Adaptation of single-track vehicles to the needs of people with disabilities

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Abstract. Globally, people with disabilities constitute 15-20% of the population, and the ability to move freely determines a person's independence and participation in socio-economic life. This paper discusses the limitations in the use of motorcycles by people with special needs as a means of personal transport and the possibilities of their adaptation for such people. There are a number of difficulties in adapting a motorcycle, including limited space for placement of mechanisms to facilitate motorcycle control, lack of universal solutions to fit different motorcycles and suitable for people with different disabilities.

1. Introduction

It is estimated that there are between 785 million (World Health Survey) and over one billion people with disabilities worldwide (World Health Organisation), representing approximately 15-20% of the population, of whom between 110 million and 190 million adults experience significant functional difficulties. In addition, about 93 million children - or one in 20 people under the age of 15 - live with moderate or severe disabilities. The number of people with special needs will continue to rise due to ageing populations and a global increase in chronic health conditions. National patterns of increasing numbers of people with special needs are influenced by trends in health conditions and environmental factors such as road accidents [1], falls, violence, humanitarian crises including natural disasters, conflict and armed action, unhealthy diet and substance abuse, conditions acquired with age, among others. [2]
Despite almost 150 years of development of motorbikes, their general design is still very close to the first solutions. Technical progress, specialization, as well as many years of using motorbikes for different tasks, resulted in the separation of several different designs of these vehicles, but mainly in terms of functional characteristics. The classification of such vehicles as scooters, choppers, cruisers, classic and touring motorbikes, off-road motorbikes (cross, enduro, funduro, etc.) and sport motorbikes is determined by the purpose, engine displacement, engine type and power, means of propulsion, frame geometry or number of wheels. This classification is also useful for people with special needs, but only in very few cases will these people be able to use a motorbike without first adapting the vehicle. [3]
However, literature related to adapting motorbikes for persons with special needs is difficult to find, and those publications that exist contain redundant or unstructured information, such as [4], and the group of persons who are both disabled and qualified to drive motorbikes may be numerous.
Based on the data made available by the Central Statistical Office (GUS) for 2018 [5], it can be stated that in Poland people with a disability certificate accounted for more than 6% (2451700 people) of the population. At the same time, in that year, the driving licence authorising to drive single-track vehicles equipped with an engine was held by nearly 23% (8793612 people) of citizens. Therefore, there may be more than half a million potential people with special needs with a licence to ride motorbikes or mopeds. Unfortunately, it is difficult to know what proportion of these people currently use single-track vehicles

and how many would like to use a single-track vehicle, but are unable to do so. For this reason, the search for solutions to adapt single-track vehicles to the needs of people with special needs appears to be an important piece of research. Therefore, the following section will discuss the difficulties encountered by people with special needs in terms of disability in general and the possibilities of adapting specific systems of a motorbike to enable such people to get around.

2. Difficulties in driving single-track vehicles encountered by people with disabilities

Limitations in performing various activities can be both congenital and acquired. On the one hand, they may be caused by the consequences of an accident, while on the other hand they may be acquired with age. While people with mobility constraints from birth do not perceive their limitations as a limitation, for people who were fully able-bodied the first encounter with a new reality can be a very difficult experience. [6]

On the basis of statements made by people with acquired disabilities it can be concluded that there are still shortcomings in the design of motorbikes which would make them easier to use for people with special needs. First of all, the problem lies in the need to place the levers or linkages in such a way that they can be used with a given mobility constraint. In the case of a person with right arm paresis, it is necessary to move the accelerator lever from the right to the left side and the front brake lever. A person with lower limb paresis, on the other hand, has more difficulties. Even just sitting on the motorbike can be difficult. This may be due not only to the fact that a motorbike is inherently unstable because it has two wheels, but also to the height at which the seat of the motorbike and the seat of the wheelchair assisting the person's daily mobility are located. However, a modified motorbike seat can transmit vibrations that can cause vibration sickness. [7] There is also still the issue of taking the wheelchair with you so that you can still get around after the journey. Lower limb paresis makes it difficult to manoeuvre the motorbike as there is no leg support for steeper inclines when riding at low speed. In the case of both upper and lower limb paresis, it is also important to fix them so that they do not move while riding. In addition, it is necessary to move the gear lever and the rear wheel brake lever. However, it is important to remember that space on the steering wheel is limited and excessive or poorly guided linkages can make it difficult to turn the wheel.

In the absence of ready-made solutions, some people with disabilities are forced to make them themselves, as each one is non-standard. This is particularly due to the variety of motorbike designs. Therefore, not only the limitations the rider has to take into account, but also to which model of motorbike they will be dedicated.

Constant advances in technology are resulting in an increase in electronically controlled systems, an example of which is the Ride By Wire system. Whilst the concept is simple, replacing the throttle linkage with a potentiometer that registers the position of the accelerator handle, not everyone will have the knowledge to make the necessary modifications without damaging the system. An additional difficulty will be changing the direction of the potentiometer. Even if such modifications are made, the new motorbike is likely to void the manufacturer's warranty.

Nevertheless, adapting a motorbike to the needs of a person with disabilities is possible and not only for touring or city riding. There are numerous examples of people taking part in motorbike racing on both paved race tracks and motocross courses. Similarly, there is no shortage of people doing stunt riding on motorbikes such as stunt. However, modifications must be done carefully as there is no obligation to homologate them, and this could translate into a number of accidents involving motorbikes. [1], [8].

3. Modifications of a single-track vehicle due to upper-body dysfunction

Regardless of the type of upper body disability, it is a good idea to fit a torsional vibration damper (commonly known as a steering damper). This solution will reduce the impulsive effects transmitted from the road to the driver's hands. There are various solutions (rotational and telescopic), each of which must be matched to the type of motorbike. Sometimes motorbikes are fitted with such a system from the outset, so that it is electronically controlled and adapts to some extent to the riding conditions.

It is also important to fix your hands to the handlebars if your grip is too weak. However, this must not be done permanently because of the possibility of an accident, the consequences of which would be much more serious. In this case it is sufficient to use a Velcro-type tape on the inside of the glove. This will make it possible for the rider to disconnect from the motorbike.

3.1. Reduced right-handedness

Motorbike components that require a capable right hand to operate include the accelerator handle, front wheel brake lever and engine start button. With a right hand impairment it is necessary to relocate the primary throttle and front wheel brake controls. It is not necessary to relocate the engine start button as it is not used while driving but only when stationary and only once.

If the difficulty in operating the accelerator handle is only due to reduced wrist mobility due to e.g. tendinitis, then the mechanism used on quads can be used, i.e. the throttle control lever with the thumb (Figure 1).

Figure 1. View of thumb operated throttle control lever.

However, it is usually sufficient to move the accelerator handle to the left side. In this case, only the cable routing is upwards (Fig. 2 and Fig. 3), which does not affect the comfort of the vehicle. If, for some reason, the length of the linkage is unsuitable, replacements can be made in a suitable length.

Figure 2. View of the left side of the steering wheel after relocating the right-hand controls (front view).

Figure 3. View of the left side of the steering wheel after relocating the right-hand controls (back view).

The second major component requiring modification is the front wheel brake lever. In this case the adaptation of the brake lever is based on a double lever system. In this case the lever is either combined with the clutch lever (Fig. 4-6) or placed next to it (Fig. 3).

Figure 4. View of double clutch lever with two cables.

Figure 5. View of double clutch lever with cable and hydraulic line.

Figure 6. View of double clutch lever with two hydraulic lines.

Due to the low force required to use the front brake lever, levers of different lengths can be used, where the longer one can serve as the clutch lever (Figure 7).

Figure 7. Combined brake and clutch lever view

On certain types of motorbikes it is also possible to dispense with the clutch lever altogether, thanks to designs that allow the clutch to be automated (Figure 8). The principle of such a clutch is based on centrifugal force. As a result of the centrifugal force, the weights between the two discs move towards the outer part of the disc. On each of them there are specially shaped surfaces which cause the discs to move apart. This works in a similar way to centrifugal clutches on mopeds, but it works much better even with small changes in speed.

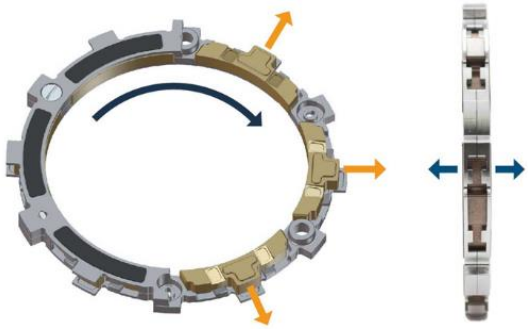

Figure 8. View of the disc for automating the clutch action.

3.2 Reduced left-handedness

If it is difficult or impossible to use the left hand, it is necessary to be able to use elements such as the clutch lever, direction indicators, horn, light switch, hazard warning lamps. The design of the clutch lever was discussed earlier and it is only necessary to move it to the right side. However, the main difficulty that remains in this case is the possibility of using switches.

A solution to such a problem could be the use of a handgrip with integrated buttons to operate the switches (Figure 9). It should be noted, however, that the left and right sides must have different inner diameters. Depending on which side the accelerator control lever will be located.

Figure 9. View of the pushbutton grips.

Unfortunately, it may be difficult or impossible to move all the switches to one side of the handlebar due to limited space. However, given the single handedness of the handlebars and the increased steering effort required, a wider handlebar may be worth considering. Increasing the width by 50-70 mm on one side will not be difficult, and may improve the riding comfort of the motorbike.

4. Modifications to a powered two-wheeler due to lower body dysfunctions

Limited lower body dexterity makes the three-wheeled motorbike an obvious choice for people with special needs. This is due to the ease of keeping the motorbike upright and manoeuvring. Of the solutions available directly from the manufacturer, here we can mention either motorbikes with two front or rear wheels - popularly known as traikes. These may come with open or closed bodies. Such vehicles are offered by manufacturers, i.e.: Yamaha, Piaggio, Harley-Davidson or Can-Am. In addition to these, there are designs that allow people using wheelchairs for people with disabilities to ride a motorbike. (Figure 10).

Figure 10. View of motorcycles for people using wheelchairs

In this case, steering of the front wheel of the motorbike is performed by a lever system. The benefit of this design is that the amount of force exerted by the rider on the motorbike's steering can be increased by adjusting the lever length. However, a vehicle of this design may not be a popular choice. On the one hand, this is due to its relatively complex design. It is still necessary to control systems which are in this case remote from the rider. Another aspect may be the difficulty in legalising such a vehicle. Not in every country is it possible to put such a modified vehicle into circulation. The final aspect to be mentioned is the perception of such a vehicle by other road users. It will certainly draw attention to itself, and not everyone is comfortable with this. Sometimes motorbikes with a sidecar without its modification are used. Although this provides stability while riding, there is still the difficulty of accommodating the wheelchair that the person uses every day.

4.1. Limited use of the right leg

The only mechanism on a typical motorbike that is operated by the right leg is the rear wheel brake lever. In this case the solution is similar to the clutch. It can be moved to the handlebars by connecting it either to the clutch lever or to the front wheel brake lever, using one of the solutions shown in Figure 2. Another solution is to move it to the left side and make a double lever, where one will be used for shifting gears and the other for the brake lever.

4.2. Limited left leg capacity

On a typical motorbike, the gearshift lever is located on the left side near the engine. On a few motorbikes, especially older ones, there were manually operated levers. However, if this is not available, there is a system with an electronically or pneumatically controlled actuator (Figure 11). Using a suitable adaptor kit it is possible to fit this to most motorbikes. The system has handlebar-mounted switches so that the gear ratio can be changed with either the right or left hand.

Figure 11. View of the actuator controlling the gear shift lever.

5. Summary and conclusions

This article presents selected methods of adapting motorbikes to the needs of people with special needs. Currently it is difficult to find solutions that would be universal for each person and for different motorbikes. Available solutions for the adaptation of individual mechanisms as well as entire vehicles are not widely available in different countries and have to be sourced in-house. The main difficulties in adapting motorbikes include the limited space available and the diversity of design solutions. There are numerous examples showing that motorbikes can be used by people with different levels of disability for both urban touring and sport riding, so a motorbike can be adapted to the needs of people with special needs, but at present this must be done on a case-by-case basis. In the future, the spread of By-Wire steering will make it easier to modify motorbikes due to the presence of actuators acting on specific mechanisms, while the position of control elements will be relatively easy to change.

Literature

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