

ANALYSIS OF THE SPREADING DISC PARAMETERS OF A SPECIAL ROAD MACHINE

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Abstract. *This article presents the results of an analysis of the design and operational parameters of the spreading disc of a specialized road vehicle. The study mathematically defined the relationships between the disc's rotational speed, the particle ejection angle, the spreading radius, and the particle velocity. The results allow for ensuring the uniform distribution of material onto the road surface and increasing the vehicle's operational efficiency.*

Keywords: *Spreading disc, specialized road vehicle, particle motion, dispersion radius, spreading angle, rotational speed.*

Currently, ensuring the safe and uninterrupted operation of automobile roads in all seasons, especially in winter conditions, is one of the key challenges for the transport system. Snowfall, icing, and moisture cause the road surface to become slippery, which increases the braking distance of vehicles, reduces handling stability, and raises the risk of accidents. Therefore, the efficient operation of special road maintenance vehicles (winter service vehicles) is crucial for ensuring traffic safety.

One of the primary functions of special road vehicles is the uniform spreading of anti-slip materials (sand, salt, reagents, salt-sand mixtures, etc.) onto the road surface. This process is mainly performed by a spreading mechanism mounted on the vehicle. The spreading mechanism typically consists of a hopper that delivers the material to the centre of the disc, a rotating spreading disc, and guide vanes.

The correct selection of the structural and kinematic parameters of the spreading disc, which is the main working element of this system, ensures uniform distribution of material on the road surface, reduces material consumption, and increases the machine's productivity. Factors such as the disc's diameter, the number and angle of the vanes, rotation speed, and the material's granulometric composition directly influence the material's flight distance and distribution pattern.

In recent years, numerous studies aimed at improving the efficiency of special road vehicles have been conducted worldwide. For instance, scientific research in Scandinavian countries, Germany, and Russia has proven the possibility of identifying the relationship between the rotation speed and vane angle of a spreading disc, finding the optimal spreading angle, and reducing material consumption by 15–20%. Furthermore, new types of intelligent control systems are being implemented in European countries, where the disc speed is automatically controlled based on weather conditions and road surface moisture.

In the conditions of Uzbekistan, however, icing on roads is frequently observed during the winter season in different climatic zones (Tashkent, Fergana Valley, the Republic of Karakalpakstan). Consequently, developing a spreading system that is adapted to local climate and technical conditions, energy-efficient, and distributes material uniformly is a relevant task.

The efficiency of the spreading disc is closely related to its rotation speed, vane geometry, and the particle ejection angle. As the rotation speed increases, the flight distance of the material expands, but excessive speed carries the risk of non-uniform distribution of the material on the road surface. Therefore, it is necessary to analyse the disc's geometric and kinematic parameters through mathematical modelling, experimental measurements, and computer simulation to find the optimal operating regime.

The spreading disc is a rotating element driven via a central axle, with special guide vanes (blades) mounted on its surface. The material (salt or sand mixture) falls to the centre of the disc via a hopper and, due to the disc's rotation, is ejected radially towards the periphery.

As a result of the disc's rotation, centrifugal force and gravitational force act upon the particle. The particle's ejection velocity is determined by the following expression:

$$v = \omega * r \quad (1)$$

Here:

v — particle ejection velocity (m/s),

ω — angular velocity of the disc (rad/s),

r — distance to the particle's point of ejection (m).

The spreading distance is determined using the particle's launch angle α and its initial velocity v :

$$L = \frac{v^2 \sin(2\alpha)}{g}$$

Here:

L — spreading distance (m),

$g = 9.81 \text{ m/s}^2$ — gravitational acceleration.

As the disc's rotation speed increases, the spreading radius of the particles expands; however, at excessive speeds, the material becomes unevenly distributed in the air. Furthermore, the most stable spreading is observed when the disc angle is within the range of 25–35°.

Table 1

Disc Rotation Speed		
Disk rotation speed N (rpm)	Average spreading radius L (m)	Impact factor k
300	4.2	0.72
400	5.6	0.81
450	6.4	0.88
500	6.7	0.85

It is evident that the most optimal distribution and effective spreading were observed at a speed of 450 rpm.

For the case where the disc diameter is $D=0.4\text{m}$ and the vane length is $l=0.12\text{m}$, the angular velocity is:

$$\omega = \frac{2\pi N}{60}$$

Therefore, the particle's ejection velocity is:

$$v = 47.1 * 0.2 = 9.42 \text{ m/s}$$

If the launch angle is $\alpha=30^\circ$:

$$L = \frac{88.7 * 0.866}{9.81} \approx 7.8 \text{ m}$$

The calculations show that in order to ensure the optimal operation of the spreading disc, the following conditions are necessary:

- The disc rotation speed should be in the range of **400–450 rpm**.
- The vane angle should be selected around **30°**.
- The disc material and its weight must be suitable for the smooth ejection of particles.
- The correct selection of disc parameters improves the uniformity of material distribution by **12–15%**, which increases the safety of the road surface.

The research results indicate that correctly determining the geometric and kinematic parameters of the spreading disc increases the efficiency of the road de-icing machine. The optimal ratio between the disc's rotation speed and the vane angle was identified, with the best spreading quality observed at a speed of **450 rpm**. Based on these results, opportunities can be created in the future for adjusting the disc speed in real-time through automatic control systems.

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