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CONDITIONS OF FUEL FILLING DISPENSER TROUBLE – FREE OPERATION

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Abstract. *Regularly on the filling stations (FS) there are failures at priming of transport vehicles, when a driver, driving away after priming, forgets to smuggle out of a pistol from the mouth of filling tank of car. Thus, at wedging of pistol in the tank of car, there are not only breaks in a chart a pistol is a hose but also serious destructions of fuel filling dispenser (FFD). In the present paper the mathematical model of functioning of chart is considered vehicle - fuel filling dispenser. From the analysis of the got model, if a car begins motion with the undrawn pistol out of a fuel tank, the geometrical parameters of chart are determined vehicle - fuel filling dispenser, at which slipping out of pistol or his wedging will be in the mouth of tank which possible consequences are considered for (tearing away of pistol from a hose, tearing away of hose from corps of filling vehicle, break of hose, deformation of fuel filling dispenser). The geometrical parameters of chart are determined fuel filling dispenser, at which "forgetfulness" of driver will not result in damages of fuel filling dispenser f, and there will be slipping out of pistol from the mouth of fuel tank of car.*

Keywords: *fuel filling dispenser, fuel tank wedging, friction coefficient.*

Introduction

One of the main dangers in the process of fuel filling dispenser (FFD), is connected with the situation when a vehicle leaves the dispenser with filling pistol in the tank. This happens at most filling stations (FS). In this case, the car often drives off only from filling pistol when on the hose is safety cutoff clutch/valve (SCCV), or with the whole column, if the bursting SCCV is not installed or it does not work that leads to severe damage: Loss of FFD and damaging the car, and even ignite because of depressurization of FFD.

Fig.1. **The accident that occurred due to not pulled out of a tank a filling pistol**

Fig.2. **Safety cutoff clutch/valve (SCCV)**

The interest to SCCV has grown into a stable demand in many countries their use is mandatory. On the hardware market FFD most widely represented bursting SCCV production Emco Wheaton (USA), OPW (USA), Elaflex (Germany) and others (see Fig. 2.)

with a force at break: 160-170 kg [5].The main the lack of some SCCV PTP associated with the method and location of installation: valve fails to break if the load angle of 90 °. That is, if the car is near to the body of FFD or not from the fuel, the valve does not work, because the axial load on the valve in this case is missing.

The publication, based on an analysis of the technological scheme of the FFD, used for housing construction, the hose and the filling pistol is a recommendation on the location of the vehicle when it is fueling the body with respect to FFD, which ensures trouble-free situation, if the car after filling drives off from the FFD with inserted into the tank filling pistol.

Materials and methods

Fig.3. **Filling pistol**

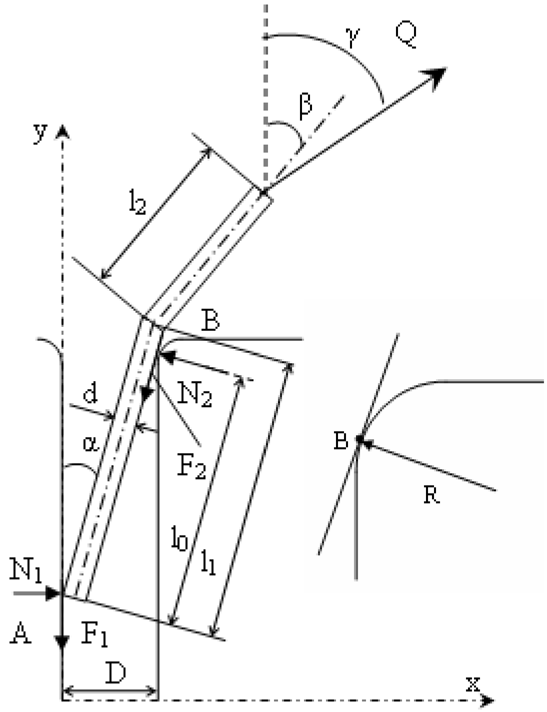

Fig. 4. **Design model**

The reaction F_1 and F_2 directed opposite to the outer movement of the pistol. Let us write the equation describing the relationship of geometric dimensions:

$$d\cos(\alpha) + l_1\sin(\alpha) = D + R(1-\cos(\alpha)) \quad (1)$$

Filling pistol and car's tank geometrical dimensions:

$l_1 = 230 \div 260$mm, $l_2 = 200 \div 270$mm, $d = 20 \div 25$mm, $D = 40 \div 50$mm, $\alpha = 2 \div 7^o$, $\beta = 13 \div 20^o$

When a pistol is not moving, the contact point a pistol and filler cap are considered as hinges, restricting movement pistol in two directions (x and y). To find the unknown quantities N_1, N_2, F_1 and F_2 solve the hyperstatic system[2,3,6]. Equation of equilibrium of body:

$$\begin{aligned}
&\sum \vec{x} : N_1 - F_2\sin\alpha - N_2\cos\alpha + Q\sin(\gamma) = 0 \\
&\sum \vec{y} : -F_1 - F_2\cos\alpha + N_2\sin\alpha + Q\cos(\gamma) = 0 \\
&\sum M_A : \; -F_2 d + N_2 l_1 - Q \cdot l_1\left(\frac{l_2}{l_1}\sin(\gamma-\beta) + \sin(\gamma-\alpha)\right) = 0
\end{aligned} \quad (2)$$

F2 reaction is found from the canonical equation (excluding the transverse force)[2,3,6]:

$$\delta_{11} F_2 + \delta_{1Q} = 0$$
$$\delta_{11} = \frac{l_1}{ES}, \; S = \frac{\pi d^2}{4}\left(1 - \left(\frac{d_0}{d}\right)^2\right),$$
$$\delta_{1Q} = -\frac{l_1}{ES} Q \cos(\gamma - \alpha) \tag{3}$$
$$F_2 = Q \cos(\gamma - \alpha)$$

From 1-3 we find the reaction N_1, N_2, F:

$$N_1 = Q\frac{D[\cos(\alpha-\gamma) - \cos(\alpha+\gamma)] - l_2[\sin(\beta)\cos(\alpha)\cos(\gamma) - \sin(\gamma)\cos(\beta)\cos(\alpha)]}{D\sin(\alpha) - l_1\cos(\alpha)^2}$$
$$N_2 = Q\frac{\{D\cos(\alpha) + l_1\cos(\alpha)\sin(\alpha)\}[\cos(\alpha-\gamma) - 1] + l_2[\cos(\gamma)\sin(\beta) - \sin(\gamma)\cos(\beta)]}{D\sin(\alpha) - l_1\cos(\alpha)^2} \tag{4}$$
$$F_1 = Q\frac{l_1\cos(\alpha)[\cos(\alpha-\gamma) - \sin(\gamma)\sin(\alpha) - \cos(\gamma)\cos(\alpha)] + l_2\sin(\alpha)[\sin(\beta)\cos(\gamma) - \sin(\gamma)\cos(\beta)]}{D\sin(\alpha) - l_1\cos(\alpha)^2}$$

Reaction of F_1 and F_2 can not be more the frictional forces F_{f1} and F_{f2}. Module the frictional forces can be expressed through of the normal reaction N_1 and N_2:

$$F_1 = F_{f1} = N_1 f_1$$
$$F_2 = F_{f2} = N_2 f_2 \tag{5}$$

In relations (5) f_1 and f_2 - the coefficients of friction, respectively, in sections of the contact with the neck of filling tank and the pistol. In overall case $f_1 \neq f_2$.
From relations (3) and (4) implies that if:

$$F_1 \geq F_{f1} = N_1 f_1 \tag{6}$$

then at the contact point A is a necessary condition under which a possible move at this point, and accordingly, if:

$$F_2 \geq F_{f2} = N_2 f_2 \tag{7}$$

then at the contact point B is a necessary condition under which a possible move at this point.
From (3) - (7) we can define the angle γ, which may slip the pistol by the throat filling the tank, respectively, in sections of the contact A and B. For the numerical example:
l_1 = 23 cm, l_2 = 20 cm, D = 5 cm, d = 3 cm, α = 5°, β = 65°, f_1 = f_2 = 0.3
To simplify the comparison of all the forces are built as a function by the angle γ in Figure 5. As is evident from the graphs in Figure 5 at point A at a smaller angle γ, are the conditions under which filling pistol's motion is possible at this point. Mean the filling pistol starts moving when in the point B are the conditions for the movement at this point.

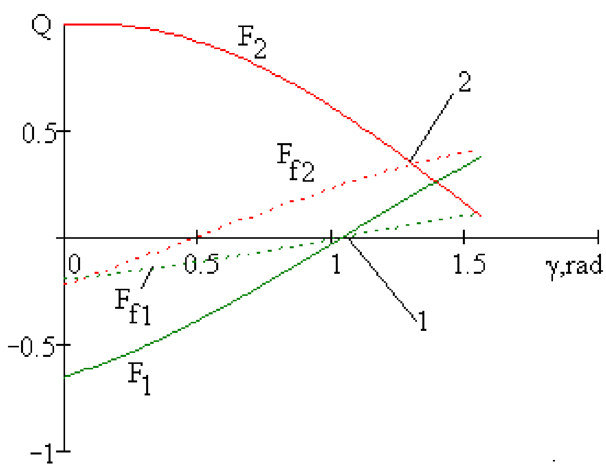

Fig. 5. **Dependence of the forces F_1, F_{f1}, F_2, F_{f2} by the angle γ**

For the limiting case where $F_1 = F_{f1} = N_1 f_1$ and $F_2 = F_{f2} = N_2 f_2$, have five equations (2), (3) and (5) with five unknowns: reaction of N_1, N_2, F_1, F_2, and the angle γ. The problem is statically defined. Determined by the normal reaction of N_1 and N_2:

$$N_1 = Q\frac{f_2\sin(\alpha)\cos(\gamma)+\cos(\alpha)\cos(\gamma)-f_2\sin(\gamma)\cos(\alpha)+\sin(\gamma)\sin(\alpha)}{f_2\cos(\alpha)+f_1 f_2\sin(\alpha)+f_1\cos(\alpha)-\sin(\alpha)}$$
$$N_2 = Q\frac{f_1\sin(\gamma)+\cos(\gamma)}{f_2\cos(\alpha)+f_1 f_2\sin(\alpha)+f_1\cos(\alpha)-\sin(\alpha)} \qquad (8)$$

For the third equation of system (2) we obtain:

$$(1.973\cdot\cos(\gamma)-1.250\cdot\sin(\gamma))\cdot Q[l_1-0.3d]d+-Q\cdot l_1\left(\frac{l_2}{l_1}\sin(\gamma-\beta)+\sin(\gamma-\alpha)\right)=0 \qquad (9)$$

which allows us to determine the greatest value of the angle γ, which is still possible to balance the pistol in refueling the tank. If the value of the angle γ is less than the value determined by equation (9), the pistol will slip out of filling tank.
For the adopted numerical values of the pistol in Fig. 6 provides a solution to (9), which implies that the movement of the pistol is possible at an angle $\gamma_{max} < 69^0$

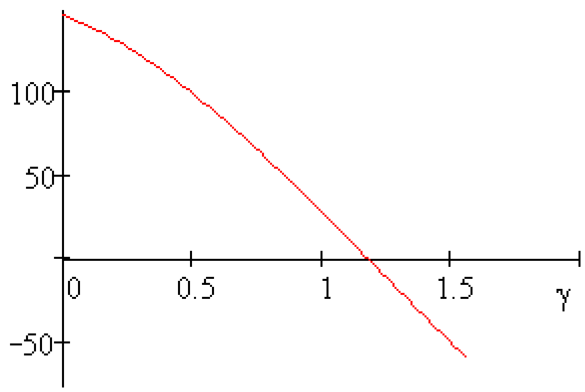

Fig. 6. **Graphical solution of equation (9)**

Results

Knowing the angle γ_{max} in Figure 7 can approximately determine the minimum distance L_{min}, which should be raised from the housing dispenser car at a fuel filling dispenser (FFD) to avoid jamming the pistol in refueling the tank, if the driver forgot to pull out after filling the the pistol out of filling the tank.

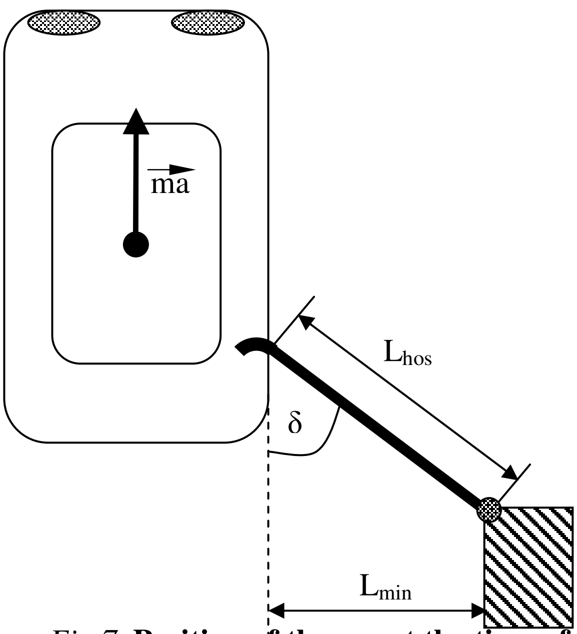

Fig.7. **Position of the car at the time of slipping or jamming the pistol**

$$L_{min} \geq L_{hos} \cdot \sin(\delta_{min}), \qquad \delta_{min} = 90 - \gamma_{max} \tag{10}$$

At the beginning of the pistol motion (could be the beginning of motion) force the tension hose can be calculated by the formula:

$$q_{hos} = F_{f1} \cdot \cos(\gamma) + F_{f2} \cdot \cos(\gamma - \beta) = N_1 f_1 \cdot \cos(\gamma) + N_2 f_2 \cdot \cos(\gamma - \beta) \tag{11}$$

where: N_1 and N_2 calculate by formula (8).

If at the time when the movement becomes possible tensile strength hose is more than the limit (q_{hos}>160-170 kg), the pistol will remain in the tank and explode safety cutoff clutch/valve. If the SCCV is not operable or not it will damage the FFD. Calculate conditions could be the beginning of pistol motion, remember that at this moment the tension force the hose does not exceed the allowable.

Conclusions

In this paper we analyze the process of jamming the pistol in the neck of the fuel tank. It can be concluded in order to avoid jamming is necessary to reduce friction coefficient at the contact points a pistol and the neck of the fuel tank. The most effective and easily implemented way to avoid the jamming is to increase the distance from the car before fuel filling dispenser.

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