Comparison Stand Tests and Road tests of brake systems under Various Conditions

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Abstract:-This work introduces one of simple method used to compare the results obtained from stand-test and road-tests of brake systems of automobiles, through the settlement factors for their relation to each other. The factors involve distribution of brake force between front and rare wheel axis, weight of automobile on front and rear axis during the brake process, force coefficients with servo-brake, moment of inertia on front and rear axles and brake way of a forward wheel of the automobile on the stand. To analysis of these importance factors, it is necessary to establish the correlations and factors influencing on the impact of diagnostic parameters. Mathematical formulations are performed to investigate the influence of these factors on both stand and road tests of automobile. The results showed that the brake way force decreases as the coefficient of force between the front and rear axles and basic surface increase while, it increases as the initial mass of automobile increases. Also the results show that the deceleration of the automobile increases as basic surface increases while; it decreases as initial mass of automobile increases.

Key-words: stand test, road test, brake way, automobile, braking.

1 Introduction

On the stand-test, dynamometer with racing drums, the estimation of brake qualities of the automobile is usually made on each wheel separately. Hence, during braking process, one wheel on each pair of racing drums absorbs kinetic energy of rotating inertial weights of the automobile (wheel) and on the tested dynamometer (racing drums, clutch, reducers).The part of general brake force comes on the given wheel and will be involved in the analysis.

However, the normative and actual sizes of brake forces on wheels axes of the automobile will be different. It is caused by a design of the automobile, when the various distributions of brake forces between its axes are accepted. This distribution can be constant or variable (at presence on the automobile of a regulator of brake forces). Thus, to calculate the factors of reduction stand of results to road it is necessary to take into consideration distribution of brake forces between axes [1, 2, and 3]. Figure (1) shows the performance based brake tester.

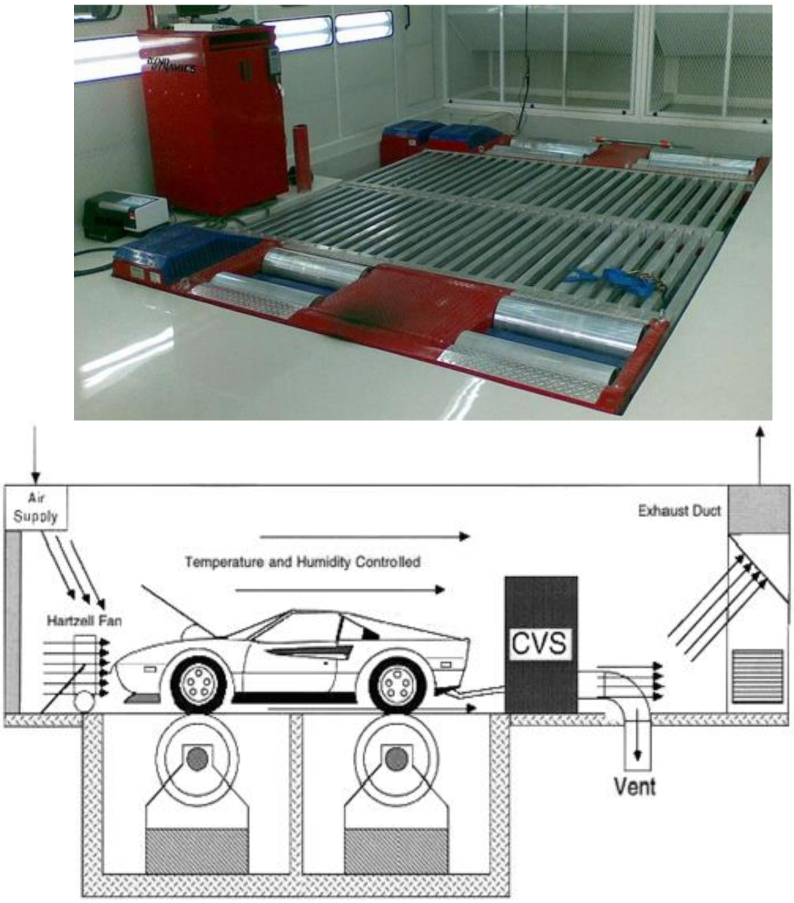

Fig.1: Performance-based brake tester (Dynamometer).

The other factor, which can render essential influence is the size of reduction, which is the ratio of inertial weights of the automobile at tests on a road m_r and on the stand m_s. This ratio, at constant inertial weight of the given model of the automobile, will be determined in design data of the stand: by the sizes of racing drums, presence of constant connections with racing drums of additional devices of the stand and elements of the electric drive during braking - connecting clutch, rotor bring of the electric motor, reducer and…etc [2-6].

On size of a brake way at brakes test of the automobile makes influence resistance factors such as swing and coupling of trunks with a basic surface, φ. The importance of these factors for stands with racing drums in many respects depend on their design, diameter of racing drums, inner axial distance of pair racing drums under one wheel, material of drums and their surface (smooth, with flutes and etc.).

Any influence in factors will result difference of results between the tests of stand and tests of road. Also, it will make difference in the absence of air resistance at test on the stand. To define the character of influence on check results of brakes condition on the stand for the factors mentioned above, a mathematical formulation, relating all factors will be explored as follows:

2-Mathematical Formulation

To calculate the factors of reduction of distribution brake forces between axes of the automobile, it is possible to use the following dependence (without calculation of a brake way during operation of brakes):

$$S_{f.exe} = v_0^2 \,.m_{f.exe} / (26p_{f.exe})$$

Where:

$S_{f.exe}$ is brake distance of a forward wheel of the automobile on the stand,
v_o is initial speed of braking, km / h;
$m_{f.exe}$ is inertial mass participating at braking of forward wheels on the stand, kg; and
$p_{f.exe}$ is brake force developed by brakes of a forward axis, N.
The brake force developed by brakes can be written as:

$$p_{f.exe} = \beta_0 \,.\, p_T,$$

Where: p_T is the total brake force applied on all wheels of the automobile, N. and
β_0 is coefficient of force between the front and rear axles.

After substitution, the brake distance on the stand can be expressed as:

$$S_{f.exe} = v_0^2 \,.m_{f.exe} / (26\, p_T)$$

To perform the calculations, the following initial data are assumed:
Initial speed of the automobile; v_o = 40 km / h;
Inertial mass participating at braking of wheels, $m_{f.exe}$ = 600 kg; and
Total brake force on all the wheels, p_T = 10190 N.

The brake distance of a forward wheel of the automobile on the stand can also be written as:

$$S_{f..exe} = v_0^2 / (26\, j_y),$$

Where: j_y =deceleration, m/s^2.

The deceleration can be expressed as:

$$j_y = (\gamma_T + f)\, g$$

Where: γ_T is coefficient of braking
f is slipping resistance coefficient
g = is the acceleration, 9.81 m/s^2
.

If we substitute expression for j_y in the Eq. (4), the following equations will result:

$$S_{f.exe} = v_0^2 / [26\, (\gamma_T + f)\, g]$$

$$S_{f.exe} = v_0^2 / (254\, \varphi)$$

$$K_f = 0.5\, \beta_0.\, m_{f.exe}\; N\; K_f / (M_f\; N\, V_a);$$

$$K_r = 0.5\, (1 - \beta_0)\; m_{r\,exe}.\; N\; K_r / (M_r\; N\; V_a);$$

Where: 0.5 is the factor which is taking into account as a share between brake forces on two wheels in the same axles, K_f and K_r are braking coefficients on front and rear wheels respectively. $m_{f.exe}$ and $m_{r\,exe}$ are masses of automobile during the braking process on front and rear wheel respectively. N is constant and its value equal to 490 N on road test M_f and M_r are coefficients of moment of inertia of braking on front and rear wheels respectively. V_a is coefficient when there is no air effects on dynamometer test. φ is friction coefficients of the wheels, $(\gamma_T + f)$ M_1 category is small automobile

3-Results and Discussion

The schematic diagram showing influence of various features tests by dynamiter on the impact of braking distance as shown in Figure (1).The experimental results for predicting the diagnostic parameters showed the dependence of these parameters on an effort of pressing force of a brake pedal that it is necessary to take in calculation the factors definition of reduction. For small automobiles of a category M_1 the standards for road tests establish usually N = 490 N. At test on stands, the effort $N_{f.s}$, as a rule, is less than 490 H, which is connected to an opportunity of wheels blocking of. Therefore, it is a necessary factor of reduction to multiply on the attitude (relation) $N_{f.s}$ / $N_{f.r}$. Also it is necessary to take into account the presence of the brake system of the amplifier. Thus, the equation of resulted reduction on stand tests to road test for case of forward K_f and back wheel K_b of the automobile are represented by Eqs. (7,8,9,10).

Figure (2) shows the variation of the brake distance of a forward wheel of the automobile on the stand, with mass of automobile during the braking process on front wheel on stand, coefficient of force between the front and rear axles and friction coefficients of the wheels. It is obvious from the relations that, the brake distance force decreases as the coefficient of force between the front and rear axles increases. The same trend was observed for brake distance force for friction coefficient of the wheels, while it increases as the initial mass increases.

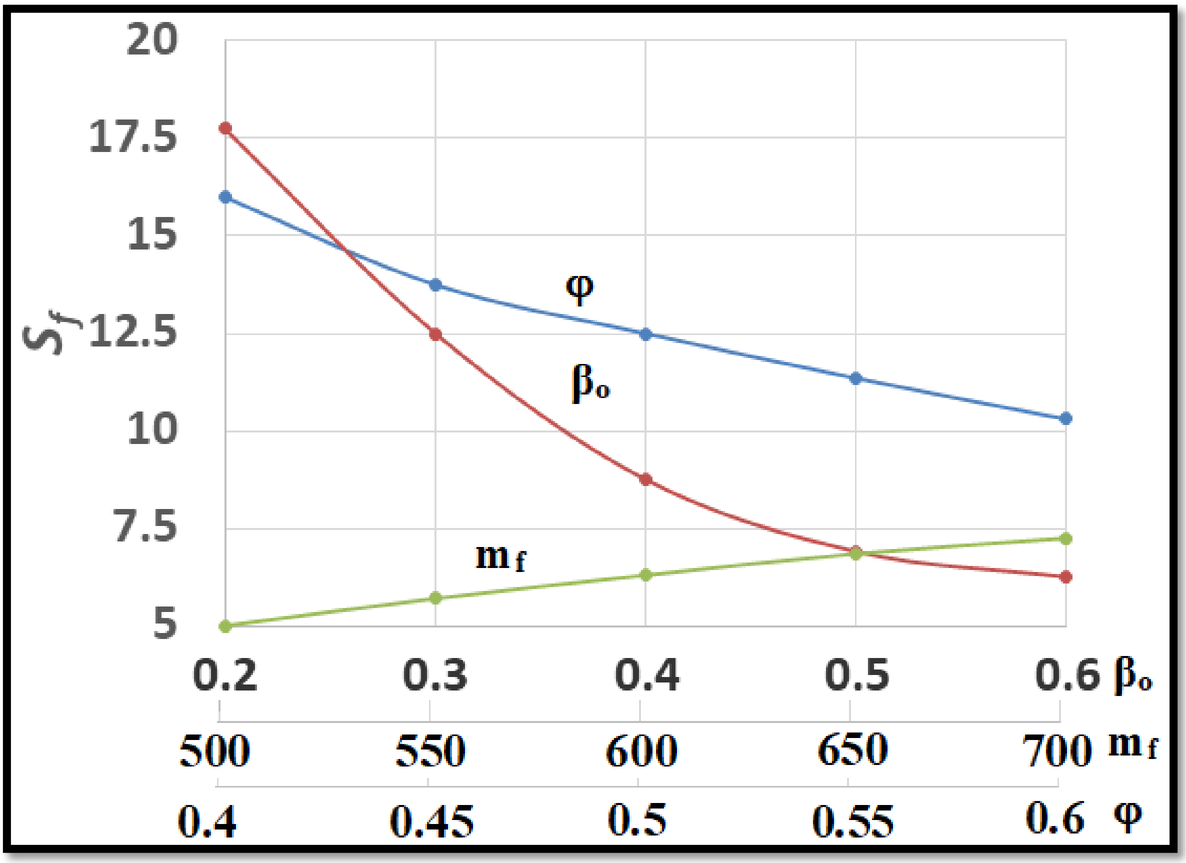

Fig. 2: Variation of a brake distance with factors β_0, $m_{f\cdot exe}$, and φ.

Figure (3) shows the relation between deceleration of the car and mass of automobile during the braking process on front wheel on stand $m_{f\cdot exe}$, and coefficient of force between the front and rear axles factors,β_0 . It can be noticed that the deceleration of the car increases as β_0 increases while, it decreases as $m_{f\cdot exe}$ increases.

Increasing the total brake force on axis and wheels is naturally reduces the impact of a brake distance. At the same time, a factor for forward wheels of the automobile will be varied proportionally withβ_0, and for back wheels ($1-\beta_0$).

The influence on brake way size of inertial mass of the stand can be considered, using the Eq. (3). The results of calculations under this form is, β_0= 0.573.

The increasing of inertial mass in the stand test results increases the brake distance and it models majority of automobiles (except for an automobile especially small class). For the most widespread designs of stand tests, its results approach the results obtained on road tests. Therefore reduction factors should be proportional to ratio of inertial mass on a road and on the stand, i.e, m_r/m_s.

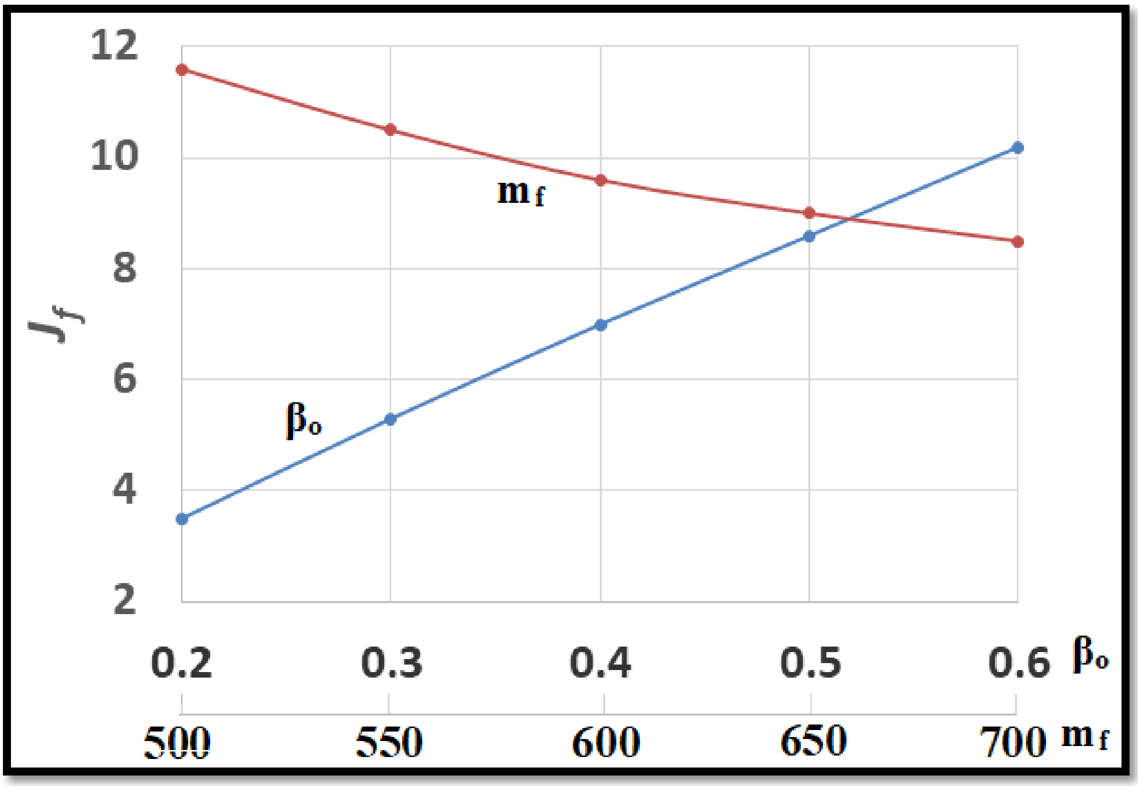

Fig. 3: Variation of a brake distance-deceleration with factor β_0, and $m_{f \cdot exe}$

The influence of swing resistance factor, f, on impact of a brake distance can be estimated from the Eq.(5). The increase of swing resistance factor of wheels on drums on the stand reduces size of a brake distance. However, the experimental tests and the calculations have showed that the influence of swing resistance factor is insignificant and can be neglected. Thus the factor of braking (the general specific brake force) comes closer to coupling factor on dry roads with a firm covering, $\varphi >> f$.

Variation of a brake distance and deceleration of the car with dynamometer drum size, D is shown in Figure (4). [8, 9, 10]

The dependence of a brake distance from factors of trunks coupling of basic surfaces of a road and a stand is clear from the equation (7).

As a case study, the changed character of a brake distance and deceleration of small automobiles of a category M_1 relative to drum diameter of dynamometer (of inertial weight of the stand) at v_o = 40 km/ h is shown in a Figure (4).

The dependence of dynamometer inertial mass, m_s and factor of brake forces distribution between axes (front and rare wheels) of the automobile, β_0 is given in a Figure (3). Using the formula $j_{s.f} = \beta_0 \Sigma p / m_{s.f}$ at $\Sigma p = 10190$ H, $\beta_0 = 0{,}573$, $m_{s.f} = 600$ kg ,it enables to choose a design of the stand and with proper diagnostic of parameters for the certain order.

However, to take into cconsideration the discrepancy of factors, it is necessary in the event that the braking on the stand and on a road is carried out on a limit of blocking on conditions of coupling. At identical efforts of pressing to a pedal of a brake without blocking wheels the factors do not need to be taken in calculation.

The previous researches results showed that the air resistance reduces the brake distance of the car approximately by 0.8 m or by 1. 5 % (at test from initial speed of braking for v_o = 80 km / h). It allows considering coefficients of air resistance, taking in calculation, while it is neglected at the stand test.

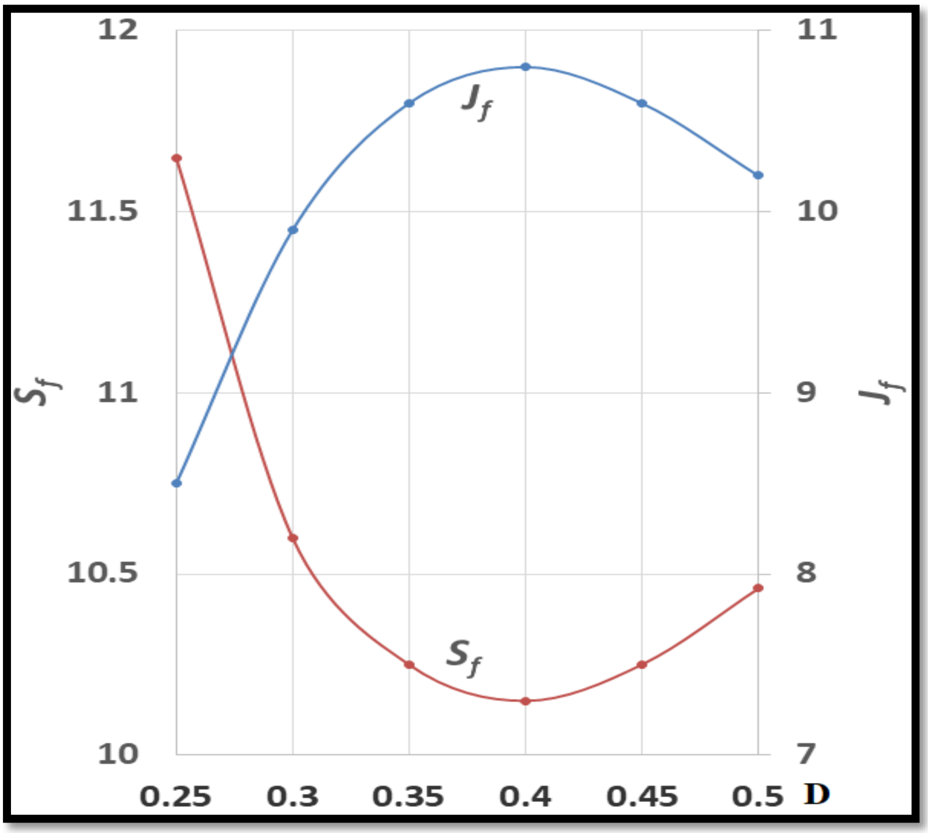

Fig. 4: Variation of a brake distance and brake distance-deceleration with coefficient of drum size of dynamometer, D.

4. Conclusions

Based on the results of the experimental tests and mathematical formulations, the following conclusions may be drawn:

- The brake way force decreases as the coefficient of force between the front and rear axles and basic surface increase.
- The brake way force increases as the initial mass of automobile increases.
- The deceleration of the automobile increases as basic surface increases.
- The deceleration of the automobile decreases as initial mass of automobile increases.
- The increase of swing resistance factor of wheels on drums on the stand reduces size of a brake distance.
- Predicting the diagnostic parameters showed the dependence of these parameters on an effort of pressing force on a brake pedal.

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