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Theoretical Foundations of the Acceleration Slip Regulation System

Abdulaziz Solijon o'g'li Khusanjonov and Makhammadjon Alijon o'g'li Qobulov

Assistant of the Department of Ground transport systems and their exploitation at the Fergana polytechnic institute;

Annotation. *In this work discusses the structure of the acceleration slip regulation system used in modern cars and the principle of its operation.*

Keywords: *transport vehicles, technical exploitation, technical condition, control.*

Introduction. Because of the growing public concern about the global environmental and energy problems, electric vehicles have become a hot research topic. Significant improvements in power electronics and power and control strategies have been achieved, which have promoted the development of electric vehicles. Accelerated slip adjustment, or accelerated stability retainer, as the name implies, is a control system that prevents the drive wheel from accelerating and sliding. The purpose is to prevent the vehicle, especially the high-powered vehicle from starting, to accelerate the wheel slip To maintain the stability of the vehicle's driving direction, to maintain good handling and the most suitable driving force to ensure safe driving. As a new research area for electric vehicles, the distributed drive electric vehicle, which employs motors to drive the wheels independently, is drawing increasing attention because of its advantages, which include a flexible chassis layout, quick torque response, easy measurements, and vehicle dynamic control with multipledegrees of control freedom due to the independent wheel torque control [1,2].

It was originally invented by Bosch in Germany. It was originally a German term and its full English name is usually considered the Acceleration Slip Regulation. Sometimes you will see a few abbreviations with similar meanings, such as Mercedes-Benz's ASC acceleration taxi control system, The name of ASR follows this. The product of a lot of advances in technology.

Methods. This system is called by different names by many manufacturers. But the principle of their operation is the same, for example:

- Audi: (ASR)
- BMW: Automatische Stabilitäts Control (ASC)
- Fiat: (ASR)
- Hyundai: (TSC)
- Mazda: Traction Control System (TCS)
- Mercedes-Benz: (ASR)
- Nissan: Traction Control System (TCS)
- Opel/GM: Traction Control Support System (TCSS)
- Peugeot: (ASR)
- Porsche: ASR als Teil des Porsche Stability Management (PSM)
- Saab: Traction Control System (TCS)
- Renault: (ASR)
- Suzuki: (ASR)
- Toyota: Traction Control (TRC)
- Volkswagen: (ASR)
- Volvo: Traction Control System (TRACS)

Discussion. Electronic engine controls are often used in articulated buses but increasingly also for other motor vehicles. The mechanical linkage between the accelerator pedal and the fuel-injection pump is then dispensable apart from a short link between the electrical control motor and the pump adjusting lever.

The mechanical linkage is replaced by an electrical setpoint generator on the accelerator pedal (potentiometer) and a control motor fitted close to the fuel-injection pump.

The control signal set by the ABS/ASR ECU is then relayed via digital interface to the ECU of the drive-by-wire system which in turn now transmits the corresponding control commands to the control motor.

Simply distribute, ASR looks like one or a few differential locks. It distributes the driving force of the engine to one or more wheels in an optimal manner, and the ASR is particularly advantageous on a flat road. The reason is the same as the reason In addition to the driving force for advancing the vehicle, the general tire should also produce a vehicle. Turning force of the turning or the braking force for stopping the vehicle, whether it is simply generating the driving force, the steering force, the braking force , or the driving force and the steering force, the braking force and the steering simultaneous exerting force, Under certain load conditions, that is, when the current emergency start causes the tire to slip, the force is determined, and this sliding phenomenon means that all the grip of the tire is used in the driving force, and therefore, the car can be controlled at this time. Since all the forces are used by the driving force, the steering force of the turning is lost, so the steering force that causes the vehicle to turn or maintain the direction of the vehicle will be lost, which may cause the direction of the vehicle to be unstable.

In deep snow or in similar conditions the traction force can be increased by actuating the "ASR off-road" button which is available as an option. If this button is activated, the ECU changes the conditions (slip thresholds) for ASR control to permit higher slip ratios. The ASR lamp flashes in regular cycles while the button is actuated to indicate to the driver that stability may be reduced.

Moving the car (λ_{an}): in this case it depends on the coefficient of adhesion or friction of the car wheels to the road surface.

The percentage of wheel speed to the speed of the car shifting the weight of the car is calculated by the following formula:

$$\lambda_{an} = \frac{V_w - V_F}{V_w} \cdot 100\ \% \quad (1)$$

V_W – wheel speed,

V_F – vehicle speed

Weight coefficient of account (μ_{an}). The traction-adhesion coefficient and thus the propulsion power depends on the same factors as the braking force coefficient described above.

Analysis. When the wheels spin heavily (λ_{an} = 100%), the adhesion will be reduced significantly below the maximum value. The cornering force coefficient also falls as drive slip increases, and by the time the wheels spin it is negligible.

ASR control Drive slip regulators influence the acceleration events only if certain threshold values of the wheel slip or the wheel acceleration are exceeded.

Electronically operated solenoid valves brake the respective wheel proportionately or reduce the engine performance until the stable adhesion range is reached again [2].

If the event of further regulating action, the wheel is held in the proximity of the maximum possible adhesion within a slip range that is as narrow as possible.

When the vehicle is running on a low friction road, if the driving torque exceeds the maximum torque provided by the road, the driving wheels will experience excessive spin.

This excessive spin of the driving wheels will lead to a decrease in the longitudinal driving force and lateral stability of the vehicle, so it is necessary to prevent the excessive spin of the driving wheels. Because the longitudinal force is mainly affected by the slip ratio, directly controlling the slip ratio is an effective and widely used way to achieve better acceleration performance.To obtain the slip ratio of the driving wheels, it’s necessary to measure the rotational speed of the driving wheels and the speed of the vehicle.

The speed of each wheel can be measured by wheel speed sensor and the speed of the vehicle can be calculated out by the speed of driven wheels.

The dynamics of a wheel during traction is modeled as Figure 1.

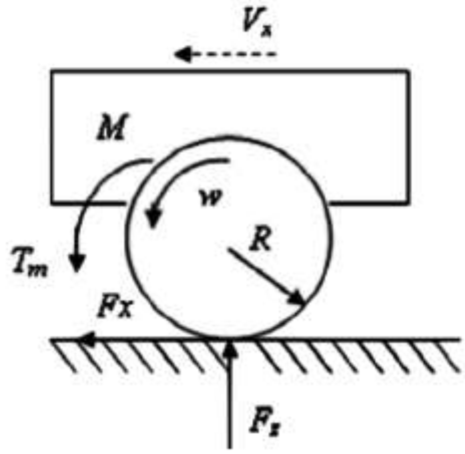

Figure 1. Single wheel model

$$M V = F_x \quad (2)$$

$$I_w \omega = T_m - F_x R \quad (3)$$

$$\lambda = (\omega R - V) / \omega R \quad (4)$$

Where M denotes 1/4 vehicle mass, kg, V_x represents the longitudinal velocity, m/s; F_x is the longitudinal road friction force, N; I_w is the wheel rotational inertia, kg·m^2 ; ω is the angular rotational speed of wheel, rad/s; T_m represents the traction torque generated by the motor, N·m; R is the wheel radius, m; λ is the generally denoted slip ratio when traction.

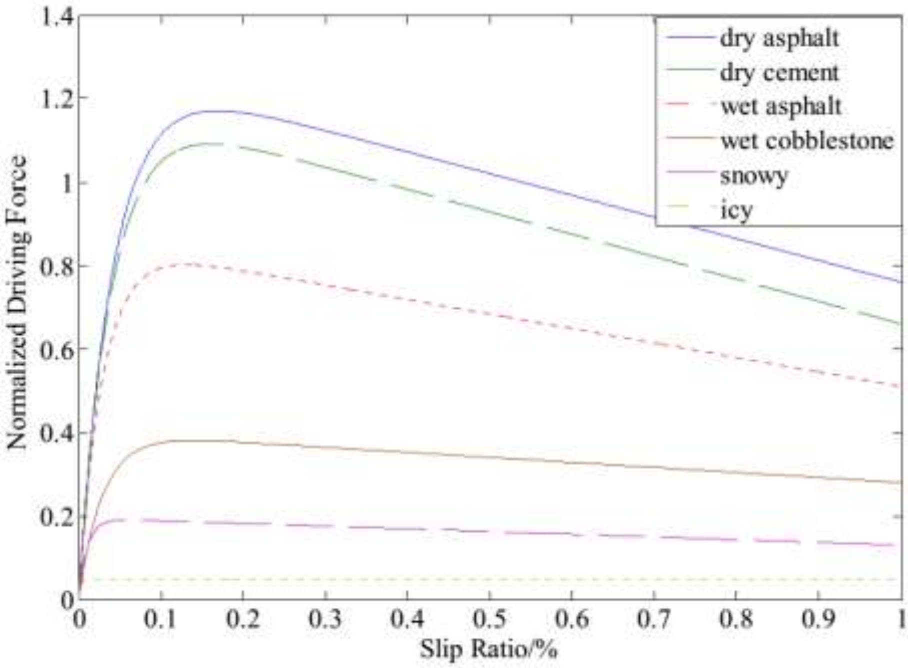

Figure 2. Longitudinal static curve of tire

Figure 2 shows the typical tire-road friction coefficient as a function of the slip ratio. Although slip slope and the value of optimal slip ratio vary with the road conditions (dry, wet or icy), road type (asphalt, concrete, gravel, or earth), tire types, and many other factors, the shape of the curve is similar, in all conditions the slope of the longitudinal static curve is first increasing in stable region and then decreasing in the unstable region [3].

Table 1

Fitting coefficients and parameters

№	Road condition	C1	C2	C3	λ_{opt}	$\mu(\lambda_{opt})$	$\mu(\lambda_0)/\mu(\lambda_{opt})$
1	Dry asphalt	1.2801	23.990	0.5200	0.17	1.1700	99.74%
2	Wet asphalt	0.857	33.822	0.347	0.13	0.8013	99.79%
3	Dry cement	1.1973	25.168	0.5373	0.16	1.09	99.91%
4	Wet cobblestone	0.4004	33.708	0.1204	0.14	0.38	99.95%
5	Snowy	0.1946	94.129	0.0646	0.06	0.1906	97.01%
6	Icy	0.05	306.39	0.001	0.03	0.05	99.7%

Conclusions. Acceleration slip regulation is an important aspect of vehicle dynamic control. It can help to prevent excessive wheel spin and to make full use of the road grip when the driver torque command exceeds the maximum torque provided by the road. Compared to conventional vehicles, the sensitive torque response and accurate torque control make the acceleration slip regulation of the electric vehicle faster and more accurate. Most acceleration slip regulation methods are based on slip ratio control. This method requires the vehicle speed, which can be obtained using the speed of the driven wheels or vehicle speed sensors.

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