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Leg Guard Chronicles: An Analysis of Motorcycle Leg Guard Variations, Market Trends, and Compatibility

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Abstract - *This paper provides an in-depth exploration of motorcycle crash guards and leg guards, essential components in enhancing rider safety and protecting motorcycles from unforeseen incidents. We navigate through the current trends in the market, analyzing what riders are looking for in terms of design and functionality. From sleek and stylish designs to those with robust protective features, we delve into the diverse landscape of options available. Additionally, we scrutinize the compatibility of these guards with various motorcycle models, ensuring a comprehensive understanding of their adaptability. This study aims to serve as a practical guide for riders seeking suitable protection and for manufacturers aiming to meet the evolving demands of the market. By combining insights into market trends, design variations, and compatibility factors, this paper offers valuable perspectives to a wide audience interested in the world of motorcycle crash guards and leg guards.*

Key Words: **Bike accessories, Leg guard, motorcycle crash guard, ride safety**

1.INTRODUCTION

The primary objectives include analyzing current market trends, understanding consumer preferences, and identifying emerging technologies. The report seeks to closely examine the diverse design variations in these guards, considering both aesthetic appeal and functional features. Additionally, a key focus is on assessing the compatibility of these guards with various bike models, recognizing the importance of adaptability to different motorcycle structures. By achieving these objectives, the report endeavors to offer valuable insights for riders, manufacturers, and industry stakeholders, contributing to the enhancement of safety measures and user-friendly experiences for motorcycle enthusiasts.

1.1 Background

Since the EEVC 1993 report, the only study that describes the problems of leg injuries is that of Otte (1994). Much of what is contained below is from Otte's report but it is important to give a very brief extract from the EEVC report for comparison, as follows:

"Mackay (1985) suggests two general mechanisms of leg injury, direct impact with the other vehicle and crushing between the motorcycle and the other vehicle, and this distinction between a direct blow and trapping between the two vehicles is clear in many injury studies, for example Hurt et al. (1981) and Nyquist et al. (1 985),who document the production of rider nearside lower leg injuries due to trapping between motorcycle and the other vehicle, or the pinching action experienced when the cycle 'slaps' against the car."

However, many of the above studies are somewhat old and the one of the recent studies is that of Otte. Therefore, this was examined in detail to determine how the current patterns of leg injuries differ from those described above. Otte completed this study to analyze the risk to motorcyclists of leg injuries in accidents and to find the opportunities for leg protection by comparing risks for those injured on machines with and without leg fairings. Each injury was analyzed by type, leg area and severity (AIS) and correlated to the impact situation with impact direction, impulse angle, load and characteristics of kinematic behavior; 258 motorcycle accidents with cars were analyzed for leg injuries. Otte's study confirms previous findings that some 60% of the motorcyclists in accidents sustained leg injuries, mostly fractures of injury severity AIS 2-3.

The presence of fairings had little effect on the overall incidence of head and thorax injuries; 19.3% with and 18.1%without fairings for the head and 25.9% with and 22.8%without fairings for the thorax. However, Otte makes the point that a change in the rider kinematics is observed with leg fairings and this accounts for the different distribution of injuries among the collision types.

Otte also quantified the likely benefits for leg injuries. It was estimated that an overall reduction of 21.1% of leg injury costs could be achieved with leg protection. The costliest collision types were type 1 (motorcycle comes across path of car resulting in an impact to the side of the bike) and type 2 (motorcycle collides with front of another vehicle) for which an estimated reduction of 31.7% could be achieved. However, the greatest benefit, 34.6%, would be for type 5 collisions (motorcycle collides with rear

of another vehicle) and 6 (another vehicle collides with rear of motorcycle).

Note*: Constructional suggestions for leg protectors included recommendations for the foot to be covered from the side and front and the design of protection to include the elimination of compression effects. It was also stated that the tibia must be protected in the front by an energy absorbing element although the rider must be free to leave the motorcycle during the impact.

1.2 Role of crash guards and leg guards in prevention of injuries

Crash guards and leg guards play a crucial role in preventing injuries during accidents, particularly in the context of motorcycles. Crash guards, also known as engine guards or crash bars, provide protection to the motorcycle's engine and other critical components in case of a fall or collision. They help absorb impact and minimize damage to the bike, reducing the risk of injuries to the rider.

Leg guards, commonly referred to as leg crash guards or highway pegs, are designed to protect the rider's legs in case of a crash. They can help prevent fractures and other injuries by acting as a barrier between the rider's legs and the ground or other obstacles.

While these guards are not foolproof, they significantly contribute to rider safety by mitigating the severity of injuries in certain situations. It's important for riders to choose and install these guards properly, considering their bike model and intended use.

2. Market Overview

In the Market Overview, we explore the diverse world of leg guard designs and variations, highlighting current trends, consumer preferences, and market dynamics. By examining the latest innovations and competitive landscape, we aim to provide a comprehensive understanding of the factors driving the market and the potential for future growth.

2.1 Design Variations

Designs in market vary with respect to bike models, but with these structural variations there are a lot more variations in material and ergonomic considerations which ultimately affect the financial market of leg guard.

Sl. No.	Model type	3D Model
1.	Single rod type	
2.	Rectangular type	
3.	Butterfly type	
4.	Diamond type	
5.	Air fly type	

Figure 1 Available Designs of leg guards

Materials used for motorcycle leg guards or engine guards often adhere to specific specifications outlined by organizations such as the Indian Standards (IS) and these are mostly as listed below.

1) Mild Steel (MS):

- Specifications: Generally, follows IS 2062 standards for hot-rolled steel.
- Designation: IS 2062:2011 - Hot Rolled Medium and High Tensile Structural Steel.

2) Aluminum Alloy:

- Specifications: Various grades such as AA6061, AA6063, or AA7075.
- Designations:
  - AA6061: IS 733:2001 - Wrought Aluminum and Aluminum Alloys Sheets and Strips for General Engineering Purposes.
  - AA6063: IS 1285:1997 - Wrought Aluminum and Aluminum Alloys Extruded Bars, Rods, Tubes, Sections and Profiles.

3) Stainless Steel:

- Specifications: Grades like SS304 or SS316 are commonly used.

- Designations:
  - SS304: IS 6911:1992 - Stainless Steel Plate, Sheet, and Strip.
  - SS316: IS 6911:1992 - Stainless Steel Plate, Sheet, and Strip.

4) Carbon Fiber:

- Specifications: Varies based on the manufacturer and intended application.
- Designations: No specific IS designation, as carbon fiber materials are generally manufactured to industry or proprietary standards.

5) Titanium Alloy:

- Specifications: Different grades such as Ti-6Al-4V or Ti-3Al-2.5V.
- Designations:
  - Ti-6Al-4V: No specific IS designation, as titanium alloys are often manufactured to ASTM (American Society for Testing and Materials) or other international standards.
  - Ti-3Al-2.5V: Same as Ti-6Al-4V, typically conforms to ASTM standards.

2.2 Current trends in Motorcycle Crash Guard Leg Guard Market

A. Electronic Implementation

In such systems, crash guard is made retractable with the help of electronic circuits. The Electronic Circuit calculates the instantaneous roll angle and controls the movement of the crash guard. The ADXL345 accelerometer is used to measure the static acceleration of gravity for tilt-sensing applications. It is a small, thin, and low power 3-axis accelerometer with high resolution (4 mg/LSB) which, enables measurement of inclination changes less than 1.0°. LCD 1602 display is used to display the instantaneous roll angle and, DC motors are used for the movement of the crash guard.

B. Mechanical Implementation

The Mechanical Implementation consists of two mechanisms; a cam mechanism, and the crash guard frame. The cam mechanism driven by the DC motors moves the crash guard frame. It transforms the rotational motion from the motors into linear motion for extending and retracting the crash guard frame.

C. Anti-skid crash guard

In moto gp type crash guards, wheels are attached at both ends of the guard so as to maintain the momentum of bike even when taking stiff turns and sliding over the dry tarmac. Therefore, acting as an independent safety system for bikes.

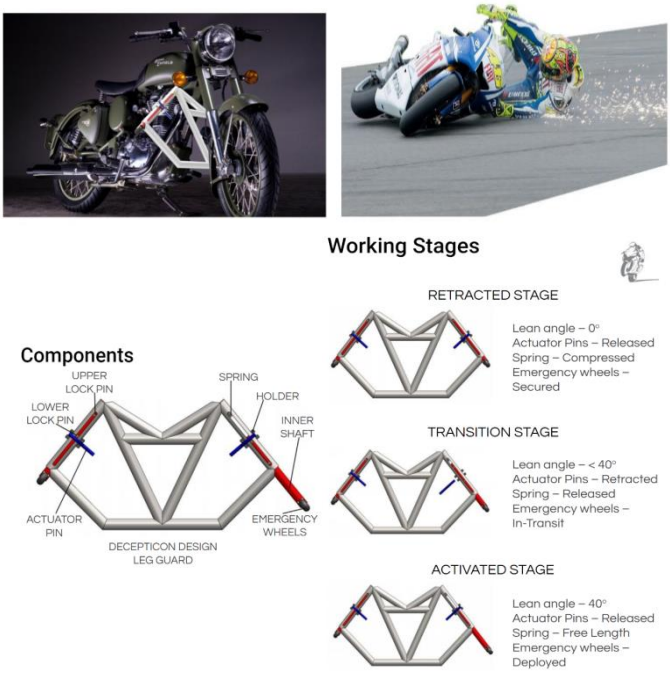

Figure 2 Anti-skid crash guard working

2.3 Market Dynamics and Influencing Factors

The market dynamics surrounding leg guards, also known as crash bars or engine guards, in the motorcycle industry are driven by a combination of safety concerns, evolving rider preferences, and technological advancements. As motorcycle safety regulations become more stringent, manufacturers must ensure that their leg guards meet or exceed these standards, leading to a focus on robust design and compliance with safety requirements. Moreover, changing trends in motorcycle usage, such as the rise of adventure touring and off-road riding, contribute to the demand for leg guards that offer enhanced protection against impacts and debris.

Material innovation plays a crucial role, with lightweight yet durable materials like aluminum alloys and composite materials gaining traction due to their ability to provide superior protection without adding excessive weight to the motorcycle. Additionally, aesthetic considerations and compatibility with various motorcycle models drive product development, as riders seek leg guards that not only offer safety but also complement the overall look and feel of their bikes. As the aftermarket

accessories market continues to thrive, manufacturers compete to offer innovative, customizable leg guards that cater to the diverse needs and preferences of motorcycle enthusiasts while maintaining affordability and brand reputation.

The global motorcycle market is likely to be of US$ 8.84 Billion in FY 2022, up from US$ 8.39 Billion in 2021. From 2022 to 2032, motorcycle accessories sales are supposed to increase at CAGR of 6% to reach a value of US$ 15 Billion by the end of 2032.

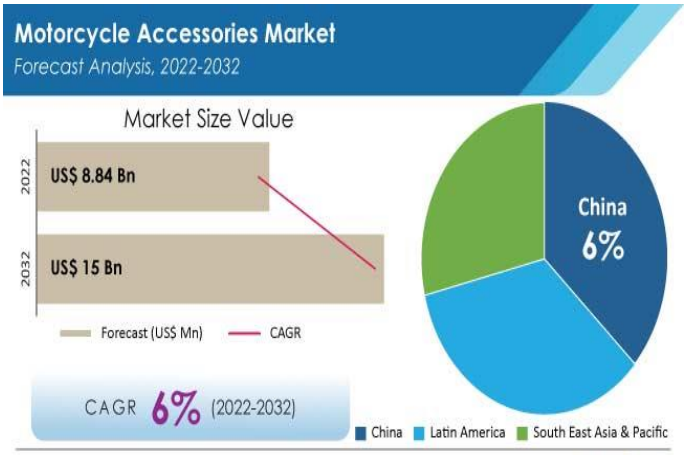

Figure 3 Motorcycle accessories market analysis

In Asia, market value is supposed flourishing to whopping amount of US$ 7.5 Billion. Key contributors to this growth are namely TVS motors, Hero MotoCorp, Yamaha Motor, Harley Davidson, Vega Auto Accessories, Studds Accessories, Om Steel industries & Steelbird Hitech India ltd, etc.

3. Opportunities for Further Research

In 1993 the European Commission in its action programme on road safety stated in the section on active and passive vehicle safety that it proposed to take new initiatives forward which included leg protection devices for mopeds. Mind you they also said that they would also look at devices for preventing increasing speed limits imposed by construction, in particular for two-wheel motor vehicles.

Stepping into the frame in practical terms and up to the plate was the then Roads Minister Peter Bottomley, the Transport Research Laboratory (TRRL) and a Doctor Bryan Chinn, who had previously in 1985 Bryan Chinn presented his PhD thesis "Injuries to Motorcyclists' Legs: Testing Procedures and Protection", with the claim that leg protectors would protect riders from serious leg injuries.

The research by the TRRL was questioned by the motorcycle industry, IMMA (International Motorcycle Manufacturers Association) and members of the Japan Automobile Research Institute and Dynamic Research, Inc. who commissioned their own studies. The results showed that the leg protector design was only beneficial in 25% of accident situations and actually detrimental in 50% of accidents.

Note*: Worse still the effects of the leg protectors on head trajectory and deceleration would lead to increased severe and fatal head injuries. This is caused by the leg protectors restraining the rider and causing pivoting around the hips bringing the head into contact with the car that the motorcycle was in collision with. There was also an increased chance of pelvis fracture, which is potentially fatal. The net result of that design was the lower leg injuries would be transferred to upper leg, torso, and head injuries.

4. CONCLUSIONS

After going through all the above details, we conclude that:

- Design of Leg guards and crash guards be such that it does not restrain the movement of rider in any case. This results in transmission of impact force to motorcycle components and not to the rider body.
- Tubular structures are preferred over Leg protectors. Because they are light weight and do not oppose the basic movement of rider in case of accidents and impacts.
- Overcoming challenges in achieving compatibility requires a holistic approach, combining innovative design, adaptable materials, rigorous testing, and a keen understanding of user preferences. The success of a universal leg guard hinges on its ability to seamlessly integrate with diverse motorcycle models while meeting safety, aesthetic, and performance expectations.

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