17th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2013, Istanbul, Turkey, 10-11 September 2013

CONTROL OF THE MOTION OF A UXOs DETECTION DEVICE

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ABSTRACT
One of the maintasks of the humanitarian demining is the 'elimination' of human role and his replacement with technical devices. In contribution to such task, a prototype of device for UXOs detection has been designed and built at laboratories of the Faculty of Mechanical Engineering in Prishtina, which motion is controlled from a distance.
The speed of the device and its motion control is of great importance during the work of device in the minefields.
Device has two independent remotely controlled movements: motion of the wheels and motion of the "Moving hand" with detectors.
Speed of motion of the wheels has to be synchronised to the configuration of the terrain. In this paper is elaborated relation of the wheels motion to motor's angular velocity and motor selection based on desired speed for the device/wheels.
Keywords: UXO, Wheels Motion, Speed, Angular Velocity, Power, Torque

1. INTRODUCTION

In this paper possibility of wheels' motion design of the RoboDet - Robot for Detection of unexploded ordnances [1] is analyzed. The device was designed and constructed at a laboratory of the Faculty of Mechanical Engineering in Prishtina based on investigation on existing equipment for detection. Knowing that detection of unexploded ordnances (UXO) and their clearance are very difficult processes the construction of device has been adapted to the conditions and configuration of our country.
To fulfill the main task – detection as a first step of UXO clearance and minimization of human role in this process - RoboDet is design to detect the unexploded ordnances through three metal detectors / sensors assembled in a 'moving hand' set to the platform which moves with two wheels with caterpillars each run by independent electric motor. The movement of the device and position of the 'moving hand' are remotely controlled through electronic circuits, exactly in the certain frequency, with the transmitter and the receiver electronic circuit.
The fast evolution of the technology and development of the electronic circuits offers different opportunities to control remotely the prototype (robot) and also evaluate its reliability [1].
Following on, in this paper the movement of the prototype was designed and analyzed considering two cases. First, the speed of the device has been calculated in relation to the electric motor characteristics (power, torque) and secondly, based on desired speed of tracks/wheels the electric motor was adapted.

2. MOVEMENT OF THE DEVICE

RoboDet, *figure 1.* was constructed assembling elements in three main parts:

1. Skeleton or main frame, composed by two wheels with caterpillars, each formed by couple of chains that runs in four gears (two different couple) linked with steel sheet profile in which the rubber peace was mounted creating tracks, *figure 2.*;
2. 'Moving hand' set in which three metal detectors was mounted, *figure 3.*;

3. Control electronic system, consist of receiver and transmitter plates (each containing two part – one to control movement of wheels, other to control movement of ‘moving hand’ set), *figure 4.*

Figure 2. Skeleton

Figure 3. ‘Moving hand’ set

Figure 1. RoboDet

Figure 4. Control electronics (Receiver and Transmitter)

In the *figure 5.*, the basic directions of device’s movements and while ‘moving hand’ move realized by the communication between the transmitter and the receiver circuit for the control motion.

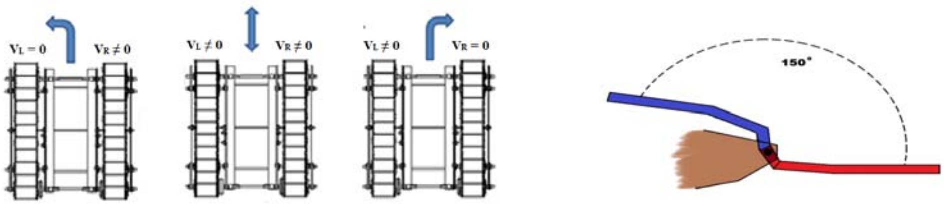

Figure 5. Wheels movement directions and ‘moving hand’ move

RoboDet, *figure 1.* is driven by three electric motors 12V 30W, *figure 6.*, one of them runs ‘moving hand’ set and is supplied by 6V 7Ah battery, while two others that drive wheels respectively are supplied by 12V 18Ah battery.

The power in rotational motion is torque times angular velocity:

$$P = T \cdot \omega \qquad (1)$$

Figure 6. DC motor

In any motor, torque is the result of the force between two magnetic fields and is proportional to the amount of current flowing through the motor.

In DC motor the torque obtained is known as the electromagnetic torque and subtracting the mechanical and rotational losses from it will be got the mechanical torque.

3. MOTION DESIGN OF RoboDet

The manufactured prototype moves with speed approximately one kilometer per hour. But, during testing of RoboDet in terrain and in improvised ‘minefields’ it was estimated that speed can be adjusted depending on configuration of the terrain (increase speed when flat or decrease when montane) and on level of contamination with UXOs (increase level is lower or decrease when high contaminated).

Based on the motion system of the platform – wheel with track driven by a DC motor, *figure 6.(top pictures)*, the ***motion model*** was built, *figure 7. (bottom)*.

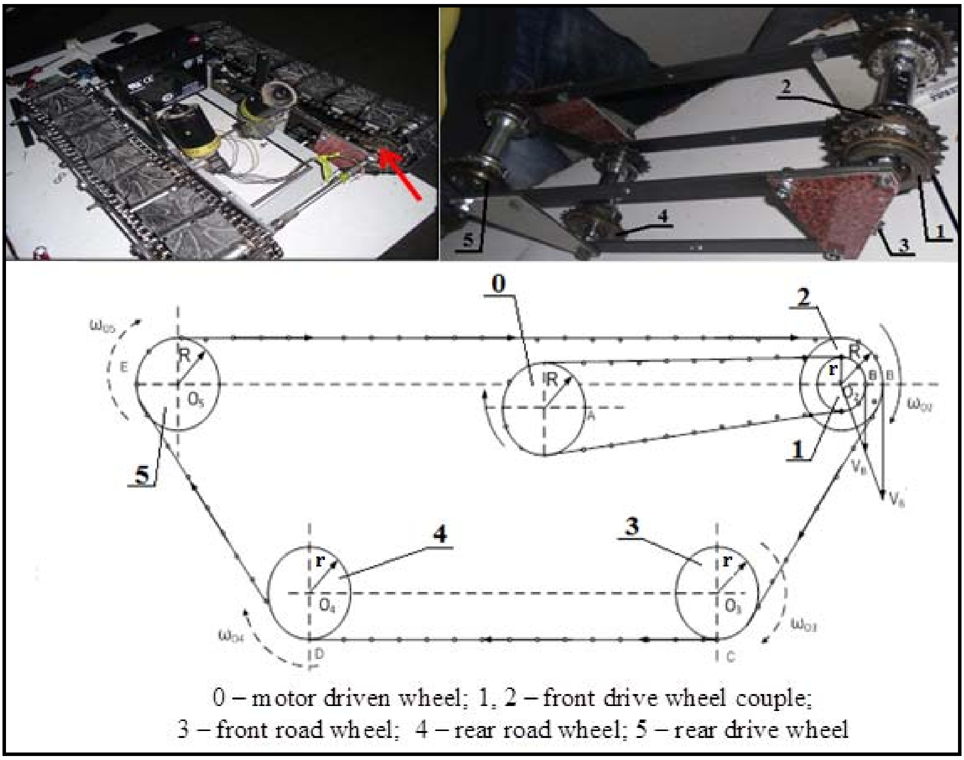

Figure 7. Device and its motion model

The ***motion model*** of 6 wheel/gears was analyzed for non-extendibility of the track and known relation between tangential speed and angular velocity of wheel/gear:

$$\vartheta = R\omega \qquad (2)$$

Using equations (1) and (2) and geometry of the wheels/gears, in *table 1.* is presented the calculation of the speed motion of the platform - tangential speed and angular velocity for each wheel – related to the DC motor power and torque, while in *table 2.* the angular velocity of DC motor was calculated related to desired motion speed of the platform.

Table 1. Speed related to DC motor characteristics

DC MOTOR CHARACTERISTICS						
	Power P [W]		Torque T [Nm]		Angular Velocity [rad/s]	
Input:	30		10	Calculated:	ω_{EM}	3.000
ANGULAR VELOCITY AND TANGENTIAL SPEED						
Wheel Gear	Wheel Radius [m]		Angular Velocity [rad/s]		Tangential Speed [m/s]	
0	R	0.07	ω_0	3.00	ϑ_A	0.210
1	r	0.05	ω_1	4.20	ϑ_B	0.210
2	R	0.07	ω_2	4.20	$\vartheta_{B'}$	0.294
3	r	0.05	ω_3	5.88	ϑ_C	0.294
4	r	0.05	ω_4	5.88	ϑ_D	0.294
5	R	0.07	ω_5	4.20	ϑ_E	0.294

Table 2. DC motor characteristics related to desired speed of platform

DEMANDED TRACK/WHEEL SPEED						
	Tangential Speed [km/h]				Motor Angular Velocity [rad/s]	
Input:	ϑ_C	1.5		Calculated:	ω_{EM}	4.252
ANGULAR VELOCITY AND TANGENTIAL SPEED						
Wheel Gear	Wheel Radius [m]		Angular Velocity [rad/s]		Tangential Speed [m/s]	
0	R	0.07	ω_0	4.25	ϑ_A	0.298
1	r	0.05	ω_1	5.95	ϑ_B	0.298
2	R	0.07	ω_2	5.95	$\vartheta_{B'}$	0.417
3	r	0.05	ω_3	8.33	ϑ_C	0.417
4	r	0.05	ω_4	8.33	ϑ_D	0.417
5	R	0.07	ω_5	5.95	ϑ_E	0.417

4. CONCLUSIONS

According to the results presented in *table 1.* and *table 2.* for the adopted motion model in *figure 7.*, can be noticed that:

- The tangential speed at wheel/gear 3 is v_C=0.294[m/s]=1.05[km/h], *table 1.* confirming the estimated motion speed (approx.. 1[km/h]) of the designed and manufactured prototype (RoboDet) driven by the DC motor, *figure 6.*;
- For the desired motion speed of the platform, tangential speed as input, *table 2.*, the angular velocity of DC motor changes;
- Calculated values for the tangential speed for wheels/gears 2, 3, 4 and 5 are equal, *table 1.* and *table 2.* confirming the non-extendibility of the track, *figure 7*.

Therefore it can be concluded that:

- RoboDet designed and manufactured at the Faculty of Mechanical Engineering laboratory in Prishtina fulfills the motion speed of one km per hour for used DC motors characteristics.
- Movement of the platform with desired speed can be achieved by replacing of the DC motor based on calculated angular velocity for the motor, *table 2.*, presenting the solution with no flexibility of adjustment relating to terrain and contamination.
- Desired speed of RoboDet driven by DC motor can be achieved easily and directly by regulating the currents that control the flux in the two magnetic fields, controlling the torque directly by regulating armature current.
- The use of the adjustable speed motor controllers allows motors to operate on a desired speed/torque.

5. REFERENCES

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