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MOTORCYCLE DESIGN: OBSERVATIONS ON STATUS AND RESEARCH NEEDS

Report of the Subcommittee on Motorcycle Design of the Committee on Motorcycles and Mopeds Transportation Research Board

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The last several years have brought about continuing change in the design of motorcycles and associated equipment. These changes have sought to improve the performance, safety, comfort, and enjoyment of motorcycle operators.

The nature of recent design changes, and their implications for future research, have been reviewed by the Motorcycle Design Subcommittee of the Committee on Motorcycles and Mopeds of the Transportation Research Board. This report summarizes the results of this review.

The specific vehicle components and equipment reviewed by the committee include the following:

- Brakes
- Suspension Systems
- Lights
- Helmets

These components are some of the ones subject to design changes in recent years. Other components, such as fairings or cargo carrying equipment, were not addressed.

Brakes

Some of the potential changes in the design of motorcycle brake systems that were discussed include:

- Special friction materials
- Anti-lock brake systems
- Integrated braking systems.

Special Friction Materials

In wet weather, the collection of water on brake discs, pads, and linings may affect the performance of brake systems and increase stopping distance. While the fact that motorcycles are not widely operated in wet weather tends to minimize the consequences of this factor, a number of alternative designs have been considered and their effect upon wet weather operations studied. Generally speaking, these materials may improve wet weather brake performance, under some conditions, without compromising performance in dry weather.

One drawback to such designs is the direct and indirect costs involved. First, they can be more expensive to produce and can add to the purchase cost of the vehicle. Secondly, some of these materials may lead to greater wear of both disc and pad and, therefore, require more frequent replacement. Thirdly, for some materials there may be side effects that can produce an undesirable brake feel. For these and other reasons, such brake materials may not be widely used except on vehicles subject to a high frequency of wet weather operation.

Anti-Lock Brake Systems

Wheel lockup on a motorcycle can cause the vehicle to capsize, particularly where it is the front wheel that locks up. Fear of locking wheels is believed one of the reasons why riders do not apply the brakes to the maximum when faced with an emergency. To encourage and permit effective brake application, particularly under low coefficient conditions, anti-lock systems have been studied for some time. As a result of this effort, several mechanical and electronic, prototype anti-lock systems have been developed.

Because an anti-lock brake system can involve reducing the brake force for very short periods, it may not stop the vehicle quite as quickly as a steady force just short of lockup, particularly on a high coefficient surface. On dry pavement it may not, therefore, achieve quite as short a stopping distance as a regular brake system operated by an expert. On wet surfaces, anti-lock systems may stop the vehicle more effectively than regular brakes. For the motorcycle rider, anti-lock systems can permit relatively short stops without fear of capsize on wet or dry surfaces.

Anti-lock brakes are most effective in preventing capsize if both wheels are so equipped. To do so might add several hundred dollars to the cost of the vehicle. How many motorcyclists would be willing to pay this amount for a device that is most effective in unusual circumstances is a question. Another question is to what extent motorcycle operators are prepared to make effective use of anti-lock systems on low coefficient surfaces.

The questions just raised are researchable. Specifically:

- Can motor cycle operators be induced or trained to utilize an anti-lock brake system to apply one or both brakes effectively in an emergency, particularly on low coefficient surfaces?

- How much are riders willing to pay for an anti-lock system?

Other research and development questions related to such systems are clearly the province of the manufacturer. Beyond the research questions, there are obvious legal issues related to liability in the event an anti-lock system fails.

Integrated Braking Systems

The fact that motorcycle riders do not make effective use of the front brake has led to the study of integrated or single-point braking systems, in which operation of a single brake control results in application of both front and rear systems. An integrated braking system can help assure that the braking contribution of the front brake is utilized more effectively by some riders.

Several motorcycles already employ integrated braking systems. They have the advantage of allowing operators who only use the rear (foot) brake to achieve better braking without changing their current habits. On the other hand, some designs may have the disadvantage of preventing truly proficient operators from using brake feel to achieve closer to maximum braking than an integrated system. It is also difficult (and often impractical) to alter the mix of front and rear brake forces to match changes in loading, roadway, and traffic conditions.

A combination of integrated and anti-lock braking systems could permit operators to achieve close to maximum braking under all conditions with the application of a single brake control. The integrated brake system would apply both brakes while the anti-lock system could assure that both brakes were applied to a degree just short of wheel lock, under most conditions.

The research questions which might be addressed in connection with integrated braking systems include the following:

- How does the response and performance of various existing and potential integrated braking systems compare with that of dual braking systems for a range of operators under various conditions?

- How might the further addition of an anti-lock braking system alter the answers to the above question?

- What cost are operators willing to pay for such an integrated brake system, with and without anti-lock, to achieve their benefits?

Other research and development questions in this area can best be addressed by the designers and manufacturers.

Suspension Systems

Recent design trends in motorcycle suspension systems have included such factors as:

- Shaft drives

- Adjustable suspensions.

These developments have been aimed at improving rider comfort, ride quality, handling and braking performance. At the moment, there appear to be no research issues beyond those falling in the domain of the actual design and manufacturing process.

Headlights

The motorcycle headlight serves two functions:

- To illuminate the path ahead at night
- To make the motorcycle more noticeable.

Recent developments have offered opportunities to improve the headlight's ability to serve both of these functions.

Nighttime Illumination

The level of illumination that can be provided to motorcycle operators has increased in recent years due to (1) advances in headlight design (e.g., permissibility of halogen lamps), and (2) the incorporation of improved electrical systems on motorcycles. These developments have ameliorated possible nighttime driving problems that may have arisen from the low illumination available from the single, low-power headlamps that have characterized some motorcycles in the past.

While brighter headlights may improve the motorcycle rider's ability to see, they may do so by increasing hazard and annoyance to other motorists. First, a single high-intensity headlight may cause greater glare than two automobile headlights having the same combined luminance. Second, a motorcycle headlight may be mounted at a greater height than an automobile headlight which could cause greater glare when following a vehicle ahead. However, properly designed and adjusted quartz lights can minimize excessive glare.

Conceivably, the problem of glare could be reduced by the use of multiple lights or variable intensity lamps to allow luminance to be reduced in traffic or when there is adequate highway illumination. These accomodations, however, might require attention and action on the part of the rider.

Research questions that should be addressed include the following:

- What is the effect of higher intensity lights upon other motorists?
- What changes in headlight design and/or location might minimize glare or other adverse side effects?
- What levels of intensity might be the optimum for both motorcycle operators and motorists, i.e., the overall traffic mix?

Noticeability

One of the factors that contributes to the motorcycle's accident vulnerability may be its small profile, which makes it very difficult to detect in a head-on position. Research has shown that daytime use of headlights makes the motorcycle more noticeable and reduces accident risk.

In recent years, consideration has been given to the use of flashing headlights to further increase noticeability. Research has shown that the use of oscillating, pulsating, interrupted, or stroboscopic lights may increase the probability of detection and response by other motorists. The effectiveness of flashing lights has not as yet been assessed in terms of accident reduction.

Some concern has been expressed over the possible epileptic-seizure-inducing properties of flashing lights. However, the objective evidence that is available suggests that this concern is not justified. The ability of flashing lights to cause seizures appears to be confined to a fairly narrow range of flicker frequencies, coupled with high intensities, which can be avoided in the use of headlights. Apparently, there is no evidence of seizures having been caused by the types of flashing lights used by emergency vehicles or in outdoor advertising.

Consideration of flashing headlights gives rise to the following researchable questions:

- What is the effect of combinations of headlight frequency, intensity, and wave form upon the conspicuity of the motorcycle?
- What is the effect of the same variables upon such factors as potential distraction, interference, confusion, and annoyance?
- What effect does the addition of flashing motorcycle headlights have upon the detection of other emergency signals (e.g., emergency vehicles, four-way flashers)? Does the flashing light detract from or obscure same?
- What is the relationship between the conspicuity of a flashing light and a steady light of greater intensity?
- What is the feasibility of headlights that can be switched from steady to flashing status on an as-needed basis?
- What is the effect of "other motorist" variability?

Helmets

Recent continuing changes in helmet design involve their crash protection qualities and the use of inside-the-helmet audio receivers.

Crash Protection

The wearing of a helmet probably represents the single most important step that can be taken to reduce the likelihood of injury in a motorcycle accident. Recent years have brought about great advances in the impact resistance of helmets. For example, the use of polycarbonate and fiberglass shells, coupled with styrene padding, have greatly increased the protection afforded by helmets.

For the past ten years, the manufacture of helmets has been strongly influenced by mandatory Department of Transportation standards. The fact that helmets do not prevent all head injuries has led, in some quarters, to the question of whether DOT standards are adequate. Accident research indicates that very few injuries sustained by riders wearing helmets meeting the DOT or other standards would have been prevented by increases in impact resistance. Greater facial coverage would have a more beneficial effect. Tougher mandatory standards might actually prove counter-productive. In states where helmet wear is not mandatory, the increased cost of helmets meeting stiffer standards could discourage the purchase and wear of any helmet.

At the present time, there does not appear to be a great need for improvements or research in the crash protective qualities of helmets, or for stiffer construction standards.

Audio Systems

In their efforts to make motorcycle riding more comfortable and enjoyable, riders are interested in equipping their vehicle with the amenities heretofore found only in automobiles. Among these

are radios. They have proven so popular that most large fairings are now manufactured with punchouts for mounting amplifiers and stero speakers.

The sound quality of fairing speakers is severely compromised by such things as the noise of the engine, road, traffic, and rushing air. To overcome this problem, riders and manufacturers have been experimenting with small transducers that can be mounted inside the helmet. If placed in the lower part of the helmet, these speakers need not compromise the helmet's impact protection qualities. Another safety consideration is the possible effect of helmet speakers upon the detection of horns, sirens, and other emergency warnings. Since they do not cover the ears -- such would be illegal in most areas -- they do not physically interfere with the reception of such sounds. However, at higher volumes, they might easily mask critical warnings. Research completed recently shows that such masking does indeed take place. However, with the installation of suitable filters, the masking effect can be reduced to a point where the ability to detect warning signals is equal to that which characterizes fairing speakers.