CONCEPTUAL DESIGN OF A MOTORCYCLE TIRE DISMOUNTING TOOL FOR ONE-HANDED USER

Mohd Nizam Sudin[1], Safwan Zamani[2]

[1,2]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah jaya, 76100 Durian Tunggal, Melaka, Malaysia

Corresponding email: [1] nizamsudin@utem.edu.my

ABSTRACT

Most existing products are designed without consideration of one-handed users. This includes the equipment and tools normally used in motorcycle workshops. A majority of these products demand a two-handed user by default and unintentionally deny access to one-handed users. Thus, this project aims to design and fabricate a prototype of a motorcycle tire dismounting tool intended for one-handed users. The project starts with a preliminary study, a preliminary concepts evaluation, concepts generation, concept selection and concept refinement. Methods such as observation, brainstorming and the weighted objective method were employed in the course of the design process. Solid modeling software, CATIA V5 was used to produce a 3D drawing of the concept designs and the final design of the motorcycle tire dismounting tool. Finally, the prototype of the tool was built and tested. The tire dismounting process is possible to carry out with one hand using this product. Users just need to push or pull the handle of the product with a 29 N force.

***KEYWORDS**: One-handed user, Tire dismounting, Motorcycle, Product development*

1.0 INTRODUCTION

A majority of existing products are designed without the consideration of one-handed users. Most products demand two hands to operate by default. This situation unintentionally denies access to a certain segment of users (Ahmed et.al., 2003). According to the World Health Organisation (WHO), 7% of the populations of all countries suffer from disability. In Malaysia, the statistics revealed by the Department of Social Welfare shows that the registered numbers of disabled people is 197,517 (Department of Social Welfare, 2006). The types of disabilities include; 1) visually impairment, 2) hearing impairment, 3) physical handicap, 4) Mental impairment, 5) Learning disability, 6) Cerebral palsy and 7) miscellaneous. Among these types of disabilities, physical handicap is the second highest, at 66,250. According to the International Labour Organisation (ILO), the right to training, employment and job development for disable people is often overlooked (ILO, 1994). To help disabled people

be self-reliant in society, the Department of Social Welfare in Malaysia has provided economic assistance by purchasing items manufactured by the disabled, and various types of activities have been devised to respond to their needs in ways that facilitate participation in society. In cases where transport is needed, i.e. wheelchair, the department also provides facilities (subsidy to) to be purchased (Department of Social Welfare, 2006). Noraini et.al. (2001) study job opportunities for disabled people in Malaysia and aim to find job opportunities for disabled people in Malaysia. They found that the majority of disabled people (67.96%, 507 people) work in non-professional (skilled) jobs, and 41.22% (209 people) of them are physically handicapped. They also found that opportunities for disabled people with physical handicaps to work in professional, semi-professional and non-professional non-skilled sectors is low, 2.3%, 2.7% and 7% respectively. In the context of Malaysia, ex-Prime Minister Dr. Mahathir Mohammed announced that a more aggressive effort should be implemented to ensure that the 1% allocation for employment of the handicapped in the public sector was achieved and that the private sector should emulate this (News Straits Times 13 January 1990 in Noraini et.al. (2001)). Ahmed et.al. (2003) found that one-handed users often need assistance to use personal care products.

The brief review revealed a few important points:

- Populations in all countries suffer from disabilities
- Employment opportunity should be made available for disabled people
- A majority of products are designed to be operated by two-handed users
- The majority of disabled people work as skilled, non-professional workers
- Designers can design products with the consideration of one-handed users

To acknowledge the role of disabled people in society, this project is aimed to facilitate one-handed people in getting jobs as skilled, non-professional workers, i.e. a motorcycle mechanic, by designing and fabricating a prototype of a motorcycle tire dismounting tool. This paper presents the steps in the development of a motorcycle tire dismounting tool intended for one-handed use.

2.0 METHODS, TOOLS AND RESULTS

This section explains the approach used in the development of a motorcycle tire dismounting tool. The stages, objectives and methods/tools employed in the course of the product development are presented. Since the results of each stage influenced the direction of the next stage in product development, this section also presents the results at each stage. The design approach for this research is shown in Figure 1.

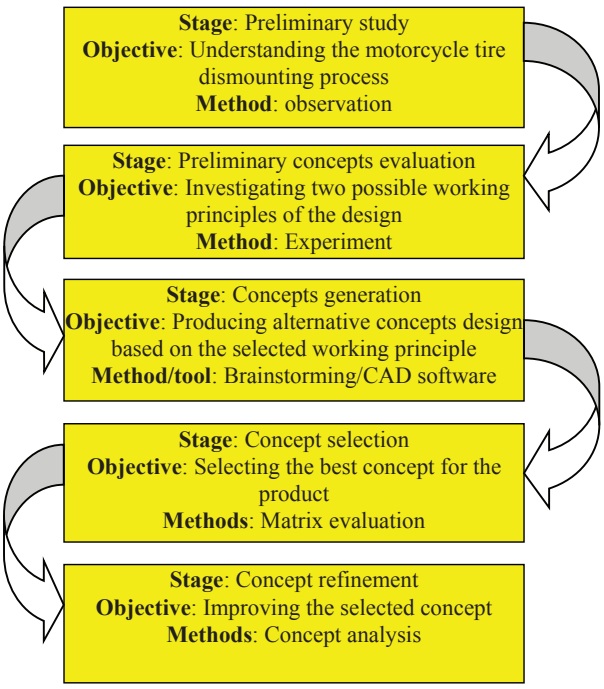

FIGURE 1
The design approach in the design of one-handed tool

2.1 Preliminary study

A preliminary study was conducted to understand the current practices in motorcycle tire dismounting. The observation method was employed to investigate the process and tools used to dismount motorcycle tires. Observation has been used as a method of research in the social sciences for many years. Observations are undertaken in real time, and if carried out in their natural environment, can capture the context of the event (Yin, 2002). This method has been employed to understand how novice and experienced design engineers approach design tasks (Ahmed, 2000). To understand the process of dismounting motorcycle tires, the observation was carried out for two days at a motorcycle workshop in Durian Tunggal Melaka. The workshop owner was contacted a day in advance for permission to conduct this study and the purpose of the study was explained. The owner granted permission as long as the observation process did not interrupt the normal operations of the workshop. During the observation, the observant simply watched and took note of what the mechanics did to dismount motorcycle tires.

The results of the preliminary study showed that the mechanics used both of their hands for dismounting motorcycle tires. Mechanics used their first hand to dismount tires from the rims at one spot, then used their other hand to dismount the tires at other spots around the rims at incremental distances using two levers, as illustrated in Figure 2. From the observation, it was

concluded that with the existing tools, the task of dismounting tires demands two-handed users. Thus, the existing tool needs modifications to be used by a one-handed user. The next stage of this research was to investigate possible working principles for the motorcycle tire dismounting tool for one-handed users by default.

FIGURE 2
Current practice of the motorcycle tire dismounting process

2.2 Product design requirement

Preparing design requirements was important to provide design guidelines for the engineers of the product. In addition, the design requirements also provided criteria for the design evaluation during the later design phases (Cross, 2000). Pugh's checklist (Pugh, 1997) was used to determine relevant issues of the product. These issues were later transformed into a set of design requirements. The most relevant requirements in the design of a motorcycle tire dismounting tool were the following:

Performance:
- Can be operated by one-handed persons
- Can dismount motorcycle tires in a short time
- Can lock the motorcycle tire in position during the dismounting process
- Should not harm the motorcycle rim

Ergonomic:
- Easy to use
- Low effort needed to use the tool
- No sharp edge

Safety
- Should not harm the user

Material for lever
- Low coefficient of friction to steel
- Can withstand up to 10kN load resistance

Standard:

- Standard size tire for the 100 to 125 cc of motorcycles

2.3 Feasibility study

An investigation of two initial working concepts for motorcycle tire dismounting tools was carried out to find the best working principles for dismounting motorcycle's tires from the rims. To evaluate these two working principles, a simple testing rig was developed, as shown in Figure 3. During the first working principle, users need to push or pull the handle around the pivot and the tire is locked into position by hand. Meanwhile, during the second working principle, the lever is locked into position by hand and the users need to push or pull the tire around the pivot. During these working principles, users need both hands.

In general, these two concepts are reasonable for a motorcycle tire dismounting tool. However, since the purpose of this project is to produce a simple tool, another factor needs to be considered. One of the constraints is that all actions of dismounting the motorcycle tire must be done manually, including the actions of pushing or pulling the tire or lever. This constraint helped meet the target cost and allowed for a simplistic tool. Through the experiment, it was found that the action of pushing or pulling the lever was easier than rotating the tire. Thus, the first working principle was adopted as a working principle of the motorcycle tire dismounting tool. However, the design of a tool intended for one-handed users must include a locking mechanism so both hands are not necessary to perform the action.

FIGURE 3
The evaluation of feasible working principle with the simple test rig

2.4 Concept generation

In the concept generation stage, four different concepts of the motorcycle tire dismounting tool were developed based on the chosen working principle. The brainstorming technique was employed to generate concepts. In the brainstorming session, many ideas were produced, although not all are reported here. Both researchers carried out the initial screening of concepts. Finally, each researcher selected two concepts, four in total, for further evaluation. These four concepts, as shown in Figures 4 to 7, were drawn with

the help of CATIA V5 solid modeling software. The characteristics of each concept are explained in Table 1.

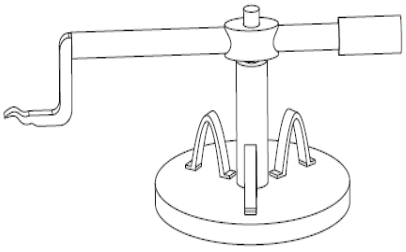

FIGURE 4 Concept-1

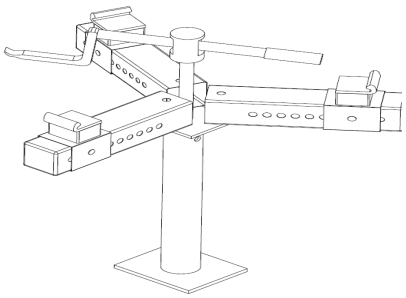

FIGURE 5 Concept- 2

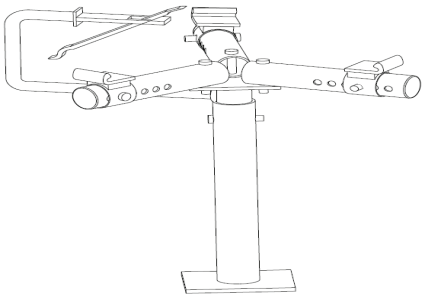

FIGURE 6 Concept-3

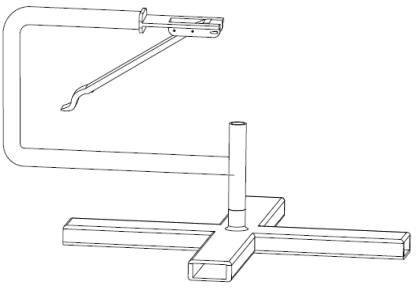

FIGURE 7 Concept-4

2.5 Concept selection

Selection of design concepts began by identifying the evaluation criteria. According to Pahl and Beitz (1996), the evaluation criteria should be based on the requirement list, thus unfulfilled requirements may lead to elimination of variants found to be unsuitable in principle. During the evaluation of motorcycle tire dismounting tools, the evaluation criteria were simple operation, function, simple construction and ergonomic aspects. These criteria were determined simply by converting the statement of objectives into measurable parameters that could be estimated with some confidence. These criteria take into consideration both the technical and the economic aspects of the product. All criteria were treated as equally important during this evaluation. The assessing values of the concepts were based on a scale of 0-4, as proposed in VDI 2225 in Pahl and Beitz (1996). To assign a score for each evaluation criteria, the designer often referred to the characteristics of each concept described in Table 1. For each particular evaluation criteria, one or more characteristics of concept design were considered. For example, to evaluate the 'simple operation' criterion, the characteristic of 'lever and handle', 'rim locking mechanism' and 'operation steps' were considered. Table 2 shows the mapping of the evaluation criteria to characteristics in the concept design. The characteristics of the concepts considered for each evaluation

criterion were indicated by 'x'. Selection of the best concepts was based on the total value obtained by the concepts. To assign a total value for each concept, the score of each evaluation criterion was multiplied by its weight. Later on, the value of each criterion was added up to find the total value for the concept. As the maximum score of each criterion is 4 points and the weight of each criterion is 0.25, the four criterias together have a maximum value limited to 4 points. As shown in Table 3, concept-3 scored the highest and was the best candidate for the motorcycle tire dismounting tool. However, the scored value of concept-3 was only 3.5, which was less than the maximum value (4 points). This concept was selected, but it was recognized as needing refinement.

TABLE 1
Characteristics of concepts design for the motorcycle tire dismounting tool

Characteristics	**Concept-1**	**Concept-2**	**Concept-3**	**Concept-4**
Lever and handle	Two components with weld joint	Two component with weld joint	Two separate components	Two separate components
Rim locking mechanism	Fixed restrictor	Adjustable clamp with pin locking	Adjustable clamp with pin locking	Nil
Working posture	Squatting	Standing	Standing	Squatting
Operation steps	The user has to put the tire and rim on the base plate; Slot the lever tip in between the tire and rim; Fit in the centre of lever to the pivot; Pull the tire vertically from the rim and push/pull the lever in horizontally.	The user has to put the tire and rim on the holder; Lock the rim with the adjustable clamping mechanism; Slot lever tip in between the tire and rim; Fit in the centre of lever at the pivot; Pull the tire vertically from the rim and push/pull the lever horizontally.	The user has to put the tire and rim on the holder; Lock the tire and rim with the adjustable clamping mechanism; Slot the lever tip in between the tire and rim; Fit in another end of lever to the handle; Push/pull the handle horizontally.	The user has to put the tire and rim on the base; Slot the lever tip in between the tire and rim; Fit in another end of lever to the handle; Push/pull the handle horizontally; Restrict the movement of tire and rim by hand.

TABLE 2
Mapping of the evaluation criteria to the characteristics of concept design

Characteristic / **Evaluation criteria**	Lever and handle	Rim locking mechanism	Working posture	Operation steps
Simple operation	**x**	**x**		**x**
Functions	**x**	**x**		
Simple construction	**x**	**x**		
Ergonomic	**x**	**x**	**x**	**x**

TABLE 3
Weighted objective method for the evaluation of motorcycle tire dismounting tool

Evaluation criteria	Weight	Concept-1		Concept-2		Concept-3		Concept-4	
		Score	Value	Score	Value	Score	Value	Score	Value
Simple operation	0.25	2	0.50	2	0.50	4	1.00	3	0.75
Functions	0.25	4	1.00	4	1.00	4	1.00	2	0.50
Simple construction	0.25	3	0.75	2	0.50	2	0.50	4	1.00
Ergonomic	0.25	1	0.25	3	0.75	4	1.00	2	0.50
Total value	4.00		2.50		2.75		3.50		2.75

2.6 Concept refinement

Concept-3 was further refined to improve the efficiency of the tool. To carry out this task, both researchers discussed the means to meet the functions of concept-3. As shown in Table 2, concept-3 scored the highest point value for the three criteria; simple operation, function and ergonomic, but was found lacking in construction. Thus, the focus of concept refinement was to simplify the construction of concept-3 without sacrificing the intended function of the tool. The functions of 'supporting the tire' and 'locking the tire' in the current design of concept-3 were fulfilled by three cylindrical tubes and adjustable clamps with a locking pin (refer to Figure 6). The researchers decided to redesign these two components with a circular plate and two clamping mechanisms, as shown in Figure 8.

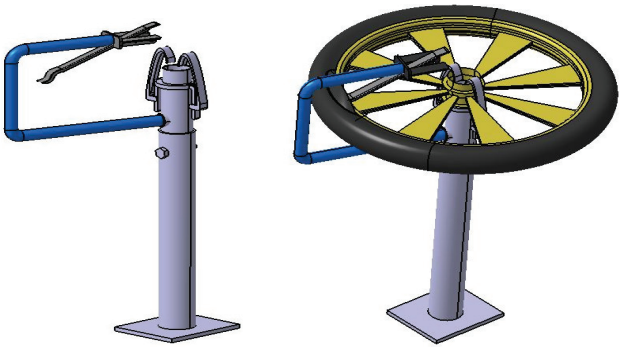

FIGURE 8
Final concept of the motorcycle tire dismounting tool

3.0 PROTOTYPE DEVELOPMENT AND PRODUCT TESTING

The fabrication of the motorcycle tire dismounting tool was carried out in the fabrication laboratory of Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka. The material used for the tool was mild steel.

Initially, each individual part of the tool was made and later was assembled with a welding process. Figure 8 shows the final design of the motorcycle tire dismounting tool. The functionality of the product was tested, as shown in Figure 9. The purpose of the testing was to measure the required force for pushing or pulling the tool handle to dismount tires from rims. The experiment showed a required force of 29 N was needed to push or pull the tool holder.

FIGURE 9
Measuring the required force to pull or push the tool handle

4.0 CONCLUSIONS

This project focused on the design and prototype development of a motorcycle tire dismounting tool for use by one-handed users. The aim was to provide access to one-handed users, subsequently providing work opportunities for disabled people, specifically one-handed users. The design of the motorcycle tire dismounting tool achieved the purpose of this project as one-handed users can operate the tool without need for assistance. In addition, users only need to exert 29 N force to push or pull the handle of the tool.

5.0 ACKNOWLEDGMENT

The author would like to thank Universiti Teknikal Malaysia Melaka for the technical support.

5.0 REFERENCES

Ahmed, S. and Dong, H. and Clarkson, P.J., *Understanding issues facing one-handed users. In: International Conference on Inclusive Design and Communications* (INCLUDE 2003), 25- 28 March, London, UK, 2003.

Ahmed, S., Understanding the use and reuse of experience in engineering design, *PhD Thesis*, Clare Hall, University of Cambridge, 2000.

Cross, N., Engineering design methods: strategies for product design, 3rd edition, John Wiley & Sons Ltd., West Sussex, UK. 2000.

Department of Social Welfare, Rehabilitation centre for the orthopedically handicapped centre, Kuala Lumpur: *Legal and Advocacy Division*, 2006.

ILO, Disability and employment in Asia, Bangkok, 1994.

Pugh, S., Total design: integrated methods for successful product engineering, Addison-Wesley Longman Ltd., Essex, UK. 1997.

Pahl, G. and Beitz, W., Engineering design: a systematic approach, 2nd. Addition, Springer-Verlag London Ltd., Great Britain, 1996.

Salleh, N.M., Abdullah, K. and Buang, N.A., Job opportunities for special needs population in Malaysia, *Jurnal Pendidikan, 27* (2001) 77-85.

Yin, R. K., Case study research, design and methods, 3rd ed. *Newbury Park*, Sage Publications,2002.