Powered Two-Wheeler with Integrated Safety Using Recurdyn Multi-Body Dynamics

Article *in* Applied Mechanics and Materials · July 2014

DOI: 10.4028/www.scientific.net/AMM.591.193

6 authors, including:

Vijaya Ramnath
Sri Sairam Engineering college
168 PUBLICATIONS **4,087** CITATIONS

K. Venkataraman
Sri Sairam Engineering college
4 PUBLICATIONS **138** CITATIONS

Venkatram Selvaraj
University of Windsor
2 PUBLICATIONS **1** CITATION

N. Dinesh
Sri Sairam Engineering college
2 PUBLICATIONS **1** CITATION

Applied Mechanics and Materials Vol. 591 (2014) pp 193-196
© (2014) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMM.591.193

POWERED TWO-WHEELER WITH INTEGRATED SAFETY USING RECURDYN MULTI-BODY DYNAMICS

B.Vijaya Ramnath[1,a] , K.Venkatraman[2,b] S.Venkatram[3,c], Sohil Thomas[4,d] , M.Maheshwaran[5,e] , N.Dinesh[6,f]

[1] Professor, Department of Mechanical Engineering
Sri Sairam Engineering College, Chennai

[2.] Research Scholar, Vels University,Chennai
[3,4,5,6] Department of Mechanical Engineering
Sri Sairam Engineering College, Chennai
[a] vijayaramnathb@gmail.com, [b] kvraman66@gmail.com [c] svenkatram2511@gmail.com,
[d] sohilt123@gmail.com, [e] maheshwaranmech021@gmail.com , [f] dineshsai208@gmail.com

Keywords: Powered two-wheeler safety, Side collisions, Leg holding device, Side airbags, ISO 13232 scenarios, RecurDyn simulation.

Abstract - Powered Two Wheelers (PTW) are very sensitive to environmental conditions and advancement in two-wheeler safety has not kept pace with the advancement in two-wheelers. The objective of our research is to bring about an improved design for powered two wheelers, analyzing the changes through simulation and thereby improving the safety considerations. According to the databases referred regarding accidents in depth study, it is observed that two-wheelers top the chart in number of accidents by a big margin and these accidents causes more fatal injuries. To save the rider, this paper proposes to constraint the rider along with pillion to the vehicle using "Leg holding device" and seat belt. Side airbags are employed to absorb the impact of accident. The present safety system saves the rider in frontal collisions, while this research also focuses on side collisions. ISO 13232 standard accident scenarios were followed. For simulation of scenarios multi body dynamics software called RecurDyn is used. The improvement in employing safety measures is compared with its absence and results are plotted.

1. Introduction

In present days Travel is an essential requirement and not a luxury. With growing urban spaces, the need to travel also increases proportionally. In the absence of efficient and reliable public transportation services, people resort to individual modes of travel depending on affordability. With many people unable to afford cars, motorized two-wheelers are an obvious choice. There is an increased risk of injury and death as the vehicle moves on two points and hence unstable making the rider and pillion exposed and unprotected[1,2]. One feature of motorcycle-car collisions is that the rider is likely to experience secondary impact with the environment and therefore the analysis time to be considered is much longer than that in car-to-car collisions[3,7]. Considering this feature, multi-body dynamics-based software RecurDyn was adopted as a basic simulation tool. The purpose of this research is to reduce the number of accidents and severity of user injuries associated with PTWs for the most relevant accident types. This will be achieved by means of in-depth analysis of the different accident scenarios in which motorcyclists were involved[4,5]. In this simulation, a chopper-type motorcycle model (a prototype test vehicle), a rider dummy model and a car model are used.

2.Design of safety

2.1 Salient features

1) **Leg Holding Device (LHD)**

A leg holding device has been employed on both sides of vehicle to fix the rider with the bike so as to build a better chance of saving than getting freed from the bike(as shown in figure.1).

The height of the device is set to 220mm considering average height of a person (175cm), from the gear axis, 140mm clearance is given to facilitate free movement of ankle. It consists of two movable parts closing together to completely constrain the passenger. One moving member translates about the doom while the other rotates about its axis. A fixed inner member is placed along the posterior of the engine to improve the hold, reduce stress concentration areas and to avoid exposure to engine heat. As the engine is closed, the air cooling of the engine is affected, so a radiator is fixed to cool the engine. Thus the member rotates about its pivot to accommodate the rider. The leg holding device is operated electrically using motor which is powered by the bike battery. The sensor sends signal to the ecu , from the ecu signal goes to the motor which in turn operates the LHD. And considering balancing the vehicle at low speeds, the LHD holds the leg when the speed touches 25 kmph[11].

2) Seat and belt

In case of frontal collision, due to inertia of the vehicle rider gets thrown to front side and collides with the object causing serious injuries. To avoid this condition a seat along with a belt to hold the pelvis is provided. Even under sliding scenario, the rider is retained in sitting posture. If the rider is thrown away along with the two-wheeler, chances are less for the head of the rider to hit the road. The two-wheeler is likely to hit the road. It is to be decided whether the belt should break away in case of a crash causing a slow release of the rider.

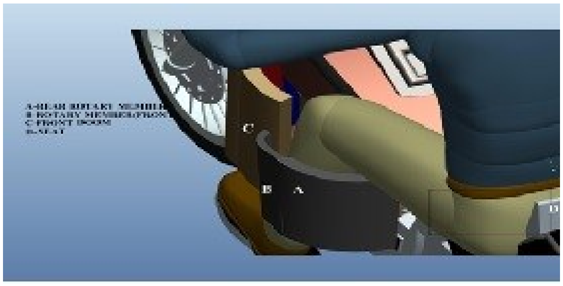

Fig. 1 Modeled Leg Holding Device (LHD)

3) Airbag

The development of airbags began with the idea for system that would restrain automobile drivers and passengers in an accident whether or not they were wearing their seat belts. Crash test shows that for an airbag to be useful as a protective device, the bag must deploy and inflate within 40milli seconds [9].The airbag module is placed between front and back LHD. To control the airbag in a two-wheeler, sensor used is Inclinometer. An inclinometer is an instrument for measuring angles of slope (or tilt), elevation or depression of an object with respect to gravity. Certain highly sensitive electronic inclinometer sensors can achieve an output resolution to 0.0001 degrees depending on the technology and angle range; however inclinometers accuracy can typically range from .01^{o} to ±2^{o} depending on the sensor and situation.[8, 10]

Auxetic fiber is a flexible material which possess negative poisson ratio. This helps the material to get thicker when stretched and thinner when compressed[5]. The anchoring properties of Auxetic fibers would tend to lock the fibers into the matrix when debonding has occurred, leading to enhanced fiber-pullout resistance. These characteristic materials display properties such as improved strength, acoustic behavior, improved fracture toughness, superior energy absorption, damping improvement, and indentation resistance. Young’s modulus of auxetic fiber is 1690 MPa, poisson ratio is -0.6. These properties shows that auxetic fiber can be used for airbag manufacturing as it possess high tear strength.

Assuming initial velocity as 0 mph, final velocity as 200 mph and mass as 3kg for the airbag. The volume of the airbag for our design is 31.2 litres and temperature is assumed as 37^{o}c[7].

Using these assumed values, the mass of sodium azide required for the deployment of the airbag is calculated using ideal gas equation and was found to be 166.88 g.

3 Simulation and analysis of design

Simulation and analysis is performed in **RecurDyn Multi-body Dynamics** software.

The processes involved in simulation are as follows:

- Construct a reference surface to place PTW and a car using 'Ground' option in Profeesional -> Ground
- The bike model along with the manikin and car model is imported and placed on the ground by defining 'solid-solid' contact type.
- The initial position of PTW and car is defined by placing them with respect to the ground. Considering our case where the car overtakes the bike and hits the PTW at an angle (side collision), PTW is rotated at an angle with respect to car by placing the rotating tool and specifying the angle required.
- To calculate the forces experienced in various body parts, relative motion has been given to various joints of the manikin using spherical joints option(as shown in figure 2). The various joints considered for force analysis are shoulder, elbow, hip, pelvis, wrist, spinal cord, knee and ankle.

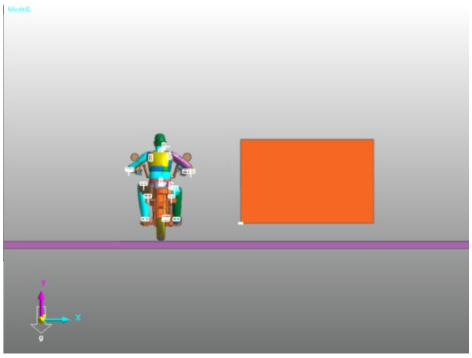

Fig. 2. Various joints considered

The graphical plot of force distribution with and without safety improvements of shoulder joint alone is shown below,

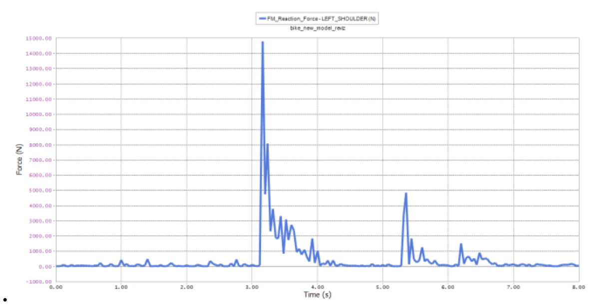

Fig. 3. Shoulder joint without safety

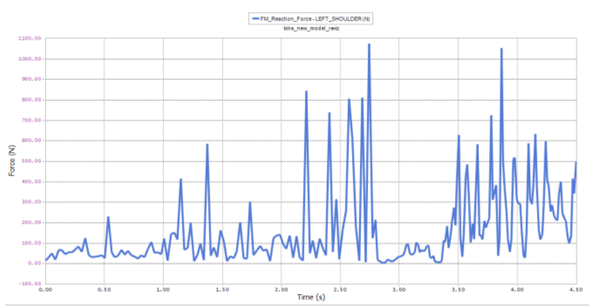

Fig. 4 Shoulder joint with safety

Table 1 Force Distribution

JOINTS	MEAN FORCE DISTRIBUTION	
	WITHOUT SAFETY IMPROVEMENTS (N)	WITH SAFETY IMPROVEMENTS (N)
WRIST	5225	690
SHOULDER	5837	620
ELBOW	5389	645
SPINAL CORD	6550	5142
PELVIS	596	358
ANKLE	478	376
HIP	530	392
KNEE	260	202

N = NEWTON

4. Conclusion

To conclude, powered-two-wheeler rider safety is a complex phenomenon that requires a comprehensive approach and the aim and responsibility of our project has addressed it with the design and development of safety devices. At present, there are numerous researches being carried out to prevent the rider during frontal collision where PTW was converted into a three-wheeler to improve balancing of the vehicle. While some other research focuses on improving the safety using balancing airbags. In these cases the rider is saved only from the accidents during frontal collisions, where the rider is in upright position at the time of the accident. This isn't the case for all accidents, the above mentioned safety systems doesn't hold good for side collisions during overtaking or during sharp turns. Close attention was paid to the side collision of the motorcycle, which has a big influence over the crash results. With safety devices employed, there is a significant improvement in safety standards. The percentage of fatality is reduced around 88% for joints such as shoulder, wrist, and elbow whereas in case of upper torso, it has been reduced to about 39%. The reaction force is expected to increase when the rider is constrained to the bike. However, compared to the scenario in which the rider topples off from the bike, our system helps in reducing the injury rate by 22 %.

References

[1] Angelo DElia, Stuart Newstead, Jim Scully, "Evaluation of vehicle side airbag effectiveness in Victoria, Australia". Accident Analysis and Prevention 54 (2013) 72

[2] Eleni I. Vlahogianni, George Yannis, John C. Golias, "Overview of critical risk factors in Power-Two-Wheeler safety". Accident Analysis and Prevention 49 (2012) 22.

[3] Kozo Tanno, Noriyoshi Ohashib, " Fatal cardiovascular injuries to the unbelted occupant associated with airbag deployment: two case-reports " . Legal Medicine 2 (2000) 231

[4] Patrick Seinigera, Kai Schröterb, Jost Gaila, "Perspectives for motorcycle stability control systems". Accident Analysis and Prevention 44 (2012) 81

[5] S. Neelakantan, W. Bosbach"Characterization and deformation response of orthotropic fiber networks with auxetic out-of-plane behaviour". Acta Materialia 66 (2014) 339

[6] Thierry Serrea, Christophe Perrinb, Jean-Louis Martinc, Aurélie Moskalc, Maxime Llaria, **"**The motorcyclist impact against a light vehicle: Epidemiological, accidentological and biomechanic analysis". Accident Analysis and Prevention 49 (2012) 228.

[7] Ciubotaru, L. Et al. "Simulation Of Motorcycle Crash Scenario Using Multibody Software LSMVirtual.Lab Motion", 29-30 Octombrie 2009, COMEC2009.

[8] Deguchi M., Modeling of a motorcycle for collision simulation, 18th ESV Paper No.157-O, 2003.

[9] Koenig, Vázquez and alt., SIM Project, "D4.1 Strategy for efficient passive safety ,2008.