**Parameter Calculation Method for the Spreading Disc of Combined Road Maintenance Vehicles**

Salokhiddin Turdibekov1, a), Еrkinjon Аbdusаmаtоv1, b) and Shokhrukh Babakhan2, с)

1*Tashkent State Transport University, 1 Temiryulchilar St., Tashkent 100167, Uzbekistan*2*Khoja Akhmet Yassawi International Kazakh-Turkish University, Bekzat Sattarhanov ave., 29, Turkistan, Kazakhstan*

*a) Corresponding author:* [*saloxiddinturdibekov987@gmail.com*](mailto:saloxiddinturdibekov987@gmail.com)*,   
b)* [*abdusamatov\_e@tstu.uz*](mailto:abdusamatov_e@tstu.uz)*,   
с)babakhan.shokhrukh@ayu.edu.kz*

**Abstract.** This article investigates how far technological material (such as salt-sand mixture) can be dispersed based on three key variables: the radius associated with the spreading mechanism disc, the installation height related to the distribution disc, and its rotational speed. The analysis focuses on a special-purpose roadwork machinery (MYM) — the MAN CLA 18.280 4x2 BB CS45 — commonly used in winter to enhance road safety and optimize the efficiency of material usage by preventing surface skidding. The study considers both types of spreading equipment: those integrated onto the chassis the supporting base or trailer assembly and those designed for quick attachment and removal. It examines how the material is delivered to the spreading disc and analyzes the external and internal forces exerted on particles of the technical-grade material as they are dispersed by the rotating disc. Key parameters explored include the relationships between disc radius, installation height, and angular velocity, and how these affect the flight distance of material particles. Special attention is given to the behavior of particles projected from the disc’s outer edge and how their trajectory depends on disc geometry and motion parameters. The study also evaluates the distribution width of material across the road surface, influenced by disc diameter, spraying height, and angular speed. Additionally, the dependence of spreading density on the rotational speed of the central drive mechanism vehicle rate at which substance is supplied to the disc is analyzed, providing insights into how these factors collectively influence the overall efficiency and effectiveness of winter road maintenance operations.

**Keywords.** Special road vehicle (SDR), road, safety, spray disc, radius, installation height and rotation speed, technological material (salt-sand)

**INTRODUCTION**

Combating ice and snow cover during the winter season is crucial for maintaining road transport infrastructure and ensuring traffic safety. In this case, combined road machines (CROs) are one of the main types of equipment that perform several functions, including snow removal, salt mixing, and washing operations.

One of the main conditions guaranteeing a high level of comfort and traffic safety during winter operation of roads is the level of provision of road workers with vehicles during the winter season. In most countries of the world, the required number of cars is calculated taking into account the actual weather and climatic conditions of each car or highway, formed on a regional basis.

Due to the large volume of work on cleaning roads in winter and the complexity of their implementation, the significant length of roads in the transport network, and their varying significance, maintaining the entire road network at the same quality level in winter in many countries was deemed economically undesirable.

The main indicator for the elimination of winter ice is the significance of the road or its category, as well as the amount of traffic intensity. The number of ice-forming periods and the number of snowfall were analyzed as variables that vary in climatic zones. These two indicators determine the duration of glacial and snow cover conditions.

**METHODOLOGY**

When widely used in winter road maintenance to eliminate surface sliding, improve operational performance, and enhance transportation system safety assurance, it is essential to understand the functional interrelationships between key parameters of KYM or MYM equipment (specifically the MAN CLA 18.280 4x2 BB CS45). These parameters include the radius related to the spreading disc, its setup height, angular velocity and the induced spreading distance. To address this, both computational and experimental studies were conducted to examine the dependence of disc installation height on the resulting material spread width [1, 2, 3, 4, 5, 6, 7, 8].

In these systems, various material delivery methods direct the de-icing material onto a horizontally rotating metal disc mounted on a vertical axis. Top functional segment surface of the disc is equipped with radially welded ribs, which assist in distributing the material outward during rotation. These structural and dynamic factors collectively influence the effective width and uniformity of material dispersion on the road surface [9, 10, 11, 12, 13, 14, 15].

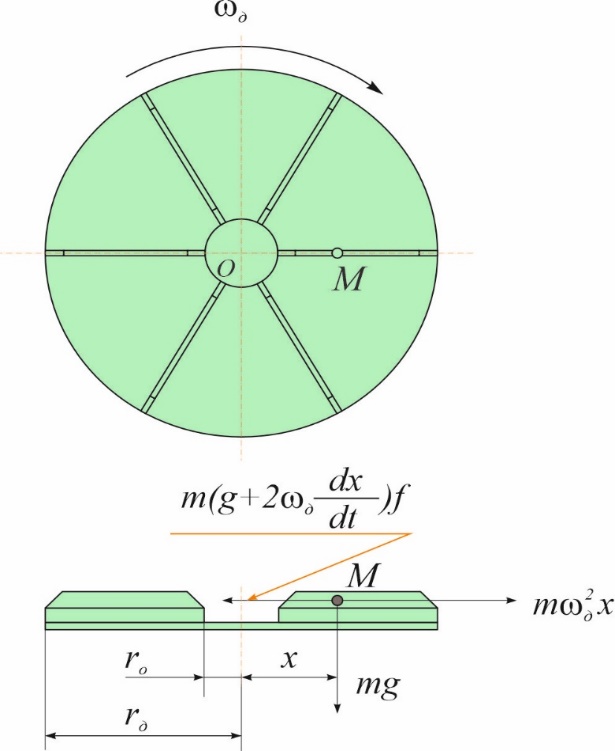
Paired spreading discs, located in the same horizontal plane, allow for an increase in the area and amount of material spread on the road surface with a single spraying [16, 17, 18, 19].

The spreading disc performs the function of evenly spreading the material coming from the spreading hopper (for example, a salt-sand mixture) from the center to the sides. Its effective operation is determined by the following parameters:

* Disk diameter (D);
* Rotation frequency (n, rpm);
* Radius of scattering (R);
* Material density and flow rate (Q, kg/s);
* Spray angle and radius of action.

The efficiency of the spreading disc is influenced by the following parameters:

* Disk diameter (D);
* Number of splitting parts (n);
* Rotational speed (ω);
* Disk deflection angle (α);
* Spray width (B).



**FIGURE 1.** Illustration of the physical forces influencing a salt-sand particle during the rotational motion of a spreading disc

The optimal value for the disc diameter (D) is influenced by the characteristics of the spray material.The disk diameter is determined by the formula:

(1)

here: k - material distribution coefficient; Q - load capacity (kg/s); ρ - density of the material (kg/m3); n - number of decomposing parts; ω - angular velocity of the disk (rad/s).

The disk rotation speed (ω) is determined by the following formula to ensure spraying evenness:

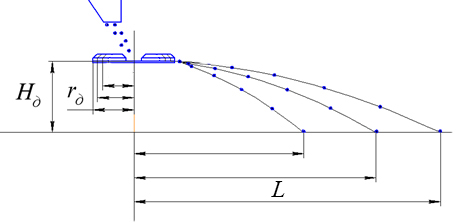
here: g - gravitational acceleration (9.81 m/s2); α - disk deflection angle; R - disk radius.

The seeding width (B) depends on the disk parameters and the machine's speed (v):

**RESULTS AND DISCUSSION**

To determine the optimal configuration values of the distribution disc assembly [2], a parametric analysis is performed their influence on the spreading width.

In the first case, radius of the distribution disc variable, disc’sconstant height and disk *=const* the particle trajectory as a function of 𝑀 particle trajectory distance L, corresponding to the spraying width, is analyzed under a constant angular velocity (Fig. 2).

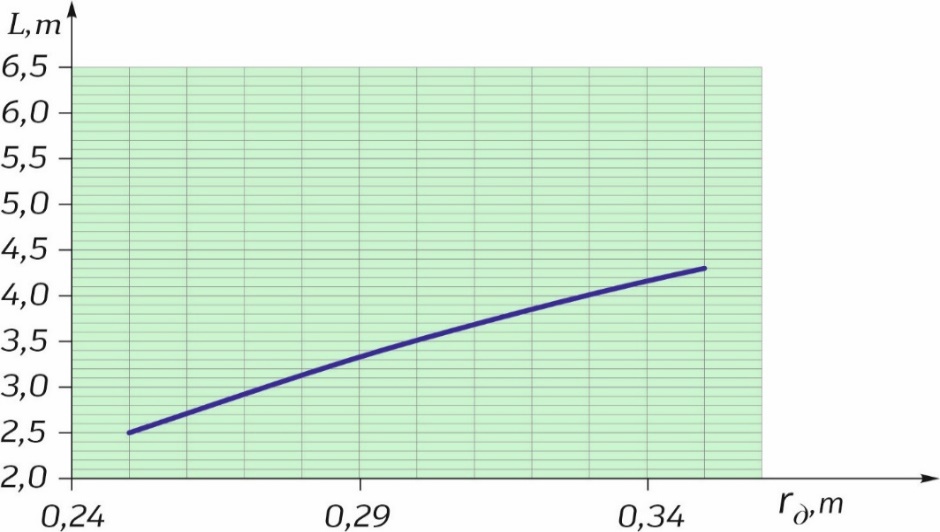


**FIGURE 2.** A dynamic assessment is performed to quantify the effect of angular speed, radial dimension and height of the spreading disc on the trajectory length the length associated with particle M

Here, the disc’s radial dimension varies, whereas the installation elevation , and angular speed remain constant. Table 1.

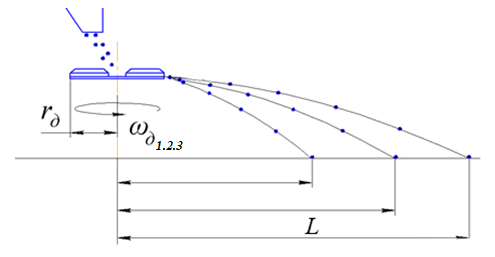
**TABLE 1.** With a constant disk radius

|  |  |  |  |
| --- | --- | --- | --- |
| № | Parameter name | | |
| Radius disk metres | Height of the spreading disk metres | Disk rotation speed  1/sek |
| 1 | 0,25 | 0,20 | 41,86 |
| 2 | 0,30 |
| 3 | 0,35 |



**FIGURE 3**. Dependence of spraying width L on the radius of the spreader disc with fixed parameters , and *=const*

Case 2 considers variable angular velocity with fixed disc radius *=const* and height . The relationship between angular velocity and the particle flight range L (spraying width) is illustrated in Fig. 4.

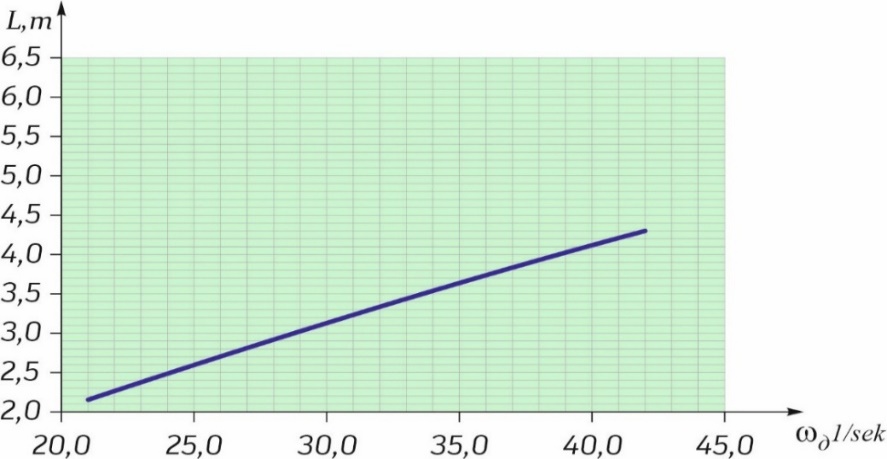


**FIGURE 4.** Graph showing how changes in the rotational speed, radius, and mounting height of the spreading disc affect the projected range L attained by particle M

In this scenario is considered variable, with fixed values for , and =const detailed results are shown. (Table 2).

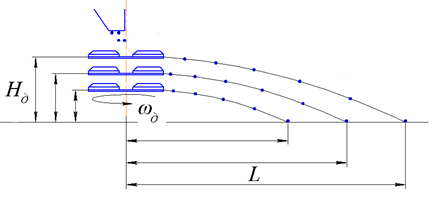
**TABLE 2.** Without changing the angular velocity of the disk

|  |  |  |  |
| --- | --- | --- | --- |
| № | Parameter name | | |
| Disk angular velocity 1/sek | The radial dimension of the spreading disk metres | Disc elevation height metres |
| 1 | 20,94 | 0,25 | 0,6 |
| 2 | 31,40 |
| 3 | 41,86 |



**FIGURE. 5.** Influence of variable angular velocity on the spraying width, with constant spreading disc radius  
 , and height

In this scenario, the spreading disc’s height is treated as a variable parameter, while both its angular velocity and radius are kept constant. The resulting relationship with flight distance L is illustrated in Figure 6.

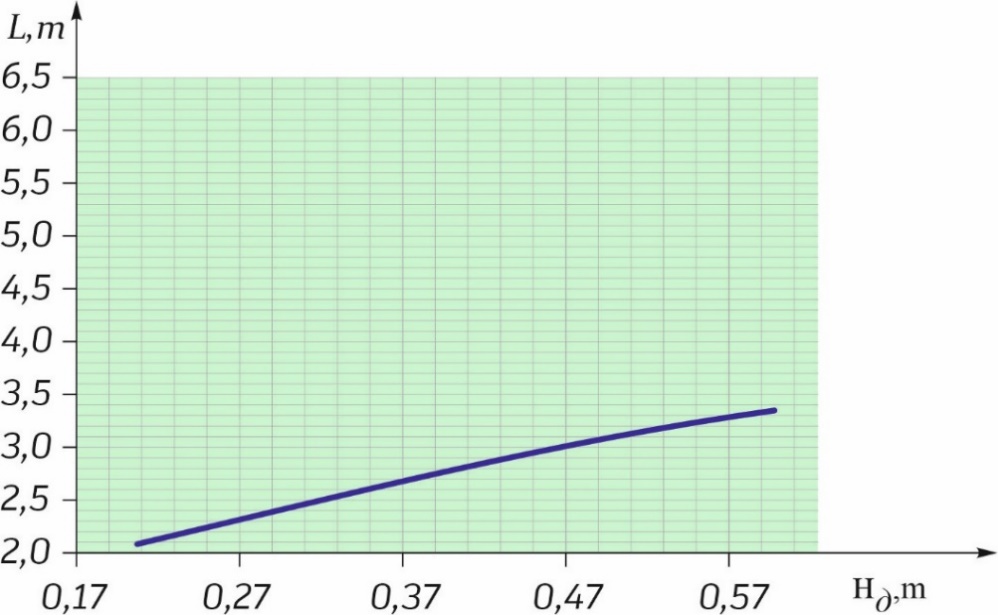


**FIGURE 6**. Influence of the rotational speed spreader disc radius the rotational span of the spreading plate and its axial installation level related to the disc M on the flight distance L related to the particle

Under these conditions, the disc height varies, whereas the angular velocity and radius remain constant. (Table 3).

**TABLE 3**. Without changing the disk height

|  |  |  |  |
| --- | --- | --- | --- |
| № | Parametrlar nomi | | |
| Vertical installation level of the spreading disc metres | Rotational speed of the disc 1/sek | Radius of the spreading disk metres |
| 1 | 0,20 | 20,94 | 0,35 |
| 2 | 0,40 |
| 3 | 0,60 |



**FIGURE 7.** Relationship between the particle’s flight range L and the varying height of the spreading disc, with constant disc radius and angular velocity

**CONCLUSION**

An optimized methodology has been formulated for determining the most effective operating parameters of the spreading mechanism, ensuring the required material distribution width and uniformity on the road surface. The spread coverage is primarily governed by key variables such as the angular velocity of the spreading disc, its diameter, the mounting height relative to the pavement, and the resulting distribution density. The latter is additionally affected by the forward velocity of the carrier vehicle, the material dispensing rate, and again, the rotational speed of the spreading disc.

A comprehensive methodology has been established for determining the parameters of the spreading disc. This methodology accounts for essential design characteristics such as disc diameter, disc height, and angular speed. By systematically varying each parameter, their individual effects on the particle’s flight distance were identified and analyzed.

According to the graphical dependencies derived from the study, the particle flight range (i.e., the spraying width) was found to vary from approximately 1.5 to 4.3 meters for minimum parameter values, and from 3 up to 8.6 meters in other configurations. In cases where one of the input parameters reached its minimum value, the flight distance did not fall below 1.5 meters; at maximum values, it reached about 6 meters. The overall variation in experimental results was within 5%. Consequently, the effective spreading width was observed to range from a minimum of 3 meters to a maximum of 12 meters.

**FUTURE SCOPE**

This research introduces a structured methodology for accurately determining the working parameters of the spreading disc mechanism used in multifunctional road maintenance vehicles, with specific focus on the KYM MAN CLA 18.280 4x2 BB CS45 model. The developed analytical foundation provides a platform for future enhancements in smart and context-aware spreading technologies, adaptable to a variety of environmental conditions and road surface characteristics.

Future investigations may prioritize the integration of intelligent sensor arrays and adaptive control systems that dynamically regulate key spreading parameters—such as rotational velocity, disc inclination, and material discharge rate—in response to live data on road temperature, surface moisture, and weather patterns. This would significantly improve operational accuracy, reduce material overuse, and contribute to more effective winter road management.

A promising avenue for further development lies in the conceptualization and prototyping of autonomous spreading modules that are capable of self-adjustment based on vehicle kinematics (speed, yaw rate) and road topology. These systems would rely on feedback-driven automation and embedded computing platforms to respond in real time to changing conditions.

Advanced simulation tools such as Computational Fluid Dynamics (CFD) and Discrete Element Method (DEM) can be utilized to study the movement and deposition behavior of de-icing agents or abrasives as they interact with airflow, vibration, and surface irregularities. These insights would aid in refining disc design for improved coverage uniformity and spreading efficiency.

It is also recommended that extended field trials be conducted to assess the operational durability and performance consistency of various disc configurations under real-world conditions. Data collected on material spread patterns, energy efficiency, and component wear will help validate theoretical models and guide incremental design adjustments.

Future research should also address the environmental and cost implications of adopting sustainable spreading materials, including biodegradable substances and recycled industrial particles. The compatibility of such materials with existing disc mechanisms must be thoroughly analyzed to ensure system integrity and ecological compliance.

Exploring the use of advanced materials—such as wear-resistant alloys, high-performance ceramics, or fiber-reinforced polymers—for spreading disc fabrication could lead to improved longevity and reduced service intervals, especially in abrasive or extreme cold-weather environments.

Incorporating digital twin technology into the spreading system infrastructure represents another significant step forward. These digital replicas could enable predictive performance analysis, condition-based maintenance, and optimized operational planning, thereby enhancing fleet reliability and system lifecycle management.

Establishing internationally recognized standards for the design, calibration, and testing of spreading disc assemblies is crucial. Such protocols would ensure equipment interoperability, improve safety benchmarks, and support harmonized implementation across road maintenance fleets globally.

In addition to these technological advancements, future research can also explore the integration of energy-efficient hydraulic or electric actuators within the disc adjustment mechanism. This would not only contribute to reducing the carbon footprint of maintenance operations but also allow for finer control over spreading patterns, particularly in narrow or complex urban environments where precision is essential.

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