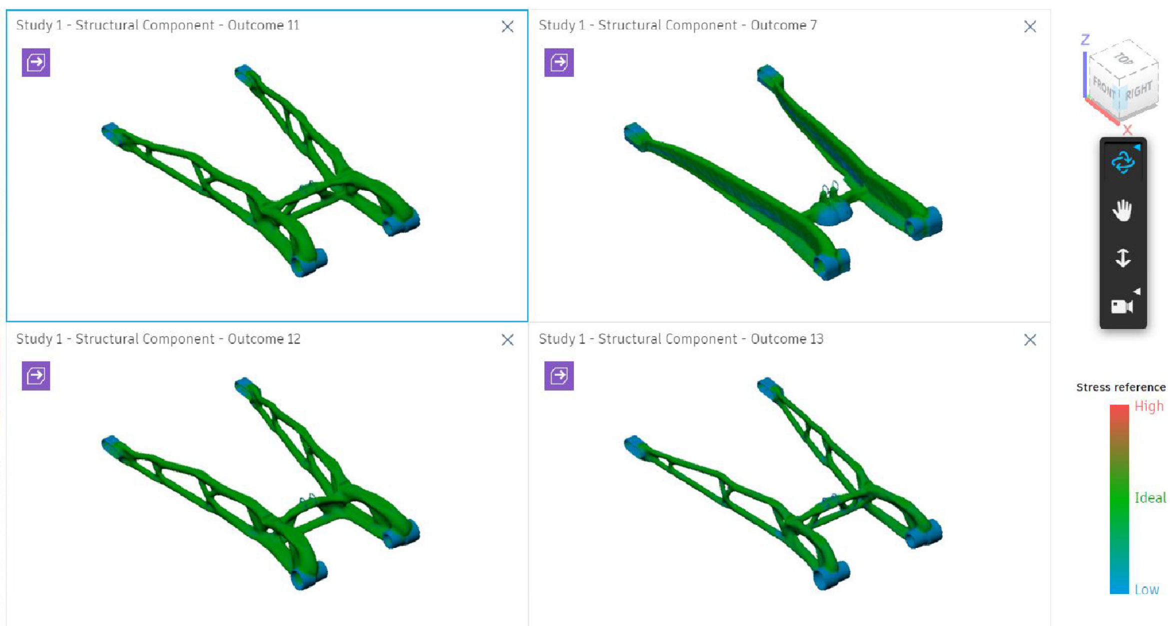
Figure 6. load case 2



Generative design solutions

Various different solutions which meet the applied load, dimensional and structural constraints are produced with different design philosophies and material selections. Each design features its own set of design iterations from which a design could be refined and adjusted according to the particular parameters. Optimum design is selected according to the parameters like total mass, FOS (factor of safety), estimated manufacturing costs, material properties, material availability etc.

Figure 7. Possible solutions



An optimum outcome is chosen while keeping factors like weight, material and stress in mind. That particular iteration is taken into detailed study and further finite element analysis is processed on it under detailed real world load cases and the stresses and deformation is observed. If found adequate, the design goes through further refinement and changes.

Literature review

- (Leitner et al., 1995) The research introduced a suspension system for the front wheel of a bicycle and motorcycle, which has a minimum amount of friction. The invention also includes various elements which provide for the structural rigidity of the suspension assembly and light weight.
- (Hong et al., 2005) this study derived modelling of suspension and swingarm for improved shock resistance in the micro optical disk drive using topology optimization and shape optimization. The objective of swing arm design is weight reduction for reducing power consumption and to achieve good result. The resultant swingarm has 15% mass reduction compared with last model.
- (Yoo & Lee, 2007) The study is about Topology optimization of a swingarm type actuator. In technique based on the response surface method is used and generated a swing arm type actuator. Each single-objective

 ©IJSRED:All Rights are Reserved

functions derived by DOE (The design of experiments). The final optimized model shows 3% improvement of compliance.

- (Hassaan Abdullah et al., 2018) This study shows how to utilize the shape optimization method to further optimize the MotoGP Honda RC213V swingarm. Optimization was done based on the multi-axial loads and the analysis was done on the swingarm's CAD model. It has been observed that a 15% of mass reduction has been achieved without compromising the FOS.

Figure 8. Generative design swing arm renders

IV. RESULTS AND DISCUSSION

Analysis

Stress and deformation analysis of both the original swing arm of kayo 250 as well as swing arm developed by generative design is done by finite element analysis methodology and both the design are compared.

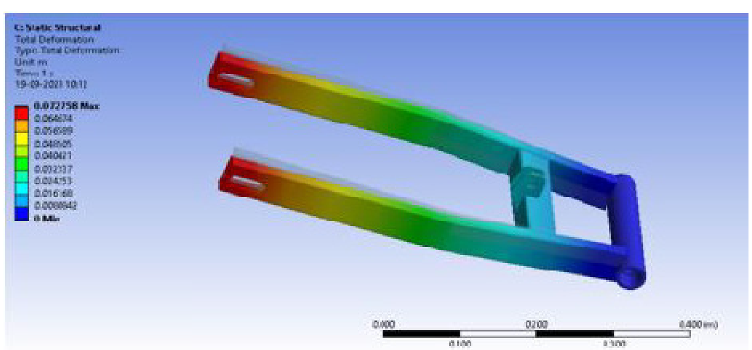
Original swingarm analysis

FEA analysis of original swingarm is done under aforementioned load cases and deformation is observed while using the same material as the generative swingarm i.e.. Ti 6AL 4V.

Table 2: Material properties of Ti 6Al 4V

Sr no.	Property	Value
1.	Density (g/cc)	4.433
2.	Melting point (°C)	1600-1660
3.	Ultimate tensile strength (MPa)	1170
4.	Yielding stress (MPa)	1100
5.	Max elongation (%)	10
6.	Modulas of elasticity (GPa)	114

Figure 9. FEA of original swingarm

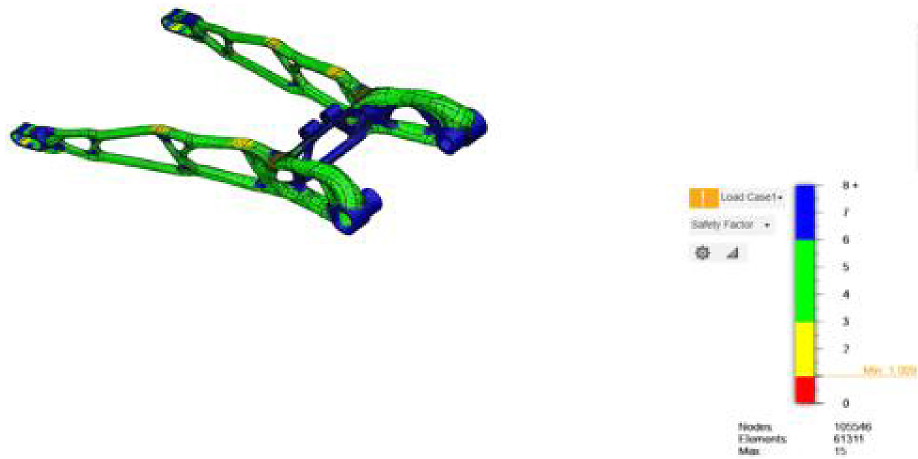


Generative swing arm

FEA analysis of swing arm obtained by employing generative design is done under same conditions as original swing arm load cases. The material used in the analysis is from Fusion 360 additive manufacturing library which is Ti 6Al 4V, which is a Titanium alloy used in additive manufacturing processes. FOS or factor of safety is observed in this case which is ratio of ultimate strength of material and working stress.

 ©IJSRED:All Rights are Reserved

Figure 10. FEA of redesigned swing arm



Findings

Comparing both the design on the required parameters, generative design swing arm is seemingly more optimum. Weight reduction achieved between two designs is observed to be 56.95%.

- Weight of original design: 4.6 Kg
- Weight of optimized design: 1.98 Kg

Maximum deformation observed in original design is 7 mm, while the maximum deformation observed in generative design swing arm is 4.3 mm. Thus, there is increment of FOS between both the design, from 1.09 to 2.26.

V. CONCLUSION

The study demonstrates the application of generative design by optimizing motorbike swing arms which offers promising results in terms of enhancing performance and reducing weight. The swing arm is a critical component, impacting various aspects of a bike's dynamics, including suspension geometry, wheelbase, and weight distribution. Through the utilization of Autodesk Fusion 360's generative design capabilities, this study aimed to produce a refined swing arm design that could withstand real-world load cases while achieving significant mass reduction. Generative design processes involve establishing preserve and obstacle geometries, selecting materials and manufacturing methods, and applying real-world load cases and constraints to generate a multitude of design iterations.

The research demonstrated that generative design, when properly implemented, can lead to substantial improvements. The optimized swing arm, created through generative design, exhibited a remarkable 56.95% reduction in weight compared to the original design. This weight reduction contributes to enhancing the bike's overall agility and fuel efficiency. Moreover, the generative design swing arm demonstrated an increased factor of safety (FOS) and reduced maximum deformation, further emphasizing its structural integrity and superior performance under real-world conditions. These findings underscore the potential of generative design on giving the designer a fresh perspective.

In summary, this study's exploration of generative design for motorbike swing arm optimization provides a glimpse into the future of engineering and manufacturing. It showcases the capabilities of this innovative design approach in achieving substantial mass reduction, improved structural integrity, and overall enhanced performance.

VI. REFERENCES

1. Optimization of swing arm design using generative designN. Rohitkumar, R. Tatapudi, (2021), JETIR Volume 8 issue 6, ISSN-2349-5162.
2. Shape optimization of a high performance motorbike single sided swingarm, Casani, S., & Mancuso, A. (2005), SAE Technical Papers (Issue 724)
3. Front and Rear Swing Arm Design of an Electric Racing Motorcycle, Diogo, J., & Ramos, C. (2016).
4. Vibration Response and Optimization of Swing ARM.Dixit, V. S., Pimpale, S. S., & Graduate Scholar, P. (2016), International Journal of Engineering Science and Computing (Vol. 6, Issue 2).
5. The Kick-Back of Motorcycles: Experimental and Numerical Analysis.Lot, R., & Massaro, M. (2007), Proceedings of the ECCOMAS Thematic Conference, Multibody Dynamics (Issue June).
6. Design and analysis of single sided swing armPatil, K., Rajpurohit, G., Magade, R., & Shirphule, A. (2019), (Issue May).
7. Topology Optimization of Motorcycle Swing ArmRankhambe, T., & Kumar Nhaichaniya, G. (2017),

IJSART (Vol. 3, Issue 5).
8. Design and analysis of swingarm for performance electric motorcycleSwathikrishnan, S., Singanapalli, P., & Prakash, A. S. (2019), (Issue 8).
9. The effect of swingarm stiffness on motorcycle stability: Experimental measurements and numerical simulations. Taraborrelli, L., Favaron, V., & Doria, A. (2017), International Journal of Vehicle Systems Modelling and Testing (Vol. 12, Issues 3–4).
10. Motorcycle dynamics, Vittore Cossalter.