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THE FUNCTIONAL PROTOTYPE OF BELT MOBILE ROBOT

FUNKČNÍ PROTOTYP PÁSOVÉHO MOBILNÍHO ROBOTU

Abstract

The article presents a model of prototype of belt mobile robot, intended for service tasks in urban environment. The robot is able to execute service tasks specialized in manipulation with subjects, in monitoring, gathering and processing the 3D metric data in real time etc. Dimensions and basic characteristics of the locomotive mechanism of the robot rise from demands for application in urban environment. The designed prototype is a modular construction with possibilities to use different extension modulus. The robot is intended for application in indoor and outdoor environment. Operational and control systems of the prototype will be tested as well as riding parameters and video transmission, etc. Testing will be done on specially crafted polygons during performance of the selected particular service tasks in real environment.

Abstrakt

Článek prezentuje model prototypu pásového mobilního robotu určeného pro servisní úlohy v městském prostředí. Robot může vykonávat servisní úlohy zaměřené na manipulaci s předměty, monitoring, získávání a zpracování metrických 3D informací v reálném čase apod. Rozměry a základní charakteristiky lokomočního ústrojí robotu vycházejí z požadavků pro aplikace v městském prostředí. Navržený prototyp je modulární konstrukce s možnosti využití různých nástavbových modulů. Robot je určený pro aplikace ve vnitřním i venkovním prostředí. Na vyrobeném prototypu budou ověřovány výkonové a řídicí subsystémy, jízdní vlastnosti, přenášení obrazu apod. Testování bude uskutečněno na vyrobených polygonech a při realizaci vybraných konkrétních servisních úloh v reálném prostředí.

1 INTRODUCTION

The mobile robots suitable for application in urban environment use all types of locomotion. In terms of alignment there is wide spectrum of service tasks. These mobile robots use range of manipulating and technological extensions. Nowadays there are most of mobile robots exploited in urban environment on wheel, belt or hybrid locomotive mechanism. Robots are also equipped with environment recognition sensor, thermal camera, light sources etc. Operation of robots depends on particular service task. In most cases there is manual control by operator used. Extension modules can be hidden inside the bogie frame and manipulation extension fixed in parking position during robot movement in the field, when there is no service task realized. We can talk about "transport position" that protects modules from damage during instable or collision conditions. Furthermore there is an advantage of lowering total height of the robot regarding to transmissivity in terrain. Robot has to stop moving during realized service task (for example during manipulation with objects or during capturing 3D metric data etc.). In case of choosing the belt locomotive mechanism, there will be the possibility of movement up and down on the stairs. For outdoor applications we have to choose the locomotion mechanism which is able to pass obstacles of 150mm at minimum.

Most of applications of mobile robots in urban environment are specialized in service tasks with technological and also no-technological service character. They forms there relatively a big group of mobile robots specialized in monitoring and identification. Mobile robots intended for ser-

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vicing and cleaning form next large group. The mobile robots specialized in application for transport and handling form third large group. For mentioned groups of service tasks it is possible to use also the designed mobile robot. Character of service task will correspond to extension modulus applied on the platform of belt locomotive mechanism [1, 3].

2 3D MODEL OF MODULAR BELT MOBILE ROBOT

The 3D model of mobile robot has been designed at Department of Robotics solving such problematic in frame of science and research projects. Experience with previously developed line of robots with belt locomotive mechanism was impulsion for construction of a locomotive mechanism aimed at urban environment service tasks. The model of the robot has been designed in Pro/Engineer system and the robot is developed for indoor and outdoor application. Control and data is transmitted on wireless base from human operator station. 3D model of the locomotive mechanism is shown at Fig. 1.

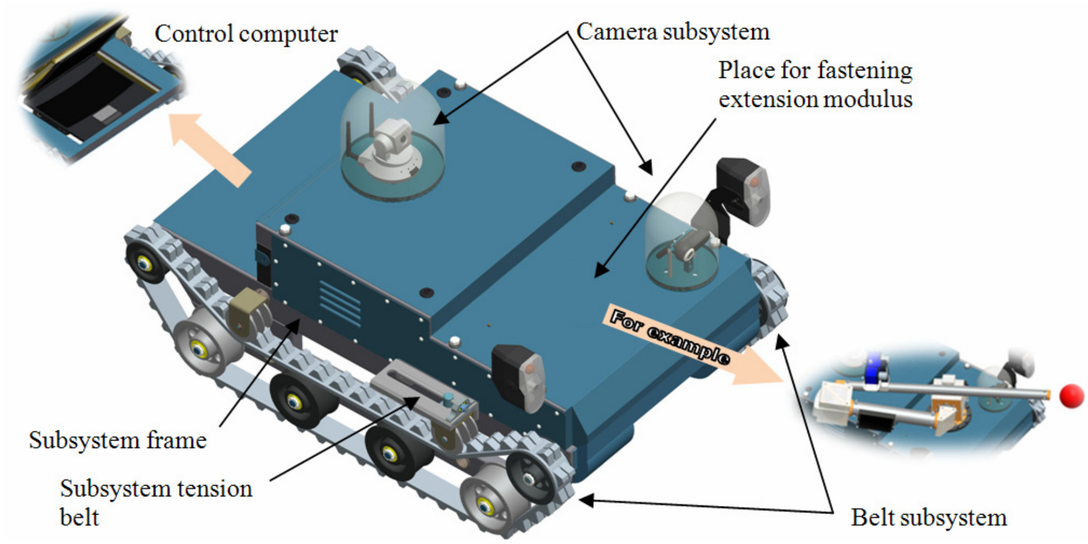

Fig. 1 The model of modular belt mobile robot

The mobile robot with belt locomotive mechanism has two major belts controlled by sliding. Regarding the conception of crawler locomotive mechanism and purpose of his usage there were its ground plan dimension parameters assessed. Ideal relationship between wheel track centre and wheelbase axletree for drive sliding equals one. There was also a demand of possibility to go through a door of width 800 mm mentioned. The robot uses belts currently used by normally supplied climb stairs designated for movement up and down on the stairs. Locomotive mechanism is unsprung and all damping jerks and small spring action take place in terms of wheelbase (710 mm) and supporting wheels. Both general belts have two supporting leading wheels with average 120 mm. Driving wheel of the main belt presents unloaded toothed steel sheave. Axis driving wheels is 221 mm over terrain. Outer diameter of driving wheel and of both supporting wheels is 120 mm. Diameter of guiding wheels is 95 mm. The belt subsystem is able to safely take the obstacle of 220 mm height and to move up and down on the stairs. The dimensional scheme of the belt locomotive mechanism is shown at Fig. 2.

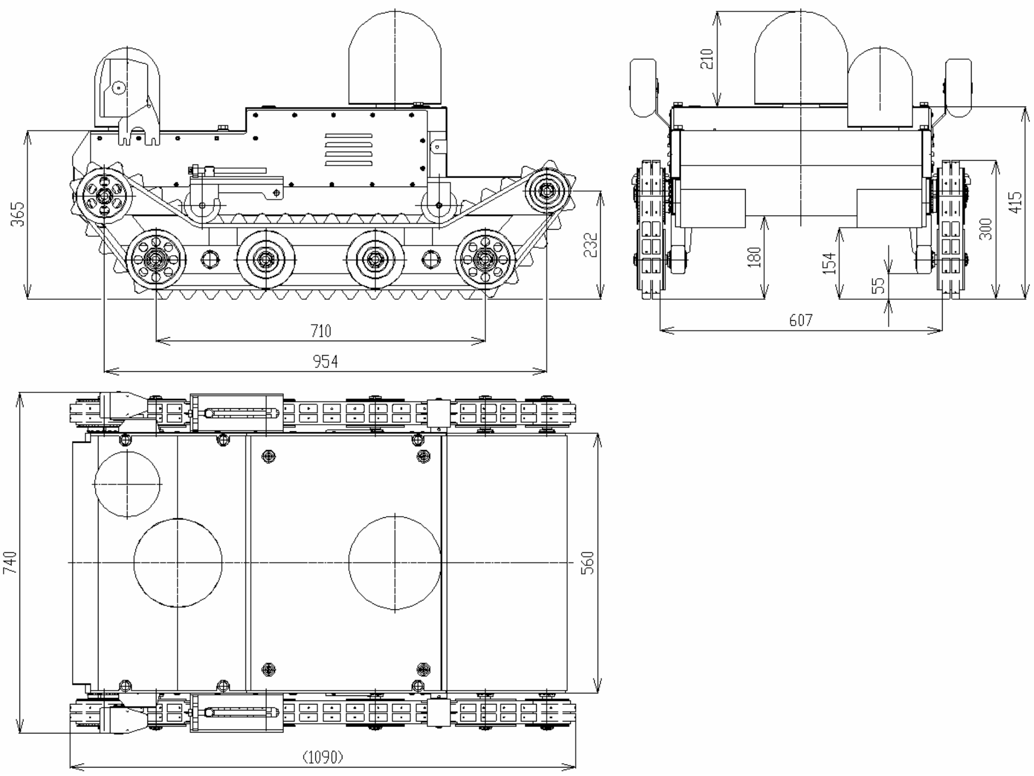

Fig. 2 The dimensional scheme of belt mobile robot

24 V DC engines with worm gearbox from VARVEL (125 W each) are used for propulsion of both chief belts. We have very good experiences with previous usage of this low cost and at the same time high operational quality value solution, compared to “professional” overpriced solutions. Both engines are placed and fastened in locomotion mechanism frame. Load bearing of the locomotion mechanism is carried by the subsystems as for example power subsystem, energy sources subsystem, steering subsystem etc. We can simply take each subsystem out if needed. In front of locomotive mechanism there is space for fixation of manipulation extension created. We count with possibility of creating space below the covering. On upper flat cases of the locomotive mechanism there is a set of camera subsystem, subsystem of lighting etc. There are tightening units for of both main belts to the frame of locomotive mechanism fixed separately. Control of movement of the robot is wireless from distant of operator stand.

The robot is powered by covers from thin metal plate. Bottom cover and side covers are fixed to the frame of modulus locomotive mechanism by force of bolts. These covers can be easily de-mounted. Upper covers of the robot are fixed to the frame by force of standard locks. Front upper cover of the robot is divided because of easy disassembling (for example in case of carrying a manipulation extension). All covers of the robot are equipped with packing, airing openings, suspension dome for straining and other elements. Robot is therefore suitable for damp or dusty environment. All elements of control subsystem and other electronics inside the robot are placed in special boxing. After unloading the upper covers it is possible to take the boxes easily out. Easily exchangeable subsystem sources electric energy (two 12V battery) is included too.

There is supporting plate with power supply, control units etc. placed into this frame. The prototype of robot (fully operational) is made in basic design. Nowadays functional testing of each subsystem starts there and also testing of behavior of robot during the movement on broken terrain. Basic parameters of the robot are shown in Tab. 1.

Tab. 1 Basic technical parameters of belt mobile robot

Parameters	Value
Total width	740 mm
Total length	1090 mm
Total high	625 mm
Total length of contact area crawler with terrain	710 mm
Clearance height trawler locomotive mechanism	180 mm
Total length crawler	2400 mm
Crawler width	50 mm
Mass trawler locomotive mechanism without manipulation extension	cca 80 kg
Bearing trawler locomotive mechanism	110 kg
High pass obstacle	220 mm
Speed of movement	8 km/hod.
Drive crawler – DC motor VARVEL	MP56L
– power	125 W
– voltage	24V
– speed	1600 min-1
– IP code	IP 44
Worm gearbox VARVEL with gear ratio	28
Battery	2x12 V

During the realization of the project it was necessary to perform a range of solidity calculations as for example strength and tension analysis of components of the belt stretching mechanism, of the locomotive mechanism frame, of reinforcer frame etc. Consequently there was optimization of size of some components regarding the obtained results performed. All strength calculations are executing in Pro/MECHANICA Structure, which is a part of Pro/ENGINEER system.

As an example there is an analysis of a component for placing a tightening wheel, which transfers force effects developed by a stretch belt and reaction evoked by a tightening screw-bolt mentioned. There were several options of tension of belt designed, where we chose and optimized the option shown at Fig. 3. Another Fig. 3a presents a 3D model in Pro/ENGINEER system and Fig. 3b presents a produced modulus of tension. Firstly there was magnitude of the force applied from belt on track adjusting wheel determined, which is 800N of calculation. Consequently there was a material of components, the way of placing (constraints) and of loading selected (Fig. 4a). There was also setting of calculation and generating of nets of geometric elements performed. After that the analysis itself started. The result of analyses is: maximum pressure inside the components 46 MPa (Fig. 4b) and maximum deformation 0,05mm (Fig. 4c). The following result of the analysis is following: designed construction of tension modulus of the belt is satisfactory [2].

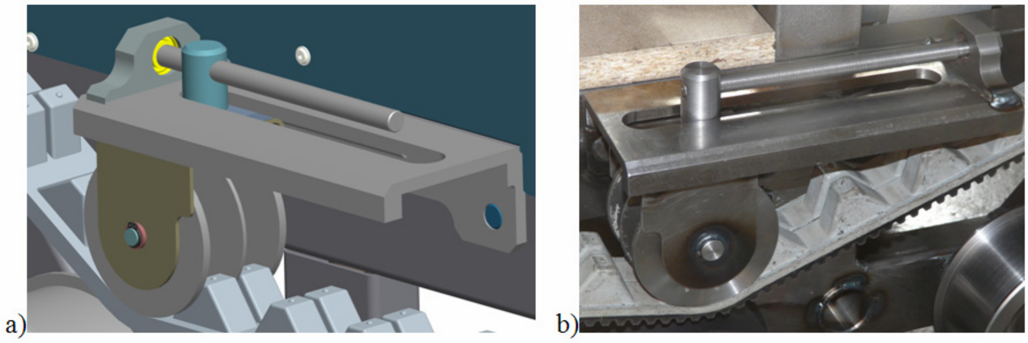

Fig. 3 3D model of 3a and made of tension modulus

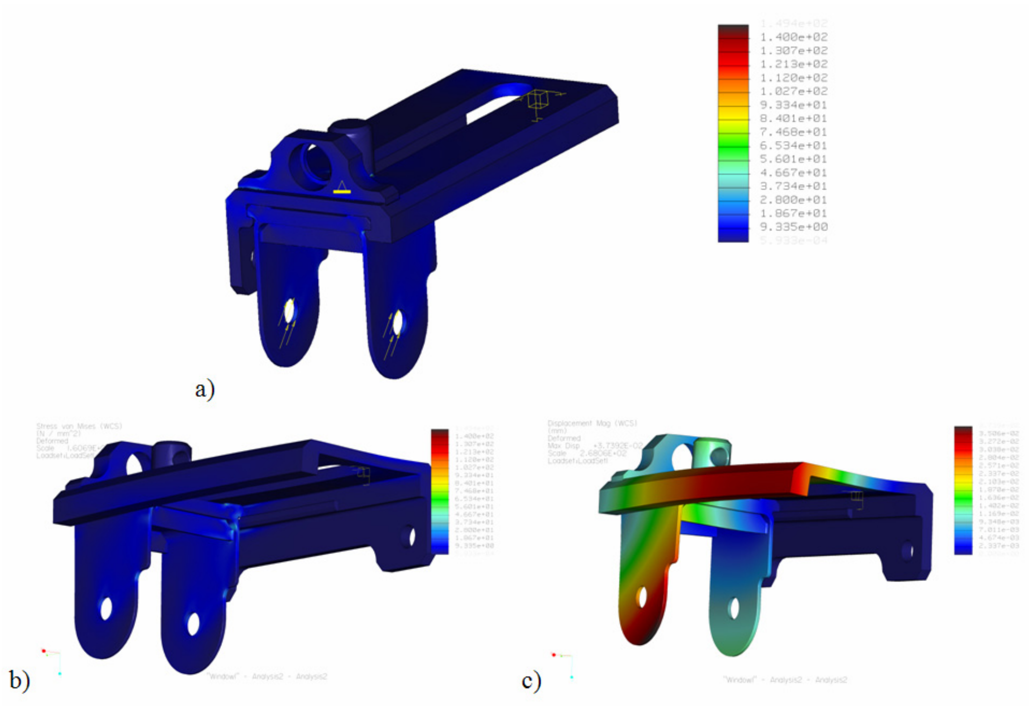

Fig. 4 Analysis component for placing tightening wheels

Nowadays there is the right function of the control modulus for motors actuating the main belts checked. The driving properties and stiffness of the frame of locomotive mechanism are also checked during the movement of the robot on broken terrain. After checking the functionality of robot basic complex and single subsystems (modulus), there will be covers and other equipment mounted. Produced prototype of the belt mobile robot without covers and outside equipment is shown at Fig. 5.

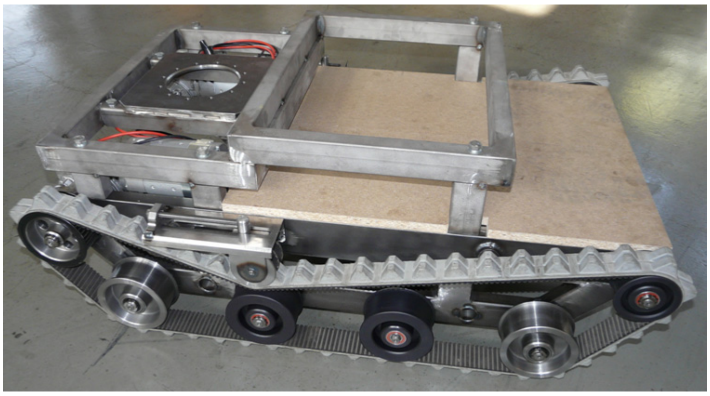

Fig. 5 Made prototype of the belt mobile robot without covers and outside equipment

3 CONCLUSIONS

Nowadays the preliminary test has shown that our prototype of belt modular mobile robot is generally suitable to perform the specified service tasks. We continue in testing on the polygons as well as in real life environments. Among other we will test the influence of various environments on behavior robots, on control subsystems and on video signal transmission. Practical results will be continuously compared with characteristics gathered from the 3D model with use of MSC/ADAMS system. This article presents knowledge gained during solution of grant project no. BI 3549011.

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