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STUDY OF VERTICAL DISPLACEMENT, PRINCIPLES OF COUPLING AND DISPLACEMENT MECHANISM

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Nowadays, vertical displacement robots (VDR) are widespread technology with a wide range of uses. The robot surface engagement parts and methods' choice are one of the most critical criteria in the development of the (VDR), based on the tasks that are already set for the robot.

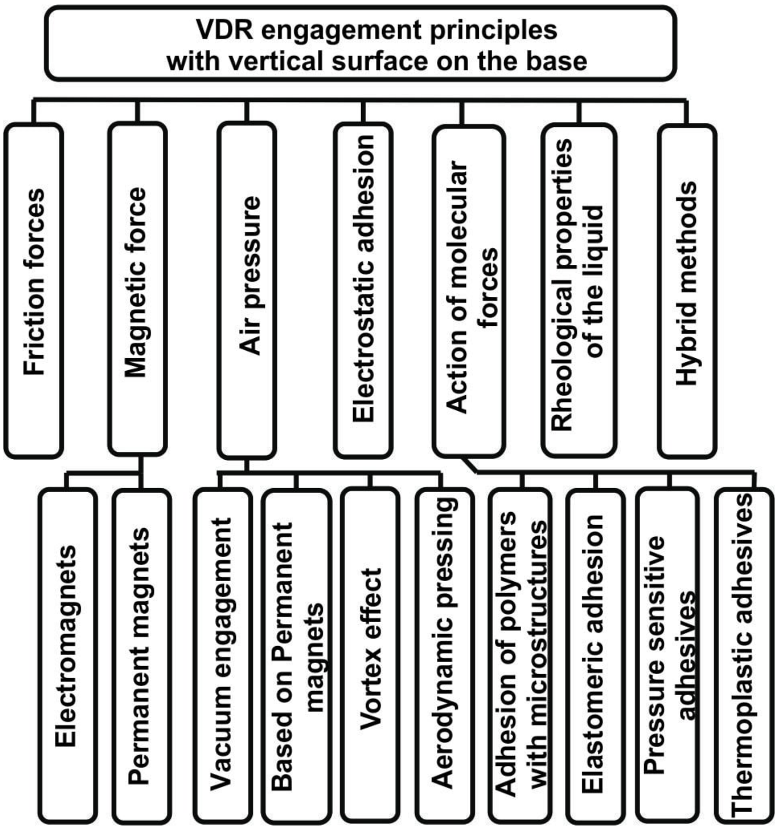

Figure 1 – Classification of (VDR) engagement principles [1].

Accordingly, based on the forces of nature that ensures the robot engagement to the work surface and the active and passive consumed energy (the energy consumed to move is regarded as active, and the consumed energy of holding force is regarded as passive energy) for (VDR), the engagement methods can be divided into the groups as shown in Figure 1.

Table 1 shows comparative qualitative indicators for VDR with different principles of engagement [2–6]. The movement mechanisms of VDR can also be divided into passive and active depending on whether the robot is equipped with an engine or not. Active mechanisms of VDR movement can be divided into several robotic groups: wheeled, caterpillar, walking, crawling, sliding (or frame), and hybrid.

Table 1 – Qualitative indicators for VDR with different engagement principles.

Principles of adhesion		Material parameters			Repeatability of work	Noise level
		Different materials	Dirty surfaces	Uneven surfaces		
Friction force		+	++	++	–	–
Magnetic	Electromagnets	–	+	+	++	–
	Permanent magnets	–	+	+	++	–
Air pressure	Active vacuum	++	+	+	++	++
	Passive vacuum	++	+	+	++	–
	Vortex effect	++	+	++	++	++
	Bernoulli effect	++	++	++	++	++
	Aerodynamics	++	++	++	++	++
Electrostatic adhesion		++	++	++	++	–
Dry adhesion	Polymers with microstructures	++	–	+	–	–
	Elastomers	++	–	+	–	–
Moisture adhesion	Glue	++	–	–	–	–
	Thermoplastics	++	–	–	–	–
– — low level, + — middle level, ++ — high level						

On the one hand, Table 1 shows the qualitative indicators for VDR with different engagement principles, where –: low level, +: middle level, and ++: high level. On the other hand, Table 2 shows a summary of data that reflects the applicability and compatibility of the VDR engagement principles with the relative mechanisms of movement, collected from the existing prototypes and experimental samples of VDR [7–10].

The analysis showed that within one engagement principle, it is impossible to develop a VDR that can move on a wide range of surface types to perform the necessary work, taking into consideration that satisfying the required specifications such as low noise, high throughput, force autonomy, relatively high payload, and other essential requirements, depends on the requests of developers.

Table 2 – Application and compatibility of engagement methods and VDR movement mechanisms.

Principles of adhesion and VDR parameters		Caterpillar	Wheeled	Walking	Rawling	Sliding	Hybrid
Friction force		–	+	+	+	–	+
Magnetic	Electromagnets	–	+	+	+	+	–
	Permanent magnets	+	+	+	+	–	–
Air pressure	Active vacuum	+	+	+	–	+	–
	Passive vacuum	+	–	+	+	–	+
	Vortex effect	+	+	–	–	+	–
	Bernoulli effect	–	+	–	–	–	–
	Aerodynamics	–	+	–	–	–	–
Electrostatic adhesion		+	–	+	+	–	+
Dry adhesion	Polymers with microstructures	+	–	+	+	–	–
	Elastomers	+	+	+	+	–	–
Moisture adhesion	Glue	–	+	+	–	–	–
	Thermoplastics	–	–	+	–	–	–
Based on the rheological properties of the fluid		–	–	+	+	–	+

Indeed, a well understanding of robots' comparative analysis enables designers to understand that robots with vacuum gripping devices differ with insufficient reliability, possibility, and the ability to move on ferromagnetic and nonferromagnetic surfaces.

Adhesive grippers are very promising but have not become widespread due to the limited number of contact cycles with surfaces and low load capacity.

To implement the layout of a zoomorphic mobile robot to move on a vertical surface, a magnetic surface-to-surface bonding method was chosen in this research work.

Though the adhesion chemical methods could be implemented for the purpose of surface-to-surface bonding, but they have several functional limits, such as moving on open metal surfaces that suffer from rust, dust deposits, pieces of dirt, water, and/or other effects; consequently, the chemical methods of adhesion are not applicable.

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