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MONOROIL MOBILE PLATFORM

Key words

Crane rails, drive, control, driving system, position stabilizing.

Abstract

This paper presents the construction of a remote-controlled monorail platform that, depending on the equipment, allows the inspection and maintenance work on various sizes of crane rails. A three-wheel driving system with magnetic drive wheels provides continuous contact of the platform with the upper surface of the rail head. A flexible roller guide system enables the clear positioning of the platform relative to the lateral surface of the head. The power source for the propulsion and devices placed on the platform are two batteries working alternately. The communication of the remote control system (wired or wireless) with the platform drive controller is through a multifunctional electrical connection. The compact design of the platform allows for efficient implementation of various kinds of work on the crane rails both on the ground and on high-rise structures.

Introduction

The constantly developing mechatronic systems related to the construction and use of remotely controlled vehicles provide a support or replacement of direct human involvement in cumbersome labour and situations likely to endanger human health or life. Remote control vehicles are used increasingly more often, for example, "The Fire-fighter," which a vehicle designed to neutralize hazardous substances [1] or robots monitoring fire zones [2]. Specialized vehicle-platforms are used in research and certification processes in the area of technical [3], and fire [4] safety.

A separate group are rail vehicles and equipment, in which monorail vehicles are included. In regards to the location of the transported objects in relation to the rail, there are two groups: overhead and floor-mounted. Suspended vehicles are used commonly in the internal systems of transport for the transport of people and goods and inter-operational transport in specific conditions (Fig. 1).

a) b)

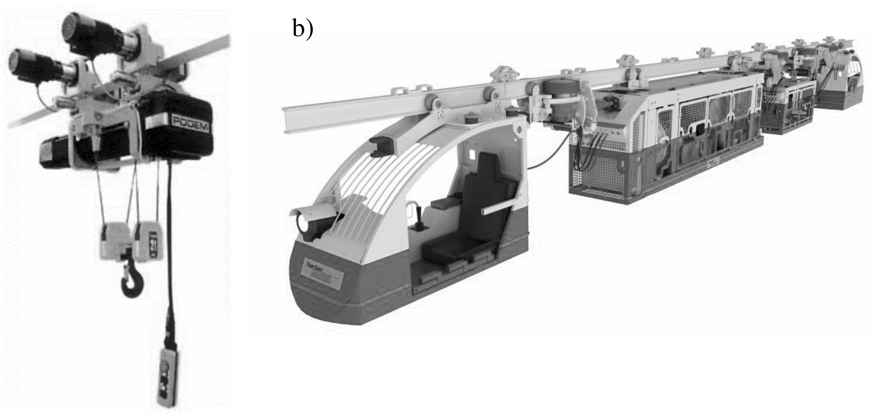

Fig. 1. Suspended vehicles: a) monorail suspended winch, b) suspended railway to transport people and materials in mines [4]

Straddle vehicles are used in conditions with limited space for placing the transport rail directly on a flat surface or a support structure (Figure 2).

Fig. 2. Straddle monorail [5]

The defining feature of a majority of rail designs is that the width of the rail is several times larger than its height, which provides stability in guiding the vehicle in various movement parameters. A significant problem arises in the limited space above the foot of a narrow track with a head on which the vehicle moves. This case is distinctive for crane tracks in which the head width-to-height ratio is about 2.

The project for a remote-control monorail mobile platform as the carrier of the developed system was developed within the framework of the international project implementation Programme Eureka E! 8819/INROSY "Integrated audit system for crane tracks and repair of rails and wheels of cranes."

1. Mobile platform concept

The concept development for mobile platforms had been preceded by a detailed analysis of the existing research and practical solutions for monorail vehicles, as for example, the device illustrated in Figure 3 [6].

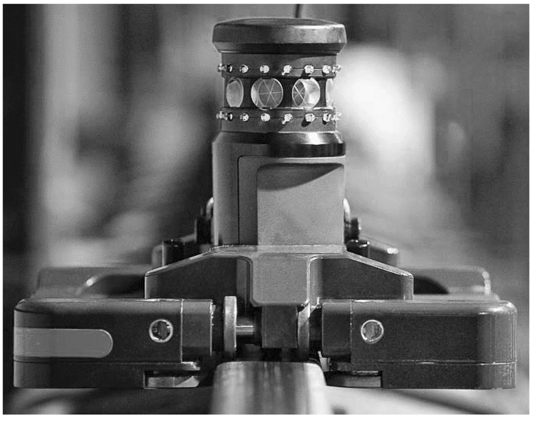

Fig. 3. A self-propelled device for system control of the geometry of the crane tracks [6]

Due to its purpose, a relevant criterion is the mobility of the device consists in the possibility of its installation on the rails of different sizes, mounted both at ground level and on supports at a significant height.

The criterion so defined consequently places a restriction on the weight and dimensions of the platform. It is assumed that the platform will be placed on a rail by a single person, and it will be able to move on crane rails of nominal size (the width of the head) from 45 to 100 mm (Figure 4).

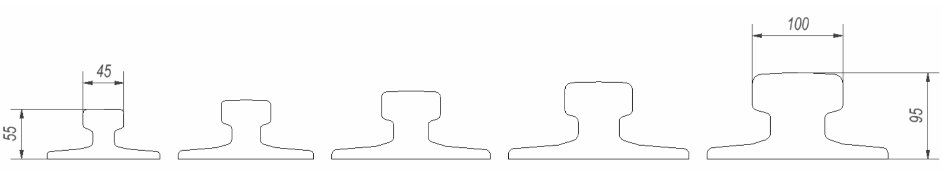

Fig. 4. Crane rail dimensions [7]

The developed concept assumes that the platform will be positioned on the upper surface and side surfaces of the rail head (Fig. 5).

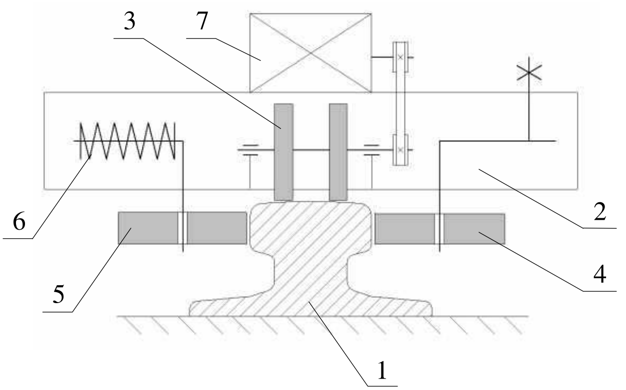

Fig. 5. Mobile platform diagram: 1 – rail, 2 – platform body, 3 – drive wheels, 4 – positioning wheels, 5 – pressure wheels, 6 – spring element, and 7 – drive

The wheels keep the structure on the rail and allow its movement along the rails. In the horizontal plane, the placing of the platform relative to the axis of the rail is determined using the adjustable positioning wheels. The pressure wheels, set up opposite positioning wheels, provide a permanent contact with the side surface of the rail. The surface of the upper platform is designed for remote control (wired or wireless) and an optional measuring or rail crane service equipment. The power source for the platform and equipment placed on it are rechargeable batteries that are their integral part. To control the movement of the platform on the rail, there is a rotary pulse transducer coupled with the drive system.

2. Platform structure

Based on the adopted concept, a virtual model platform was developed (Fig. 6), which includes three main functional components: a drive unit 2, a lateral stabilization system 3, and a power module 4.

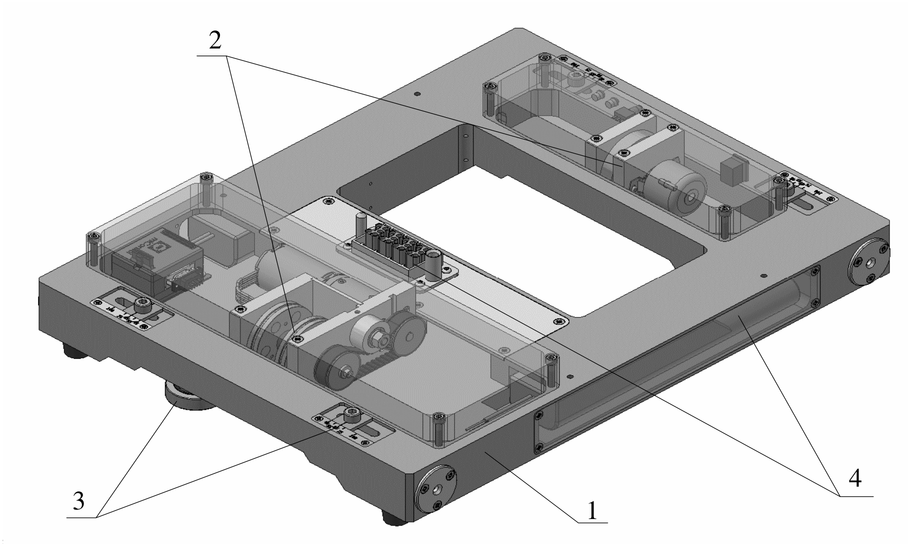

Fig. 6. A view the 3D model of the platform: 1 – body, 2 – elements of the drive unit, 3 – lateral stabilization system, and 4 – components of the power system

The three-wheel drive unit is responsible for the appropriate platform placement on the upper surface of the rail head, the movement of the platform along the rails, and the identification of the position of the platform relative to the rail (Figure 7). The drive wheels (1) and free-running wheels (2) keep the construction on the rail and allow independent travel along the track. The two drive wheels (1) are magnetic wheels offering good adhesion to the surface of the track regardless of the presence of pollutants, lubricants, or surface preservatives that cause a reduction in the friction coefficient. The drive wheels (1) are driven by a gear motor (3), with a synchronous belt transmission (4). The free-running wheel (2) coated with a non-slip layer is coupled with rotary pulse sensor (5) that relays to control system the information about the current location of the platform. The drive unit components embedded in separate slots (6) are protected by covers (7) against external influences.

The correct position of the platform relative to the plane of the symmetry of the rails (relevant from the viewpoint of its functions) is provided by the lateral stabilization system (Fig. 8).

In the horizontal plane, the platform is positioned with two adjustable rollers (1), whose position may be regulated and determined depending on the width of the rails so that the platform is centred on the rails. The two pressure rollers (2) are pressed against the rail with the spring (3), and they ensure

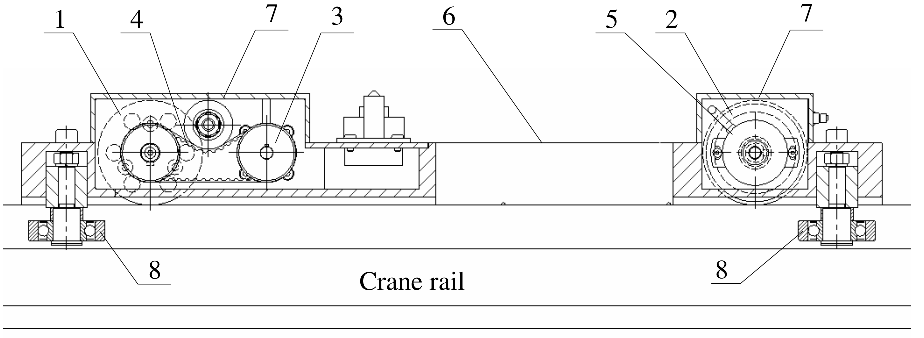

Fig. 7. Longitudinal section of the platform: 1 – drive wheels, 2 – free-running wheel, 3 – geared motor, 4 – synchronous transmission, 5 – encoder, 6 – platform body, 7 – covers, and 8 – rollers for lateral stabilization system

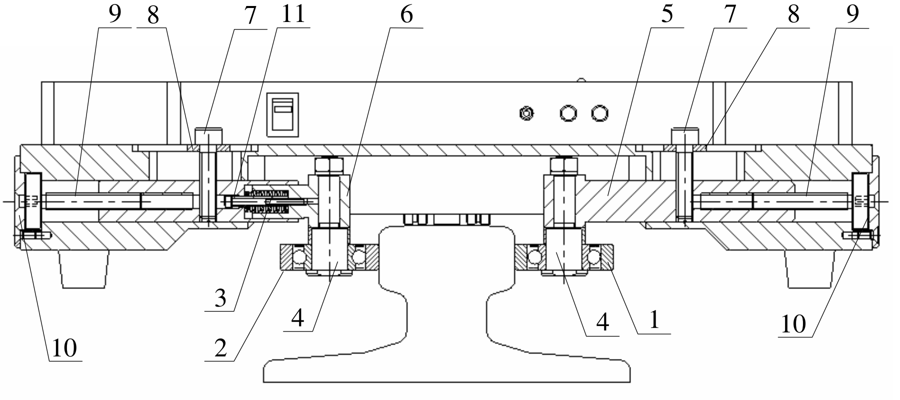

Fig. 8. A cross-section of the platform: 1 – guiding roller, 2 – pressure roller, 3 – spring, 4 – roller axis, 5 – idler guiding roller bracket, 6 – pressure roller bracket, 7 – blocking screw, 8 – board with a scale, 9 – adjusting screw, 10 – cover, and 11 – limiting screw

a continuous contact of the adjustable rollers with the side of the rail head. In this way, the platform with the equipment mounted on it is unequivocally positioned on the upper and side surface of the rail head. Rollers (1 and 2) are positioned on the axles (4) embedded in sliding brackets (5 and 6). The adjustment rollers and pressure roller brackets are guided in rectangular channels of the body in such a way that the axes of the adjustment and pressure rollers remain vertical, despite lateral loads acting on them during the movement of the platform. The roller support has two threaded apertures. In the vertical aperture, there is a screw (7), which, together with the rectangular plate (8), is designed to lock the position of the bracket. A change in the position of the support (5), which entails a change in the position of the adjustable roller (1), occurs when screw (7) is loosened as a result of turning the screw (9) with an octagonal socket with a hex key entered through the opening in the cover (10). The position of the bracket (5) with the roller (1) is controlled on the scale, on which there are indicators of positions corresponding to the standard widths for crane rails. The bracket (6) or pressure roller (2) consists of two parts joined together as a slide, between which there is a pressure spring (3) that pushes the moving part of the bracket (6) with roller (2) in the direction of the track. The movement of the roller (2) in the direction of the rail is limited by means of the screw (11). The stationary part of the bracket (6) can be moved and locked in position with the screws in the same way as the other bracket (5). Setting the bracket in the position corresponding to the width of the rail results in an appropriate pressure from rollers (2) on the side rails, which is the optimum from the point of view of guiding the platform.

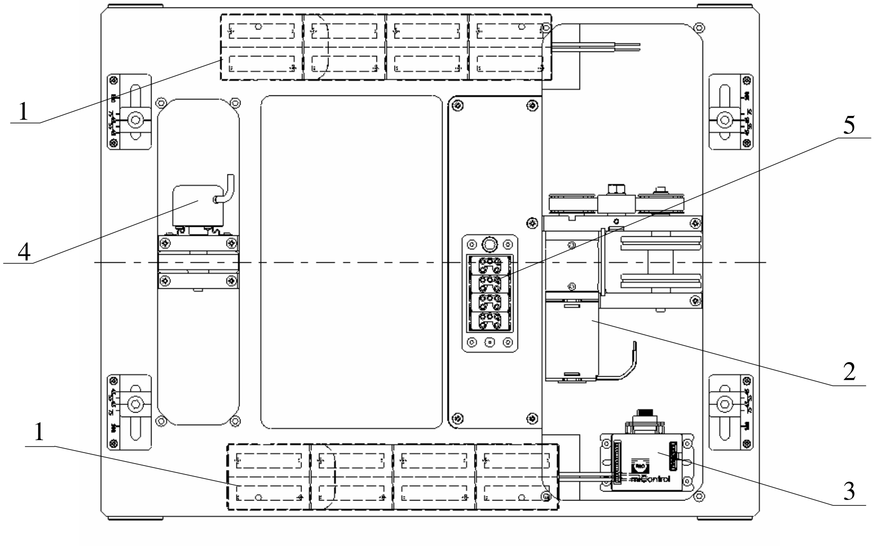

Fig. 9. A view of the platform with power system elements: 1 – battery pack, 2 – geared motor, 3 – control, 4 – encoder, and 5 – docking connector

The power supply module for the platform (Fig. 9) consists of a set of batteries (1) for motor power (2) through the control (3) and the other modules for measurement, inspection, and radio modules, placed on the platform in various configurations. In order to maximally lower the centre of gravity relative to the surface of the top rail head, the batteries are placed symmetrically in relation to the axis of the platform in the two side pockets that ensure easy access during operation. Properly selected battery capacity allows for autonomous system operation for two hours with a power consumption of up to 10A. For the transmission of electricity, the control signals, including controlling the motor and encoder (4) impulses to the modules mounted on the platform, an electric docking connector (5) is installed for a quick and definite execution of the connection.

The upper flat surface of the platform structure is designed for the optional installation of equipment performing specific measuring and maintenance functions.

The prototype of the monorail mobile platform

Based on the verified 3D model, complete technical specifications were developed, with a particular emphasis on the technology of manufacturing the body of the platform. The thin-walled, cell construction of the body for rigidity with low weight required developing a technology that minimizes the possibility of deformation as a result of the removal of large (over 70%) of the volume of material during machining.

The prototype of the mobile platform produced in ITeE – PIB in Radom (Fig. 10) is characterized by the following parameters:

- Dimensions (length/width/height) – 525/412/98 mm
- Weight – 15 kg
- Rail type – from A45 to A100
- Nominal velocity – 0.2 m/s
- Power supply – 2 × 24V; 2.5Ah
- Electricity consumption – max 10A

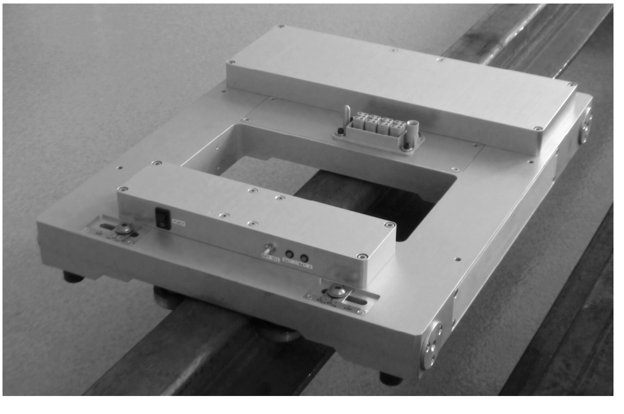

Fig. 10. A view of the monorail mobile platform

The prototype of the monorail mobile platform has undergone the procedure for research prototypes and technical equipment units at the Institute [9, 10]. The study did not only verify the assumed functional parameters, but it also forecast the ability of maintaining them while in operation.

The detailed studies concerned mainly two components that have priority for the functioning of the platform: the drive and stabiliser of the position relative to the rails (Figure 11).

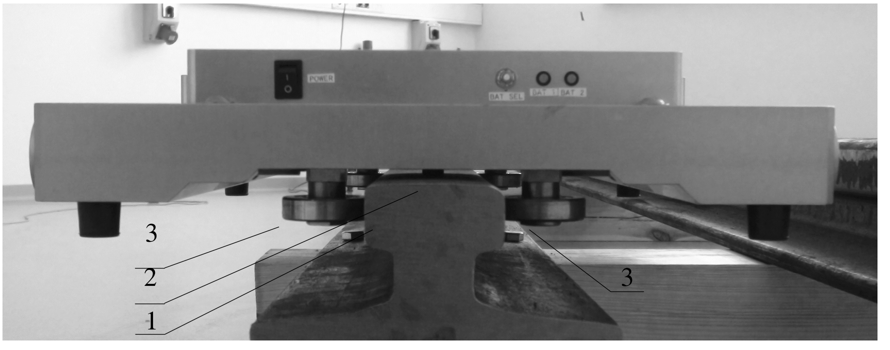

Fig. 11. A view of the monorail mobile platform positioned on the rail A65:1 - rail 2 – drive wheels, and 3 – cross-stabilising rollers

As a result of the research, changes have been made in the geometry of drive wheels cooperating with the surface of the rail head. The introduced adjustment consisted in cambering the drive wheels in relation to the rotational axis in order to increase the distance between the points of contact of the wheel with rails head. This adjustment led to an improvement of the lateral stability of the platform's motion on single rail, which was verified using inclinometer built on the rail.

Conclusions

The remote control, mobile monorail platform provides the means to inspect or maintain, depending on the equipment, crane rails of different sizes. The three-wheel system provides continuous contact of the platform with the upper surface of the rail head. The application of magnetic drive wheels provide great adhesion to the surface of the track regardless of whether there are pollutants, or lubricants, or surface preservatives causing a reduction in the friction coefficient. A flexible roller guide system enables flawless positioning of the platform relative to the lateral surface of the head. The power source for the propulsion and devices placed on the platform are two batteries working alternately. The compact design of the platform allows its efficient use in various kinds of work on the crane rails located both on the ground and on overhead structures.

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Jednoszynowa platforma mobilna

Słowa kluczowe

Szyny suwnicowe, napęd, sterowanie, system jezdny, stabilizacja położenia.

Streszczenie

W artykule przedstawiono budowę jednoszynowej, zdalnie sterowanej platformy pozwalającej na prowadzenie, w zależności od wyposażenia, prac inspekcyjnych i serwisowych różnej wielkości szyn suwnicowych. Trójkołowy

system jezdny z napędowymi kołami magnetycznymi zapewnia stały kontakt platformy z górną powierzchnią główki szyny. Elastyczny system prowadnic rolkowych umożliwia jednoznaczne pozycjonowanie platformy względem powierzchni bocznej główki. Źródłem zasilania dla napędu jak również urządzeń umieszczanych na platformie są dwa pracujące naprzemiennie akumulatory. Komunikacja posadowionego na platformie systemu zdalnego sterowania (przewodowego lub bezprzewodowego) z kontrolerem napędu platformy odbywa się poprzez wielofunkcyjne złącze elektryczne. Zwarta konstrukcja platformy pozwala na efektywne wykorzystanie do realizacji różnego rodzaju prac na szynach suwnicowych zarówno naziemnych, jak i posadowionych na konstrukcjach wysokościowych.