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Research Paper

Design and Application of Special Service Tools (SST) for Telescopic Front Fork

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Abstract

Although simple, removing the front fork telescopic (TFF) seal on a motorcycle without special service tools (SST) can cause work accidents for mechanics and loss for consumers and workshops. Therefore, product development research has been carried out to design a seal remover for TFF. Then, a TRL measurement using Techno-meter was done on the prototype that has been developed. A quick measurement by Techno-meter shows that the prototype has reached level 6 (intermediate), where the prototype has been demonstrated/tested in a relevant environment. In conclusion, through continued work (reviewing products, improvising, and testing prototypes on a larger scale), this prototype promises to be mass-produced as downstream of research products to the market.

Key words: *Seal, Special service tool, Telescopic front fork*

Abstrak

Meskipun nampak sederhana, melepas seal teleskopik garpu depan pada sepeda motor tanpa *special service tools* (SST) dapat menyebabkan kecelakaan kerja bagi mekanik dan kerugian bagi konsumen dan bengkel. Oleh karena itu, sebuah penelitian pengembangan produk telah dilakukan untuk merancang pelepas seal pada garpu depan. Kemudian, pengukuran TRL menggunakan Techno-meter dilakukan pada prototipe yang telah dikembangkan. Pengukuran cepat dengan Techno-meter menunjukkan bahwa prototipe telah mencapai level 6 (*intermediate*), dimana prototipe telah berhasil didemonstrasikan/diuji dalam lingkungan yang relevan. Sebagai kesimpulan, melalui pekerjaan lanjutan (mereview produk, mengimprovisasi, dan menguji prototipe dalam skala yang lebih besar), prototipe ini menjanjikan untuk diproduksi secara massal sebagai hilirisasi produk penelitian ke pasar.

Kata Kunci: *Seal, Special service tool, garpu depan teleskopik*

1. Introduction

In the last few decades, after the swing arm suspension was abandoned, the telescopic front fork (TFF) is the most common front suspension model for motorcycles. TFF developed from the bottom tube model to the upside-down (USD) model. Basically, TFF is a hydraulic shock absorber which contains a spiral spring with several supporting components to regulate oil transfer in the system [1]. During a sudden brake, where the weight of the motorcycle shifts forward, the TFF prevents overload on the front wheels. In addition, when a motorcycle is ridden on a rough road, TFF softens the impact so it is not distributed to the handlebar. The TFF structure for motorcycles is presented in Figure 1.

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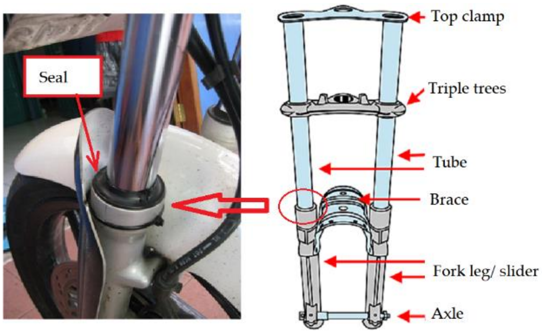

Figure 1. Schematic view of telescopic front fork (TFF) of motorcycle [1]

The front fork tubes are made of steel which has high strength, precision and has excellent sliding properties. Therefore, the steel coated makes it is hardness on the outside but ductile inside. The slider section is made of high-quality aluminum alloy, which is durable and has excellent sliding properties on the inside.

The front fork is a crucial component consisting of a front tube, front leg/slider, triple trees, axle, oil, seal, spring, and other small parts. In general, the TFF seal is replaced in 2- 3 years, depending on usage. TFF has the potential to damage the seal, tube and spring. For high-performance TFF, such as for racing and military purposes, there are several practical options for monitoring shock absorber conditions due to the harsh operating environment such as temperature, dirt, shock loading, and continuous vibration [2], [3].

The seal is a part to prevent oil in the slider and tube from leaking. To remove the seal from the seal housing requires special service tools (SST) which are usually suitable for one type or one brand of motorbike. Some mechanics do not use SST to remove the seal but choose to clamp in the vise which can cause the tube to scratch or change the cylindrical shape. In fact, according to our observations, there are amateur mechanics who open the TFF seal without special equipment, which can also damage the seal housing, as shown in Figure 2.

Besides being dangerous, there is a disadvantage of removing the seal traditionally (with tire belts), which requires power and sometimes must also be done by two mechanics [4]. Wrong seal removal methods can cause leakage and jamming in the telescopic tube.

Figure 2. Hazardous front fork seal removal

In addition, working safely in a workshop is also a demand for professional workshop management. A modern and responsible workshop, not only equipped with sophisticated equipment but also prioritises occupational safety and health [5][6]. Workshop management must also develop mechanical skills and workers to be able to prevent work accidents [7], [8]. Therefore, this study aims to develop an SST to remove the seal for TFF motorcycles that provide safety guarantees to the components and mechanics that are handling it.

2. Method

Designing a product with a market orientation cannot produce physical products directly. A series of activities with a long time and involve many disciplines is needed. Therefore, mapping of objectives and constraints to create specifications that match market demand is an essential design issue. Most product design models need continuous feedback to the previous stage [9].

In product development, the product developer determines the complete development process in detail in the initial stages of development [10]. Ideally, new product development (NPD) emphasizes the importance of introducing new products in the market for sustainable business success. The NPD process consists of activities carried out by the company when developing and launching new products. New products introduced in emerging markets go through a series of stages, starting with initial product concepts or ideas that are evaluated, developed, tested and launched on the market [11].

In this study, the design of SST for TFF motorcycle is made based on market needs, which are analyzed into market demand designs. The first stage starts from the design concept that is defining specifications and materials, determining the structure of the function and looking for the working principle of the product. The second stage is the embodiment stage, which is to develop the layout, scale the shape, design model and analyses assembly and function optimization. The third stage, namely design detail, consists of examining components in precise detail, material selection, performance optimization process and cost so that the resulting product specifications are in accordance with market needs. Finally, we try to evaluate products with techno-meters, an application to measure the technology readiness level (TRL). TRL measures the extent to which a technology is suitable to be placed in a real operational environment. This is often used as a measure of the risk associated with introducing new technology into existing systems and standard operating procedures [12], [13]. The stages of research from planning, prototyping, to evaluating are presented in Figure 3.

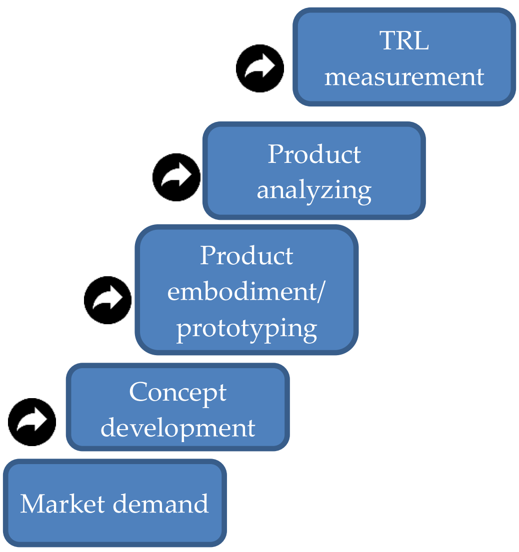

Figure 3. Research steps

3. Result and Discussion

3.1. *Design and Embodiment*

The proposed design concept is the SST seal remover for TFF with the working principle of removing TFF seals efficiently, quickly, and safely. SST seal remover includes parts: lever (a), adjustment bolt (b), lever bar (c), and handle (d). Components a, b, and c are made of ST 37 steel, while component d (handle) is made of rubber. By the present invention, the depth of the lever to the fork leg can be adjusted by tightening or loosening the adjusting bolt (b). The intended SST design is presented in Figure 4, while the detailed design with the size is presented in Appendix 1. Then, SST trials in the real environment are shown in Figure 5.

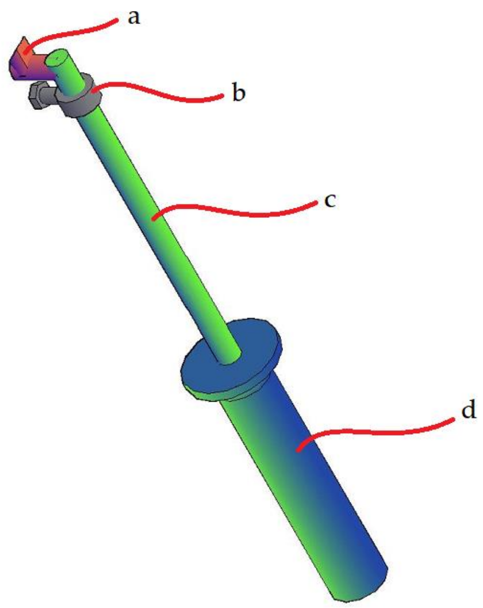

Figure 4. Seal remover: (a) lever, (d) adjusting bolt, (c) lever bar, and (d) handle

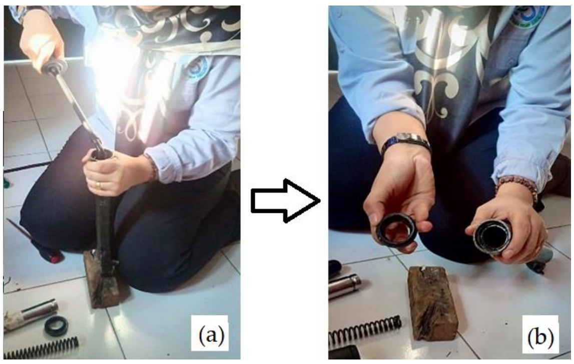

Figure 5. Photographic view of product testing by the author: the process of removing seal (a) and removed seal (b)

3.2. TRL Measuring

TRL measures the extent to which a technology is suitable to be placed in a real operational environment. This is an instrument to reduce the risk of failure when a product will be produced [14]–[17]. An outline of the TRL scale is presented in Figure 6.

Furthermore, with the specifications and physical conditions available, we took TRL measurements with a Techno-meter developed by the Agency for Assessment and Application of Technology (BPPT), Republic of Indonesia. Quick measurement results show that this prototype has reached level 6 (intermediate), where the prototype system/subsystem of the prototype has been demonstrated/tested in a relevant environment (see Figure 7). In the future, this prototype will be continued with testing in the real environment, improved quality up to TRL 9 so that it can be commercialized.

Technology Readiness Level (TRL)	
9	Commercial operation in relevant environment
8	Commercial demonstration, full scale deployment in final form
7	System prototype in an operational environment
6	Fully integrated pilot (prototype) tested in a relevant environment
5	Component validation in relevant environment (coal plant)
4	Component validation tests in laboratory environment
3	Analytical and experimental critical function proof-of-concept
2	Formulation of application
1	Basic principles

Figure 6. TRL scale [12]

TRL *Quick*			
[marked (◉) at the appropriate choice]			
UKUR CEPAT	(TRL *QUICK*)	○	The technology system / R&D results are successful (tested and proven) in the intended use (actual application).
		○	The system is complete and meets the requirements (qualified) through testing in the actual (application) environment.
		○	The model / prototype of the system / subsystem has been demonstrated / tested in the actual (application) environment.
		◉	The system / subsystem model or prototype has been demonstrated / tested in a relevant environment.
		○	Code validation, component (breadboard validation) technology / R&D results in a simulated environment.
		○	Code validation, component (breadboard validation) technology / R&D results in a (controlled) laboratory environment.
		○	Analytical tests and experiments have been carried out to prove the concept (proof-of-concept) technology / R&D results.
		○	Concept formulation or technology application / R&D results have been carried out.
		○	The basic principles of technology / R&D results have been studied (researched and reported).
		○	
TRL *QUICK* = 6			

Figure 7. Quick TRL measurement by Techno-meter

4. Conclusion

Through a prototyping process, a special service tool (SST) for the telescopic front fork (TFF) motorcycle in the form of a seal remover has been successfully developed. SST has been able to be applied well in the relevant environment but has not been tested for toughness, how many times this tool has been used. Quick measurement by Techno-meter shows that this product has reached level 6 (intermediate), where the prototype system/subsystem of the SST has been demonstrated/tested in a relevant environment. We will continue this work by reviewing products, improvising, and testing prototypes on a larger scale. An idea for mass production will also be developed in the context of downstream research products to the market.

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Appendix 1. Design of Prototype