Simulations of Anti-Lock Breaking System of Motorcycles in Turn

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Abstract

Antilock braking systems (ABS) prevent wheels from locking during hard braking and may reduce motorcycle drivers’ reluctance to apply full braking force. Prior research found that ABS reduced motorcycle fatal crash rates. The objective of the current study was to provide an examination of the effects of ABS while turning on different surfaces and different scenarios.

One reason that most of the motorbikes do not include ABS is the difference in price between antilock breaking system and normal breaks, the difference in price is around $500 (20,500NTD) to $1,000(41,000NTD), so we can say that having ABS is not that cheap, but in this report we will be study the advantages of why it should be used more often.

From the experiment it seems that the best way to brake is having ABS activated, is highly accurate on high speeds while turning at the same time, also the percentage of an accident will reduce braking on a wet surface in an emergency.

Different situations were created, to understand the importance of ABS, in some cases not even applying good pressure on both levers will give us a good braking distance, which means that in some situations not even professional drivers will be able to get the bike to stop the way they want.
1. Introduction

Operating brakes on most motorcycles is more complicated than applying brakes in a four wheel car. Most motorcycles have separate controls of the front and rear brakes, during hard braking the rider needs to have good knowledge on how much pressure he wants to apply to each lever, in the other hand in most four wheel cars just the pedal is enough.

During hard braking, a common situation is a wheel lock up, creating an unstable situation. When the front wheel locks up, the motorcycle will be even more unstable, with a high probability of falling down. The other case is getting a rear wheel lock up; in this situation the motorcycle will be a bit stable but a probability of falling down is still really high.

Antilock braking systems have been adapted to solve this problem. An antilock braking system works by constantly measuring wheel speed. One common way to do this is with a small grooved ring near the brake disc often called a tone wheel. The wheel speed sensor sends the tone wheel readings to the ABS unit, which can determine whether the wheel is about to stop rotating. If it is, wheel speed information is used to adjust the pressure from the brake cylinder on the brake caliper multiple times per second.

ABS has show a lot of benefits for motorcyclists. A lot of studies have been done demonstrating that Antilock braking systems improve the braking performance in different situations, in both novice and experience drivers.
2. Background

Several analyses and research papers have been done prior to this research. In most of them the same conclusion is obtained, ABS will help the driver in most situations. In 1988 the first motorcycle with ABS was sold, BMW was the first company to sell it; since then ABS has avoided numerous cases of accidents; different companies have been creating their own style of Antilock braking systems, trying to make it more and more accurate; some of them are Combined Locking Systems (CBS), or like Harley Davidson make a non-linked system.

In this study we took a little bit of information from all the studies that were studied before and simulate them, we will analyze deeper braking in curves, braking in low coefficient friction roads.

Another method that is applied in this research is to make an average of the maximum value and minimum value of pressure applied from each wheel brake cylinder chamber, after calculating this a big improvement was shown in the driver without ABS, but this is not the case for all the simulations. In some cases even calculating an average of both values the driver without Antilock braking system will not be able to brake and have control over the bike at the same time.
3. Related Information

Anti-lock Brake System (ABS) prevents the wheels of a powered two wheeler from locking during braking situations. Based on information from wheel speed sensors the ABS unit adjusts the pressure of the brake fluid in order to keep traction and avoid fall downs (e.g. maintain deceleration). Motorcycle ABS helps the rider to maintain stability during braking and to decrease the stopping distance. It provides traction even on low friction surfaces. While older ABS models are derived from cars, recent ABS is the result of research, oriented on the specifics of motorcycles in case of size, weight and functionality.

Studies of fatal crashes, insurance claims and test track performance have confirmed the importance of Anti-lock brakes. The rate of fatal crashes is 31% lower for motorcycles equipped with ABS than for those same models without ABS equipped (Insurance Institute for Highway Safety 2013). Collision Insurance claims for motorcycle with ABS are filed 20% less frequently than motorbikes without it – 31% when the ABS bikes have combined controls (Highway Loss Data Institute 2013). On test track, both new and experienced riders stop more quickly with Anti-lock braking system. Stopping distances improve on wet and dry surfaces alike.

Most bikes have separate brake controls for the front and rear wheels, which makes stopping a bike more difficult than braking with a car. The chances of a lock up wheel during hard braking are really high. On a car, a lock up might be just skid but on a motorcycle might be a dangerous fall.

Motorcycles are inherently less stable than four-wheel vehicles and rely on riders’ skills to remain upright during extreme maneuvers such as hard braking. Locking the front wheel is particularly dangerous, with loss of control being almost certain. A locked rear wheel is more controllable but still can lead to loss of control if the rider simultaneously tries to steer the motorcycle, as in an emergency avoidance maneuver.

While riding a motorbike you cannot predict when a rider ahead of you will cut off, forcing a hard brake. Also, the road can be unexpectedly sandy or more slippery than they actually look.

With ABS, riders can brake fully without fear of locking up. ABS automatically reduces brake pressure when a lockup is about to occur and increase it again after traction is restored.

The overall global road traffic fatality rate is 18 per 100 000 population, and the 23% of this occur among motorcyclist (23%). (Global status report on road safety 2013)
3.1 Different types of ABS Brakes.

Every company has their own design, same principle but different features. I will cover some of them.

3.1.1 ABS 2 (BMW Design)

ABS II was designed by BMW and FAG I. The ABS II main feature is its compact design, the ABS II is only half as heavy as the ABS I and is characterized by its greatly enhanced control convenience. The weight of ABS II is 5.3 kg as compared with slightly less than 10 kg.
The ABS II is characterized by its compact design coupled with high electromagnetic compatibility (E\textsuperscript{C}), making it ideal for motorcycles. It has only half the weight of ABS I and is optimally sited (i.e. motorcycle handling is not adversely affected).

By virtue of the triple-microprocessor system, a level of safety and security is attained which is unparalleled in ABS systems to date.

The ABS II features outstanding control convenience, offering the rider a valuable, easy-to-use tool whenever needed.

The perfected software enables even extreme braking conditions, e.g. rearing of the rear wheel, to be compensated. In addition, safety while riding on difficult surfaces, e.g. alternately wet, dry or slippery surfaces, is enhanced.

The displacement measurement of the reciprocating piston enables the rotating speed of the wheel to be maintained just below the locking limit. This ensures complete, virtually optimal utilization of tire-road traction.

![Figure 3. Front and rear brake chamber cylinder pressure vs. time data illustrating CBS, brakes were just applied on the rear tire](image)

3.1.2 Electronically Controlled ‘Combined ABS’ (Honda design)

Electronically Controlled Combined ABS is the world's first electronically controlled braking system for super sport bikes. All levels of licensed riders can experience a new level of advanced braking performance on a large motorcycle simply by applying the
brakes normally and firmly. The system is designed to electronically distribute front and rear braking forces to facilitate smooth braking without wheel lock.

Combining a short wheelbase and light weight with a high center of gravity, super sport bikes are designed for high performance.

In contrast to conventional systems, Electronically Controlled Combined ABS features ultra-precise control of brake fluid pressure that helps prevent wheel lock. As a result, the system minimizes vehicle vibration and eliminates brake lever pulsing for superior, ultra-smooth ABS performance and braking. Electronically Controlled Combined ABS allows riders to apply precise rear-wheel braking with the foot pedal. Application of the rear brake does not result in immediate front brake activation unless rear-wheel lockup is sensed, allowing an experienced rider to use the rear brake like a traditional non-linked unit during spirited riding such as track days for outstanding speed, suspension and steering control.

Many parts are mounted on the suspension’s moving parts near the brakes, increasing the unsprung weight. But in C-ABS the system is mounted in the center of the body, so
no additional brake parts are required and there is minimal impact on the unsprung weight.

3.1.3 Harley Davidson ABS System

In 2008 Harley-Davidson ABS was introduced. Harley-Davidson along with Brembo developed the new Harley ABS.

The Harley ABS is a non-linked system. A non-linked system allows independent control of the front and rear brake.

The sensors on the Harley-Davidson ABS are incorporated into a wheel-bearing spacer on each spacer cap has alternate polarized magnetized segments. The sensor reads the speed of the magnets, sending wheel speed information to the ABS control module.

3.2 Components of ABS.

3.2.1 Tone Wheel.

A metal "tone ring" with a predetermined number of teeth sits between the inner and outer bearings. A Hall Effect sensor plugs into a carefully machined hole in the forging, locating it just above the tone ring. As the bike's wheel turns, the tone ring teeth pass by the sensor. The gaps between the teeth trigger the sensor in direct relationship to their speed. As the wheel turns faster, the teeth pass faster under the sensor. Under braking, the anti-lock computer compares the signals from the wheel speed sensors. If it sees the wheels are locked or turning at different speeds (skidding), it triggers the ABS braking system to modulate the brakes.

Figure 6. Tone ring mounted on the tire.
3.2.2 Sensor

It is a sender device used for reading the speed for a vehicle’s wheel rotation.

It usually consists of a toothed ring and a pickup.

Speed is measured constantly for feeding real-time data to the ABS ECU. While some bikes only have one-wheel ABS, most modern systems have dual-channel ECUs, meaning they receive info from both wheels.

These sensors are detecting the actual speed of the wheels themselves, and not the absolute speed of the motorcycle in relation to the ground: it's exactly this variable that allows the ABS ECU to help detect whether wheel slip will occur in certain situations, as you'll see ahead.

Alongside wheel speed sensors, modern ABS also comprises gyroscopes and handlebar sensors for detecting the leaning angles of the bike. Knowing the bike's lean angle helps present-day ABS provide extended functionality when turning.

![Wheel speed sensor](image.png)

Figure 7. Wheel speed sensor

3.2.3 ECU

Is any embedded system that controls one or more of the electrical system or subsystems in a motor vehicle.

The ECU or Electronic Control Unit is the brain of the ABS: it receives info from all the sensors, analyzes the data, compares the results with the specific values and when needed, uses special algorithms to regulate the braking force.

This miniature computer is specialized in such operations and higher-spec ECUs can be constantly updated and can “learn” a lot of scenarios or maps to be used in certain
situations.

Even street-oriented bikes come with different ABS mappings, maximizing the riding performance and providing safe braking in various scenarios. Thanks to the digital technology, these ABS mappings can be recalled and cycled through with just a press of a button and they become operational in milliseconds.

The ECU receives multiple readouts from all the bike sensors it is connected to and whose info it can interpret: the higher the frequency of these readouts and the comparison computations, the higher the efficiency of the ABS.

In case the ECU detects a scenario that matches to what the real world would see as a locking wheel followed by the inevitable skid, this computer sends a command to the pump and valves adjusting the braking force as necessary.

![ECU system of a Honda ST1100](image)

**Figure 8.** ECU system of a Honda ST1100

### 3.2.4 The pump and the valves

These are the physical elements used by the ABS to control the braking force. Since the ABS is regulating the pressure in the brake lines, it needs a pump to work both ways, that is, decreasing and increasing the pressure to normal specifications.

While the pump acts like any casual electric pump using a master cylinder and a piston, the operation of the valves is equally simple. When the ABS kicks in, it means the braking pressure the rider applies to the discs is too big, and the ECU calculates how much it should lower it to prevent the wheels from losing grip.

The amount of “release” is sent as electronic data to the solenoid valves which are moved in the right position to decrease the pressure pushing the caliper pistons, easing the stopping force. As the wheel slip potential is eliminated, the ECU sends another
command to the pump and moves the valves in another position, allowing the pressure of the initial braking maneuver to be restored and basically re-applying the hard brake.

This process only takes fractions of a second and it will be repeated until the bike stops. When the ABS works, riders will feel slight vibrations in the lever or pedal, as the pressure in the line is constantly modulated.

An antilock braking system works by constantly measuring wheel speed. One common way to do this is with a small grooved ring near the brake disc often called a tone wheel. The wheel speed sensor sends the tone wheel readings to the ABS unit, which can determine whether the wheel is about to stop rotating. If it is, wheel speed information is used to adjust the pressure from the brake cylinder on the brake caliper multiple times per second.
4. Method

4.1 Simulation Software

The method used for the simulation was the software from Mechanical Solutions, Mechanical Simulation Corporation is the world leader in the development and distribution of advanced software used to simulate vehicle behavior involving interactions between the 3D dynamic vehicle response, advanced, controllers, driver controls, and 3D roads.

The simulation design is called BikeSim which provide the most accurate and realistic predictions that are possible, in a form that can be easily used by most engineers and technical staff. Each package includes the BS database browser, plotter, animator, online help and solver programs for the detailed math models. The math models run alone or with third-party simulation software such as Simulink, LabVIEW, ETAS ASCET, and others.

BikeSim is a software specifically designed to simulate the dynamic behavior of motorcycles and scooters.

BikeSim provides engineers with the power and flexibility to dynamically evaluate virtually any two wheeled production or concept motorcycle. Bikesim analyzes the response to the rider's inputs — steering torque, braking, shifting, throttle, body lean, and lateral shifting of the body mass. Environmental inputs are included — aerodynamics, road geometry and friction. By modeling and controlling the complex interaction between the rider-machine-environment, Bikesim accurately simulates how rider behavior affects the bike’s overall performance under the environmental condition.

The Bikesim math model has been extended to include a full power train, full nonlinear kinematics suspension, an enhanced rider positioning control, several enhanced tire model options, additional degrees-of-freedoms, and more extensions needed to provide an accurate simulation of most existing motorcycle design concepts.

OEM Companies like Harley-Davidson, Honda, Kawasaki, Suzuki, SYM, Yamaha uses BikeSim software. Some famous supplier companies are also involved with BikeSim some of them are Bosch, Hitachi, Dunlop, and Sumitomo. It is also popular at research labs and universities, some famous research laboratories using BikeSim are Dynamic Research, Inc. Hitachi and NTSEL.
4.2 Bike Specifications.

4.2.1 Powetrain

![Powetrain diagram]

Figure 9. Maximum power of the bike engine

4.2.2 Brake system

![Brake system diagram]

Figure 10. Brake specifications of the bike used in the simulation.

Two types of brake were used, ABS and Non-ABS. To simulate ABS a Simulink program was used to get the results, the Simulink program was runned simultaneously with Bikesim.
Figure 11. Simulink program to simulate Anti-lock braking system

4.2.3 Sprung mass

Figure 12. Sprung mass data used in the simulation.
4.2.4 Rider mass

Rider Upper Body
- Body mass: 43.5 kg
- Roll inertia (ho): 1.42 kg m²
- Pitch inertia (lp): 1.047 kg m²
- Yaw inertia (lz): 0.916 kg m²

Leaning stiffness: 0.68 N/m/deg
Leaning damping: 0.09 N/m/deg

Inertias and radius of gyration are related by the equation: \( I = mR^2 \)

Rider Lower Body
- Body mass: 25.88 kg
- Roll inertia (ho): 0.5 kg m²
- Pitch inertia (lp): 0.5 kg m²
- Yaw inertia (lz): 0.5 kg m²

Lateral stiffness: 10 N/mm
Lateral damping: 0.03 N m/deg

Inertias and radius of gyration are related by the equation: \( I = mR^2 \)

Figure 13. Rider mass data, 70 kg is the average weight of an adult.

4.2.5 Front and rear wheel

Figure 14. Front tire specifications

NASA suggests that about 82% of the total rider mass is associated with the upper body and 18% with the lower body.

All components of the moments of inertia for the upper body is based on the upper body coordinate system (see above figure), while the moments of inertia for the lower body is based on the sprung mass coordinate system.

Model Option: Magic Formula for Fx, Ky, and Mz (Sawyer 1.0)

Vertical Force
- Effective rolling radius: 202 mm
- Spring rate: 190 N/mm
- Maximum allowed force: 7000 N
- Wheel mass: 6 kg
- Un-deflected crown radius (mm): 50

Shear Forces and Moments
- External force
- Example Front Tire (1.1.0)

Dynamic Properties
- Tire spin moment of inertia: added to the spin inertia of the wheel

Tire Lag
- Tire force in x-direction

Rolling Resistance
- \( R_{x} = \frac{F_{x}}{R_{x} \cdot \mu} \)

Distance traveled

Cutoff speed: 5 km/h

Animator Settings
- Tire width: 150 mm
- The effective rolling radius is also used to scale the animated tire.

Use custom animator description

Scooter, Rear Wheel
4.2.6 Front and rear suspension

4.2.7 Aerodynamics

Figure 15. Rear tire specifications

Figure 16. front suspension specifications

Figure 17. Drag, Lift and Pitch coefficient data
4.2.8 Steering System

4.3 Simulation Scenario

The simulation is divided in two parts:

(a) On a dry surface (high coefficient of friction)

(b) On a wet surface (low coefficient of friction)
4.3.1 Road condition: Dry vs. Wet surface

The dry test track simulation was made on asphalt pavement having a coefficient of friction of 0.9. For the wet test track study, the test track was the same but this time with a coefficient of friction of 0.4.

4.3.2 Speed limit: Dry vs. Wet track.

As we know while driving on a rainy day, accidents are more likely to happen so the simulation speed on a wet track was set to 40 km/h and on dry surface to 95 km/h, the main point of giving a literally high speed is to show how the ABS will help the driver to have more control over the bike.

It was determined that single driver roadside departures most often occurred on dry roadways. Since the effects of ABS on braking performance differ based on pavement condition, simulation was conducted both on dry and wet pavement to more completely investigate the behavior of the motorbike.

4.3.3 Speed of the vehicle.

The simulation was done in three different speeds:

- 40 km/h
- 60 km/h
- 95 km/h
- 100 km/h

4.3.4 Track

The simulations while turning was done in a 500ft radius circle.

![Figure 20. Information about the track](image)
5. Results

This first simulation was made applying 100N on both brake levers (front and rear brakes), this pressure on the lever will be of around 3MPa on the front brake cylinder chamber and 1.5Mpa on the rear brake cylinder chamber, this kind of braking is when the vehicle sees that there is a red light in front and has plenty of time to put slowly the brakes.

On the other hand with ABS 200N on both levers were applied, around 6Mpa on the front break cylinder chamber and 2.6Mpa on the rear cylinder chamber, the reason that more pressure was applied on the bike with Anti-lock braking system is because the ABS ECU will be the one in charge to determine how much pressure will be necessary to stop, but it still needs enough pressure for it to be able to brake the way the driver wants, the pressure needs to be greater than 100N on the levers, so if we apply 200N the ECU will be able to control the pressure between 0 and 200N (0 and 6MPa).

The speed of both bikes was 60 kilometer per hour and both brakes were applied at 5 seconds after the simulation started. On the graphic above we can see the difference that it will take to stop both bikes, the motorbike with ABS will take around 1 second less to stop.

In the next figure shows how the ABS works, and how the pressure on the cylinders was regulated in order to get the best pressure so the wheels don’t lock up, the maximum value that it was used during ABS braking method was 5.95Mpa and the minimum 2.94
on the front cylinder chamber; and on the rear cylinder chamber the maximum value that was applied was 2.3Mpa and the minimum 0.4Mpa.

Figure 22. Pressure vs. time data

Figure 23. Speed vs. meter to stop the motorcycle

Fig. speed vs. time data illustrating that the bike without ABS took around 9 meters more than the one with ABS.

From these results, an average pressure was measured from each of these values, trying to see if a person with a good knowledge on braking will be able to come up with similar results.

After applying the average of the maximum and minimum values, the results were simulated and the results are shown in the next graph.
Figure 24. The results are very similar after applying the average pressure and the difference between both bikes to get to a full stop is just 0.2s.

Figure 25. Speed and distance data illustrating the difference in distance to get to a full stop.

The difference now between both bikes is just of 2 meters when before used to be of around 9 meters, this result explains that in situations like this if the driver is an expert, the results are going to be very similar.

The next simulation will be in a different scenario, this time the brakes will be applied in an emergency way, the speed used was 60 kilometers per hour and the brakes were applied 2 seconds after the simulation started. Also, the pressure applied on the front and back lever is 300N (9Mpa front wheel cylinder chamber and 4.5Mpa on the rear wheel cylinder chamber)
Figure 26. Pressure of the front brake and rear brake cylinder chamber vs. time data illustrating how pressure was applied on both bikes.

Figure 27. Speed vs. time data illustrating the speed of the vehicle.

Without Anti-lock braking system both front and rear wheel will lock up, and finish in an accident losing completely control of the motorcycle and falling to the side.
Figure 28. Roll data shows the bike falling during simulation.

The same method that we applied on the example before was used in this simulation, the average values of the pressure on the front and rear wheel were calculated to come up with a better result.

This time the results were not that good, the wheel will still lock up no matter if a professional driver tries to break in this conditions, this example shows that ABS is necessary in this kind of situations.

Figure 29. Speed vs. time data illustrating the front wheel locking up during emergency braking.
Different kind of pressure were simulated around the average trying to come up with a good result without using ABS; all the results were negative, the front brake will lock up and still an accident will happen causing the bike falling to the side.

The next case will be the analysis of braking during turning in a wet surface (low coefficient road surface), the coefficient of friction set for this simulation is 0.4, this kind of coefficient is the average in a rainy day or if the road is wet.

The purpose of this simulation is to see how different the bike will react with and without Anti-lock braking system; two speeds were set; 40km/h and 95km/h.

First, we will analyze the results of the bike when ABS is not activated, the pressure applied on the brakes was 100N (around 3MPa on the front cylinder chamber and 1.5MPa on the rear wheel cylinder chamber), and in both scenarios the brake lever was applied at 5 seconds. It can be seen that the pressure applied is not extreme, but considering that the surface of the road is not in good condition the bike will not be stable.

In Fig (still have to write the number of the figure), it shows how the front wheel will lock up, and also the rear wheel will be lock up for a while. Even going at a slow speed and applying not much pressure to the brakes, the motorbike will still fall and lose the driver will lose control of it.
Figure 31. Speed vs. Time data illustrating wheel lock up first on front wheel and then on rear wheel.

Figure 32. Yaw Rate illustrating the movement of the bike.

Applying brakes during rain and turning is a big risk; professional drivers will have big difficulty to brake in these conditions.

With the same conditions, the simulation was done with the motorbike equipped with Anti-lock braking system, for this simulation two different amount of pressure were applied to the tire.
Figure 33. Pressure brake cylinders vs. time data illustrating how the ECU worked to regulate the pressure

Figure 34. Speed vs. data illustrating the time the bike took to stop completely

Since the brake levers were applied took around 2 seconds to come to a full stop, we can see since now that with ABS is able to stop without the wheels locking up or losing control of the bike.
Figure 35. Tire lateral force vs. time data when 100 N were applied to the lever (ABS activated)

Figure 36. Speed vs. time data (100N lever in front and rear brakes with ABS activated)

From the moment the brakes were applied it took around 8 meters for the bike to stop, compared
Figure 37. Pressure vs. time data illustrating the behavior of ABS when applying 100N to the lever.

When applying less pressure to the lever, a better result can be done with ABS, what it means is that is not necessarily good to apply full pressure all the time, in cases like this that is not an emergency; is good even to try to regulate the brake pressure applied, in this scenario the more pressure that is applied the more it will take to measure is needed, and the bike will be more stable.

Figure 38. Lateral force vs. time data illustrating the stability of the motorbike when ABS was activated.
The difference might not be really big, around 1 meter faster to stop the bike compared when 100N on both levers were applied; but is enough to prove that in cases like this is better to don’t give full pressure.

The next case will be the analysis of braking while turning in a dry surface (high coefficient road surface), the coefficient of friction set for this simulation is 0.9, this kind of coefficient is the average in a cement road.

The only speed used in this case was 95 kilometers per hour, the objective of making a relative high speed simulation is to know how safe and how much difference it makes to use or not ABS.

The pressure applied on the brake lever was 200N on both front and rear tires (6MPaFront and 2.6MPa on the wheels cylinder chamber)

Fig 40. Speed vs. time data illustrating wheel lock up on both tires and the bike falling
With ABS the same pressure on the brake lever was applied, this time the ABS ECU regulate the pressure applied on the tires cylinder chamber.

Figure 41. Pressure on the wheels cylinder chamber vs. time data shows ABS activation

Figure 42. Speed vs. time data illustrating successful stop of the bike.

At the speed of 95 kilometer per hour, it is harder to have good control of the motorbike, response time is less, and trying to stop at this speed is really difficult; more for a motorbike, with ABS the success of avoiding an accident increases.
Anti-lock braking system is more useful and necessary when driving in high speeds, from this study is advisable that in the near future more and more drivers consider changing to this system, so accidents can be reduce.

Motorcycle drivers involved in fatal crashes per 10,000 registered vehicle years during 2003-2011 were examined for 13 motorcycle models offering optional ABS. Fatal crash rates for motorcycles with ABS were compared to rates for the same models without ABS.
6. Conclusion

ABS is highly effective in all situations that were simulated. The only way to get good braking distance and break response without applying Antilock Braking system is if the driver is experienced. From the experiment we show that ABS was successful even braking in a wet surface with a low coefficient of friction. It should be a law for bikes to include ABS so accidents will happen less often. The result of one of the simulations, where the motorcycle going at 60km/h and brakes are applied, the bike with ABS will stop around 9 meters before the one without it.

Discussion

Further studies need to be done to completely understand all the advantages and disadvantages of ABS; studies like how the driver will drive when he knows the bike has Antilock braking system; some drivers in four wheel cars show that when Antilock braking system is activated they tend to drive faster, relying that this will stop any situation. Training on ABS should have always be done before taking a motorcycle with this system activated; since it is not the same to apply normal hydraulic brakes and ABS; some accidents can be happen if the driver doesn’t have knowledge of how ABS works.
7. References


