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The Adoption of Poka-yoke Mechanism towards Reducing the Incident of Un-lifted Side Stand of Motorcycle

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Abstract: In recent years, human mistake related road traffic accident caused by un-lifted side stand of motorcycle is receiving much attention. However, the existing design improvement efforts to tackle the problem are more likely towards complex design and applicable to limited variants. This research attempts to produce a prototype model of safety mechanism through the adoption of Poka-yoke (human mistake proofing) approach in reducing the incident of un-lifted side stand. The proposed design comprised side stand, gear lever, spring and sensor, which is based on side stand specification of Yamaha 125ZR model. The design employed stainless steel as main material, finite element analysis (FEA) method for validation of strength, bench working and arc welding as fabrication and assembly process, and functional testing for automatic retraction analysis. The results ascertained the side stand is automatically retracted without touching by the rider when gear lever is pushed. The findings revealed the adoption of Poka-yoke mechanism is effective to prevent human mistakes and carelessness, subsequently avoiding the road accidents caused by the un-lifted side stand. Recommendations are also highlighted for further development including the use of alternative material and multiple design.

Keywords: FEA, Motorcycle, Poka-yoke, Road accident, Side stand

1. Introduction

Motorcycles or bikes in the form of two-wheelers play an important role of transportation in many countries in the world. In Southeast Asian region for instance, there are thousands of bikes running on the road every day. Despite the popularity of bikes for daily use, the percentage of road traffic accidents involving motorcyclists are also increase [1]. Motorcyclists are reported at the highest risk in accident, which lead to injuries and fatalities per distance travelled than other vehicles [2].

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In the other words, human mistake or careless could be the most significant contribution to the cause of accidents including the negligence of motorcyclists to uplift the side stand [3]. The major source for accidents caused by motorcyclists are inclusive of riding the vehicle in high speed (22%), ignores to follow traffic rules (38.0 %), and forgets to lift up the side stand while riding (36%) [4]. On the other hand, a commonly used Poka-yoke mechanism in lean process could be adopted to avoid human mistakes [3]. The main aim of poka-yoke is to frame process so that mistakes easily can be detected and corrected, and also to eliminate or reduce the human errors in a system due to mental or physical human imperfections [5].

The working system of motorcycles side stand could be categorized into several types of design such as kickstand, sprocket side stand, and automatic side stand [3][6]. In the case of automatic side stand system, a warning indication will be given to the rider through sensor output in a logic high signal if the side stand is not pulled up. If the side stand is pulled up completely, then the sensor output will indicate the stand is closed [7]. Nonetheless, motorcyclists are having the biggest risk in road accident than other vehicles. In addition, human mistakes in terms of un-lifted side stand give sigificant contribution to the cause of motorcycle accidents. However, previous efforts of preventive measure are complex and unattractive. Therefore, a comprehensive solution to fulfil the requirements of end users and society in offerring a rigid and safety mechanism without much changing in the standard design of motorcycle is needed by means of human mistake proofing of Poke-yoke approach.

2. Materials and Methods

2.1 Materials

This research study utilized the original design specification of motorcycle side stand of Yamaha 125ZR model as shown in Figure 1. The other parts include spring, gear lever, and sensor. As shown in Figure 2, the spring used in this study is made out of hardened steel. Typically, a spring is an elastic object used to store the mechanical energy.

Figure 1: Manual side stand of Yamaha 125ZR

Figure 2: Hardened steel of spring

As illustrated in Figure 3, steel based gear lever is a simple machine used to lift the weight. The function of lever in this mechanism is to uplift the side stand using spring. Meanwhile, the sensor used in this study is as shown in Figure 4. Sensor is a device that detect and respond to some type of input from the physical environment. The specific input could be light, heat, or motion.

Figure 3: Steel based gear lever

Figure 4: Sensor

2.2 Research design

Research design refers to an organised plan and scientific investigation into a specific problem, undertaken with the objective of finding solutions to it [8]. The process of research design in this study involves five main phases as shown in Figure 5. The research begins with the initial phase, which focuses on defining problem and design solution. The second phase is design of a prototype model, which comprises conceptual design, material selection, and design evaluation. The third phase emphasizes on the development of a prototype model, including equipment selection and fabrication processes. Next phase is testing and analysis through functional testing. The final phase is conclusion, which embraces the discussion and conclusion of findings.

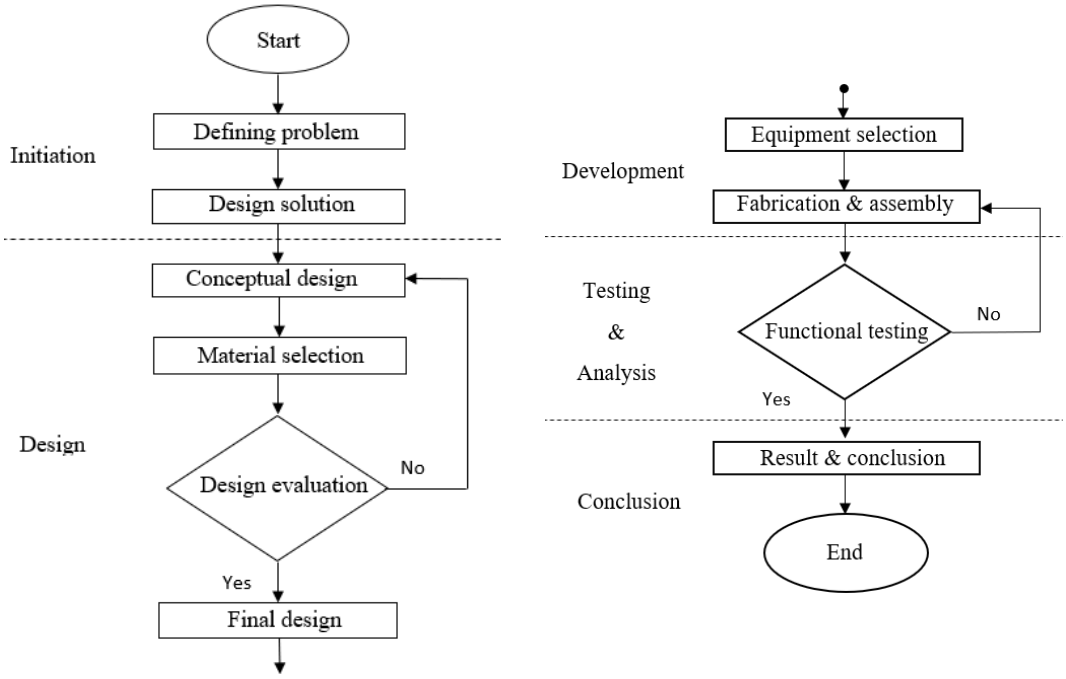

Figure 5: Research design process flow chart

2.3 Design of prototype model

The design of a prototype model of side stand device is catered for bikes model with 150cc and below as this model is widely used in the region. The design processes in this study involved the activity of brainstorming session and conceptual design. In the design processes, brainstorming is often used as a method for generating ideas to solve a design problem. In this study, brainstorming has been conducted to obtain idea and consensus on the Poka-yoke based side stand design. The conceptual design of side stand is mainly generated from the brainstorming session. The design is further drawn in 3D modelling using SolidWorks software as illustrated in Figure 6 and Figure 7, respectively.

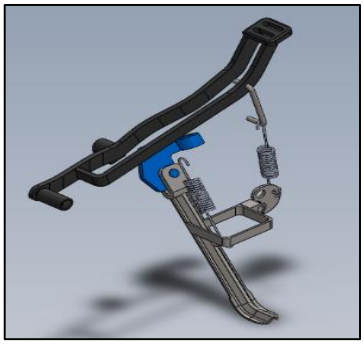

Figure 6: Isometric view

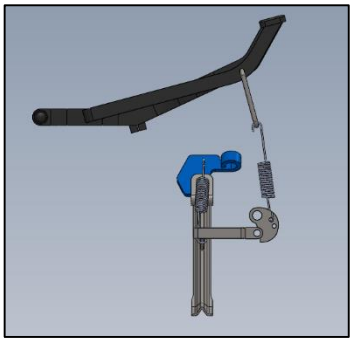

Figure 7: Side view

As for design evaluation, finite element analysis (FEA) is used in this study. It is a method of using virtual simulation technology to evaluate a product design. This include the design reacts to physical effects including heat, vibration, or other impact. The method can evaluate the design cycle, and determine the failures. In this study, FEA method is specifically adopted to determine the stress, displacement and strain using computer software of SolidWorks.

2.3 Development of prototype model

This study utilized the tools, equipment and machines for the purpose of fabrication and assembly operations. The selected equipment are based on the type of operations needed for fabrication and assembly of side stand. The equipment used in this study are inclusive of measuring equipment, cutting machine and welding machine.

The measurement process includes linear measurement and marking as shown in Figure 8. The measurement of length is done by leaving a gap on the work piece in order to spare some tolerance for the next cutting process. The work piece was also highlighted with marking to avoid cutting mistakes as shown in Figure 9.

Figure 8: Dimensional measurement

Figure 9: Marking process

The fabrication operation by cutting process needed for the work piece using a hand-held cutting machine as shown in Figure 10. In this process, cutting of work piece into a desired shape and trimming of excessive material are performed as specified in Figure 11.

Figure 10: Hand-held cutting machine

Figure 11: Cutting into desired shape

This study employed welding technology as main assembly operation. Welding is a process of joining two pieces of metal. The processes of welding use of extreme heat and some addition of other metals or gases causes the metallic structure of the two pieces to join. This study used the arc welding as welding method for joining process as shown in Figure 12. Eventually, finishing process is done to remove the excessive molten metal, uneven welded part and rough surface as illustrated in Figure 13.

Figure 12: Welding process

Figure 13: Finishing process

2.4 Functional testing

In this study, functional test has been conducted to verify the function of a prototype model of bike side stand. Specifically, the conduction of test comprised the indication of correct function of lift up mechanism of side stand when rider pushed the gear lever, and alarm indication to the rider on the display panel through installed sensor if the side stand is un-lifted.

3. Results and Discussion

3.1 Final design

The final design of side stand is decided based on the outcomes of design review and options on different models of motorcycles as summarized in Table 1. The first design (Design 1) used the original design of side stand of Yamaha Lagenda 110 model. However, the side stand could not be lifted up due to the fix position of side stand and gear lever in Design 1. The next design options (Design 2 and Design 3) involved Yamaha 125zr model. The main different between both designs could be the adoption of connection spring in Design 3 for ease of installation as compared to Design 2. Therefore, the option of Design 3 has been chosen as the final design of a prototype model of side stand.

Table 1: Design option 1, 2 and 3

No	Description	Design 1	Design 2	Design 3
1	Side Stand Design	Yamaha Legenda 110 	Yamaha 125ZR 	Yamaha 125ZR 

2	Spring Part Assembly	Not Applicable	Spring  Side Stand 	Spring  Side Stand  Connection Spring 
3	Gear Lever & Sensor Part Assembly	Not Applicable	Gear Lever  Sensor 	Gear Lever  Sensor 

3.2 Finite element analysis (FEA) result

The result of finite element analysis (FEA) of different factors of the strength by means of stress, displacement, and strain, using SolidWorks software for the final design of side stand are shown in Figure 14 – 20, respectively. In the analysis, the side stand has been applied a specific load of 114.8 N, which compatible to 11.7 kg weight of rider when pushing the side stand.

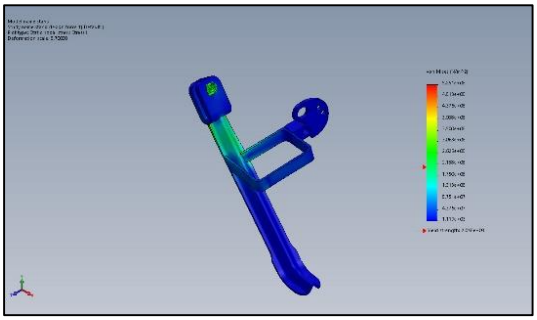

Figure 14: Stress of side stand

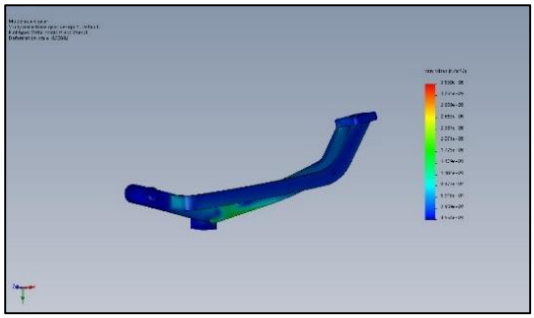

Figure 16: Stress of gear lever

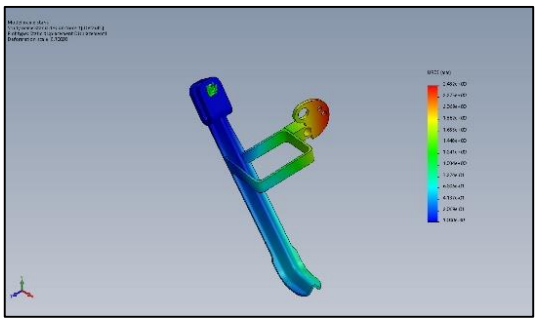

Figure 17: Displacement of side stand

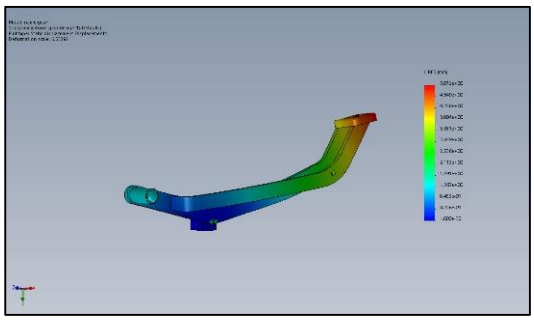

Figure 18: Displacement of gear lever

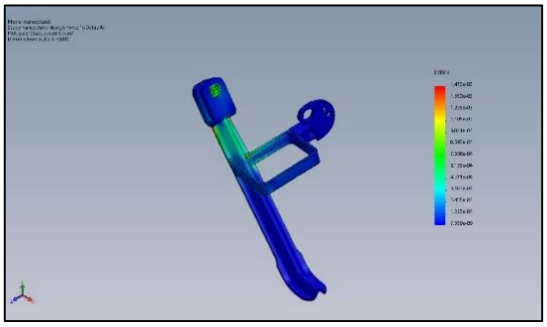

Figure 19: Strain of side stand

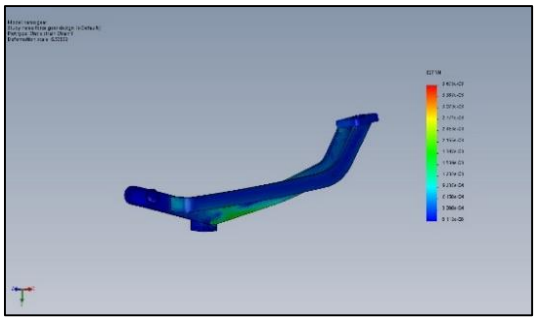

Figure 20: Strain of gear lever

The value of displacement and strain for side stand is lower than gear lever. In specific, the highest stress value of side stand is indicated as 525.1 x 106 N/mm2, while 355 x 106 N/mm2 for gear lever as shown in Figure 21. In other word, the value of stress on side stand is higher than gear lever.

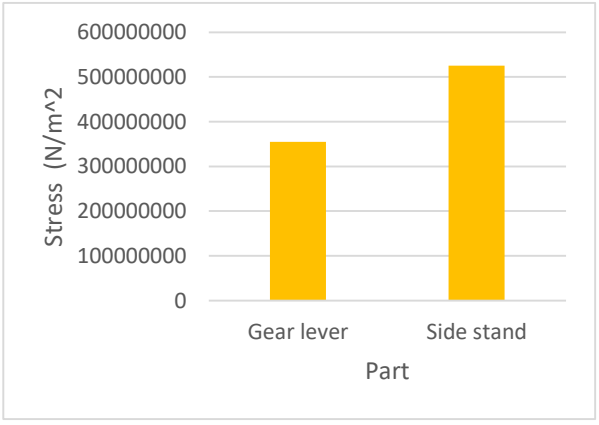

Figure 21: Value of stress of side stand design and gear lever

The value of strain indicates 3.695 x 10-3 for gear lever and 1.473 x 10-3 for side stand as depicted in Figure 22. In short, the result confirmed that the strain value for gear lever was higher than side stand.

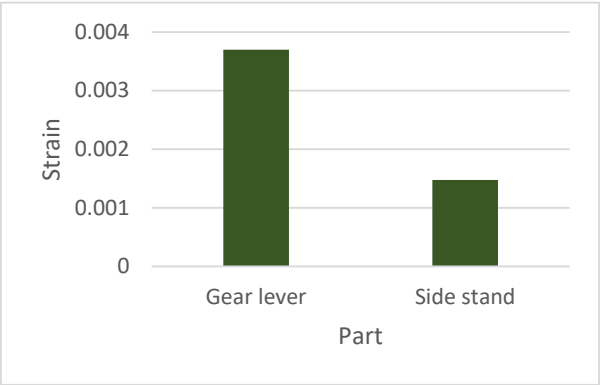

Figure 22: Value of strain of side stand design and gear lever

The value of displacement and strain for side stand is lower than gear lever. In specific, the highest stress value of side stand is indicated as 525.1 x 106 N/mm2, while 355 x 106 N/mm2 for gear lever as shown in Figure 23. In other word, the value of stress on side stand is higher than gear lever.

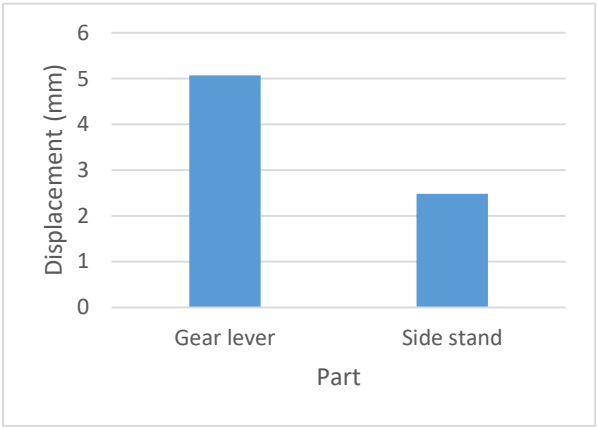

Figure 23: Value of displacement of side stand design and gear lever

3.3 Functional testing result

In this study, a single rider has conducted the functional test of a prototype model. As illustrated in Figure 24, the test results revealed that the mechanism of Poka-yoke or human mistake proofing, which attached to the prototype model is confirmed effective to automatically retract the side stand of motorcycle as preventive measure to reduce accidents caused by the un-lifted side stand.

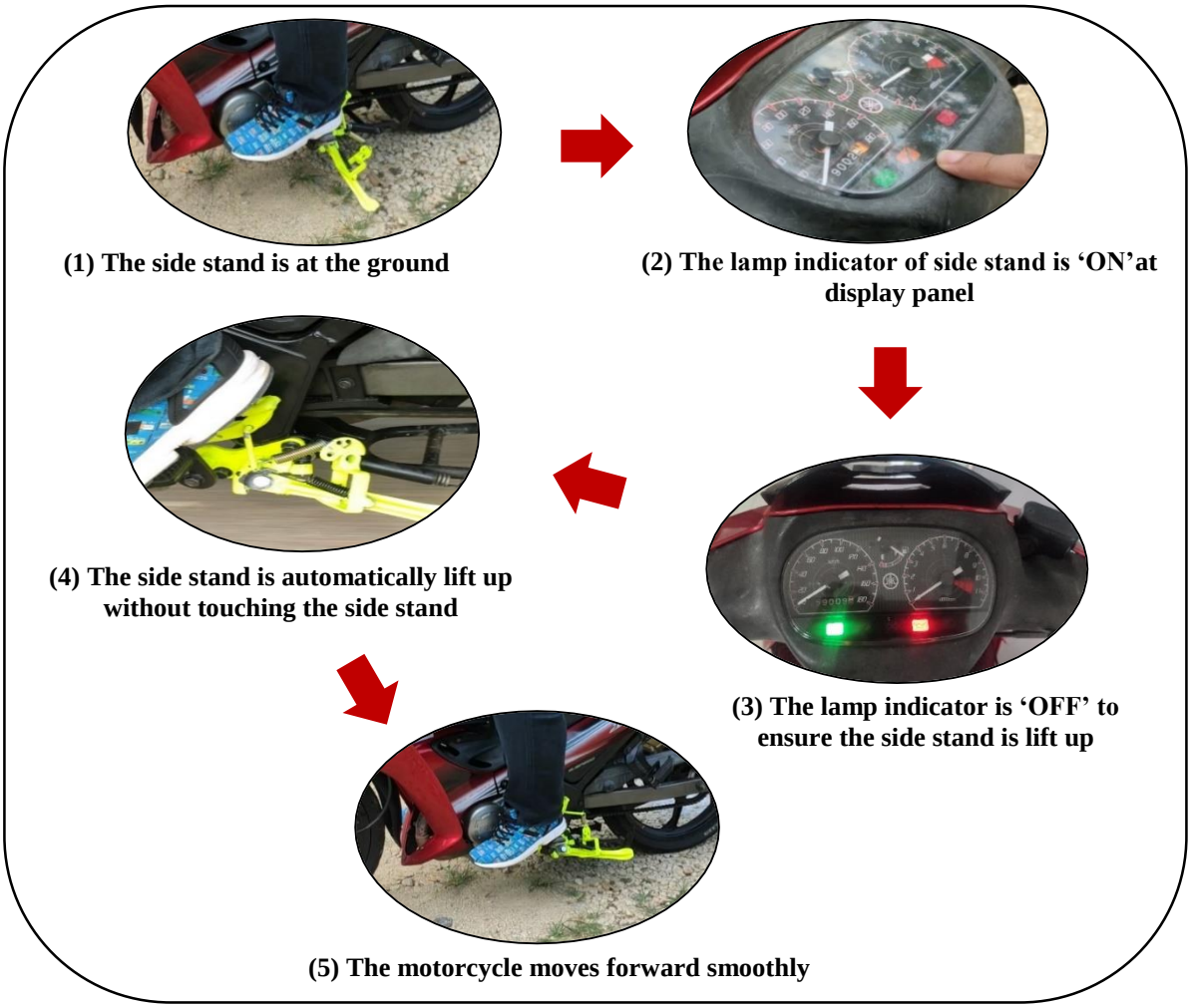

Figure 24: Functional test result

The results of functional test confirmed the prototype model of side stand could support the concept of Poka-yoke or human mistake proofing. The finding is aligned with the evidence of previous studies [7]. The prototype model in this study has been successfully designed and developed with smooth function of mechanism device to automatically retract the side stand, subsequently avoid human mistake and prevent the accident due to un-lifted side stand of motorcycle.

4. Conclusion

This study has attained and achieved the objective that has been set beforehand. In this study, the characteristics of design has been discovered by thorough literature search and the existing market study. The study has successfully produced a prototype model of side stand with automatic retraction. The results discovered the prototype model of side stand is automatically lift up without touching it when a rider pushed the gear lever to ride the motorcycle. Thus, the findings suggested the adoption of Poka-yoke mechanism as design requirement in the proposed prototype model is significance in avoiding the incident of un-lifted side stand of motorcycle caused by human mistake or carelessness.

Nonetheless, further development in future is needed to improve the design such as by using aluminium as an alternative material in the design, multiple design to accommodate numerous variants of motorcycles, and new design of spring in pull-mechanism system of side stand.

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