REVIEW OF STUDIES ON PRESS MANURE REMOVAL

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Abstract. The paper describes the principal scheme of the press manure removal, composed at the Estonian University of Life Sciences, for transportation and pressing manure through the manure pipe under a heap of muck in small livestock barns. The working tool of this press manure removal is a scraper, which is moving cyclically forward and backward. The scraper has vanes and one forced driven manipulator for pressing manure. This study reviews earlier experimental and theoretical studies at the Estonian University of Life Sciences. The results of this paper can be useful for the designers of manipulators for press manure removals and for users of the Computer Package Mathcad.

Keywords: farm machinery, manure removals, manure scrapers, modelling, manipulator.

Background of the study

There are different manure removal systems which are intended to remove manure from a cowshed and store it into a dung pit. One of them is the press manure removal that is intended to remove manure from a cowshed and store it by pressing through a manure pipe into a heap of muck. Fig. 1 shows a principal scheme of manure press removal.

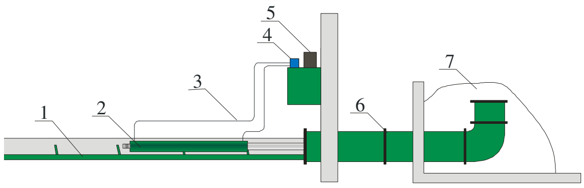


Fig. 1. **Principal scheme of press manure removal:** 1 – one-sided scraper; 2 – hydraulic cylinder; 3 – oil pipe; 4 – valve; 5 – electric engine; 6 – manure pipe; 7 – heap of muck

The principle of work of the press manure removal in Fig. 1 is the following. The manure scraper, driven by a hydraulic cylinder 2, transports the portions of manure to the manure pipe and presses these by the first manipulator of the manure scraper through the pipe 6 into a heap of muck 7. After the working stroke the valve 4 changes the direction of flow of oil in the oil pipes 3 and the scraper moves back to the initial position. By repeating this working cycle a large heap of muck will be structured. Press manure removal is economical and environmentally sound. Press manure removal can be in use in a small farm with 20-50 cows.

One-sided scraper with forced driven manipulator for press manure removal

The scientific group, headed by Vambola Veinla, at the Estonian Agricultural University have created a novel manure scraper (Fig. 2) for press manure (Fig. 1) removal in which the first working vane was considered as a forced driven manipulator with a vane.

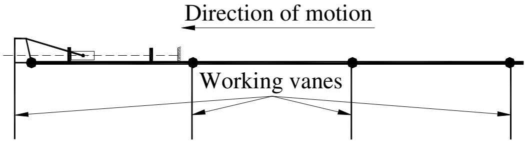


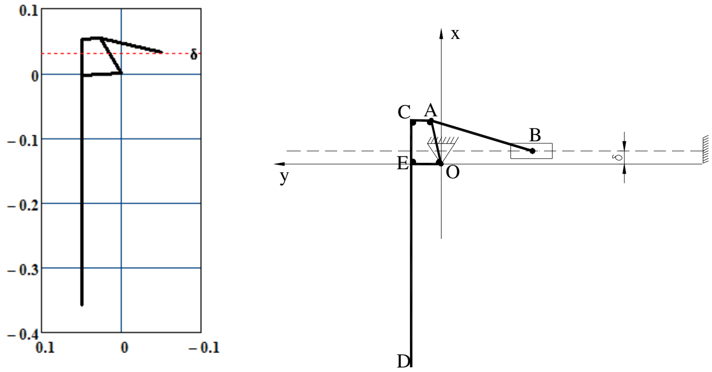
Fig. 2. **Novel manure scraper for manure press removal**

Veinla, Leola have made experimentally thorough study of the press manure removal in Fig. 1 with the manure scraper in Fig. 2 [1; 2]. The purpose of the experimental study of the manure press removal was to measure the

- resistance force, applied to the working vane by manure in the manure pipe,
- pressure, applied to the walls of the manure pipe,
- pressure inside the heap of muck, and to study the dependence of the height of the muck heap on the resistance pressure of manure in the manure pipe.

Theoretical study of the working process of the virtual manipulator

Theoretical studies of the manipulator in Fig. 2 were based on the virtual model (a) in Fig. 3 composed on the base of the computation scheme (b).



(a) (b)

Fig. 3. **Virtual model (a) and computational scheme (b) of the manipulator in Fig. 2:**
O, A, B – pivots; OACED – rigid link

Probably the first theoretical study on press manure removals was made by Leola, Veinla, Heinloo [3; 4]. They presented the results of the study of the dependence of the laws of motion of the characteristic points A, C, E, D of the virtual manipulator on the distance ρ_{AO} between the pivots O and A and on the distance δ of the grounded pivot O from the track of the slider B (Fig. 3 (b)), when the law of motion of moving pivot B is known and the virtual manipulator turns from its working position in Fig. 3 (a) to the return position (Fig. 4).

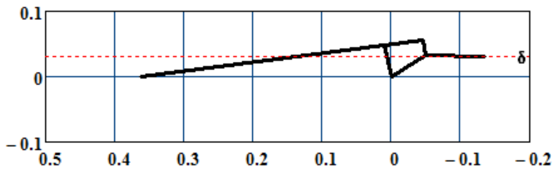


Fig. 4. **Return position of virtual manipulator**

To specify the positions of the manipulator during the full cycle of its working process Leola, Veinla, Heinloo have solved three problems of optimization [5-7]:

1. *For the given law of motion of the pivot B (Fig. 3b) to find such values for the distances δ and ρ_{AO} that guarantee at the return position the point D (Fig. 3b) to be placed exactly on the y-axis (Fig. 4) and at the end of the working stroke (Fig. 3) exact parallelism of the side CED of the virtual manipulator to the x-axis in (Fig. 3b).*

Fig. 4 shows the result of solution of this problem optimization.

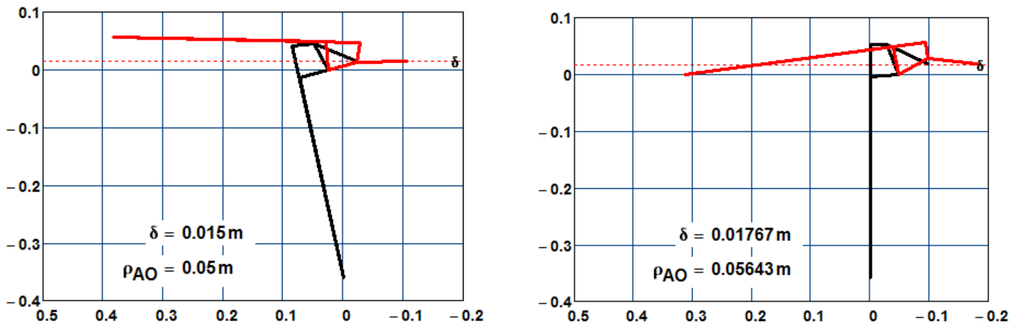


Fig. 4. **Positions of virtual manipulator before (left) and after optimization (right)**

2. *For the given law of motion of the pivot B to find the interval of the time Δt that is necessary to turn the side CED of the virtual manipulator at the end of the return stroke exactly parallel to the x-axis (to the working position)*

Fig. 5 shows the result of solution of this problem optimization.

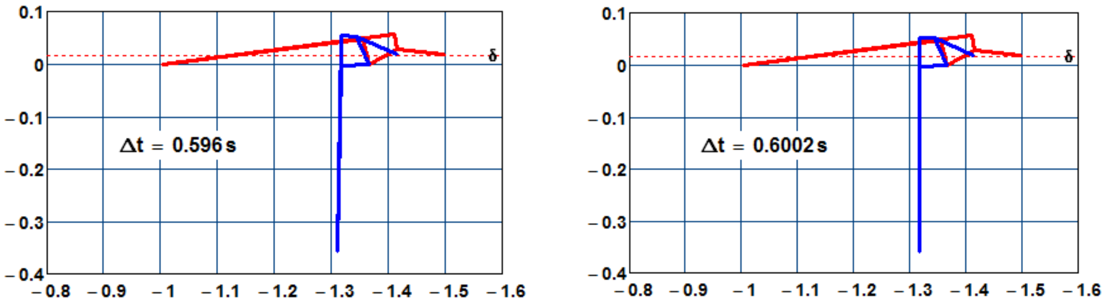


Fig. 5. **Positions of virtual manipulator before (left) and after optimization (right)**

3. *For the given law of motion of the pivot B to find the interval of the time that is necessary to return the manipulator to the initial position.*

Due to solution of this problem of optimization the initial position of the virtual manipulator coincides with its position after making a full working cycle.

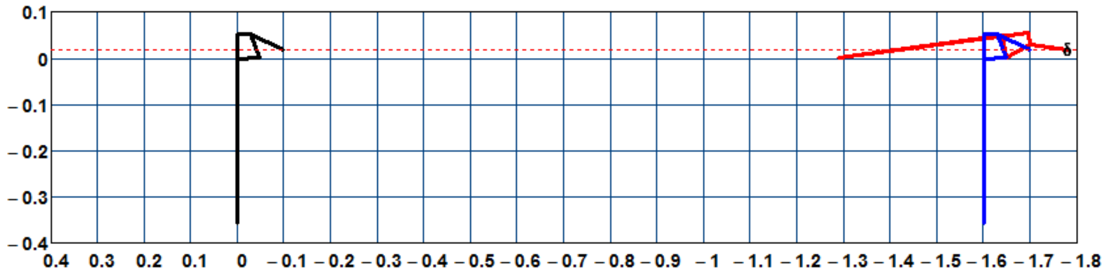


Fig. 6. **Positions of virtual manipulator at the initial position and after making a full working cycle (left) and after finishing the returning stroke and turning to the working position (right)**

Fig. 7 shows the frames from the video clip [8], composed for simulation of the working process of the virtual manipulator in one working cycle.

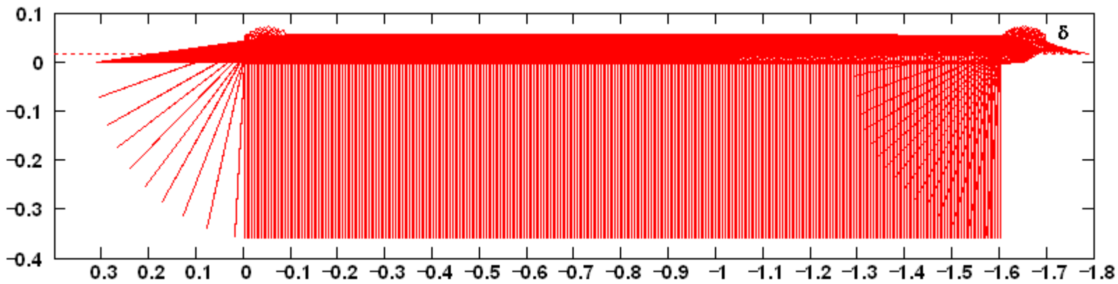


Fig. 7. **Video frames from the composed video clip that simulates the working process of the virtual manipulator in Fig. 3 (a) in one cycle**

All numerical computations were made on the worksheet of the Computer Package Mathcad. The working cycle of the virtual manipulator in Fig. 3 (a) can be realized by one driver.

All problems of optimization, considered above, were solved also for the alternative manipulators and a principally new manipulator in the next parts of this paper.

Alternative motions of considered virtual manipulator

Heinloo, Leola [9] have considered the moving of the virtual manipulator and scraper by two independent drivers. The global driver drives the scraper and local driver drives the manipulator. The principal scheme of a manure scraper with a local driver driven manipulator is shown in Fig. 8.

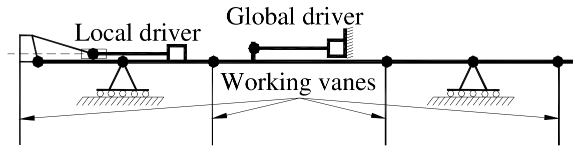


Fig. 8. **A manure scraper with local driver driven manipulator**

Fig. 9 shows the frames from the video clip [10], composed for simulation of the working process of the virtual manipulator, driven by two independent drivers, in one working cycle.

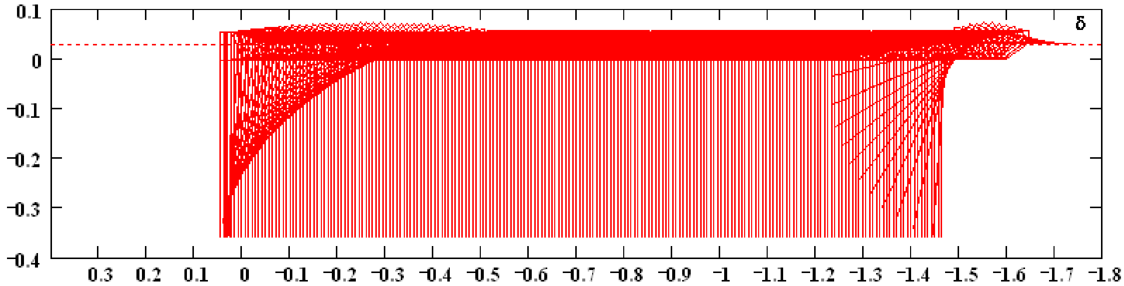


Fig. 9. **Video frames from the composed video clip that simulates the working process of the virtual manipulator in Fig. 3 (a), driven by two independent drivers, in one working cycle**

Heinloo, Leola [12] have studied also the moving of the virtual manipulator driven by two dependent drivers. The principal scheme of such manipulator is shown in Fig. 10. This case allows using new restriction that the point D has to move exactly vertically along the axis x_1 in turning the manipulator clockwise.

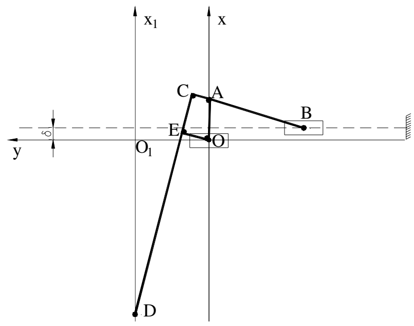


Fig. 10. **Manipulator, driven by two dependent drivers**

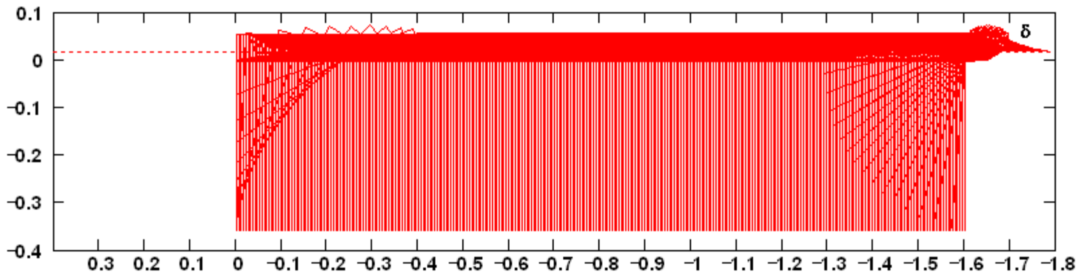


Fig. 11. **Video frames from the composed video clip that simulates the working process of the virtual manipulator in Fig. 10 in one cycle**

Fig. 11 shows the frames from the video clip [11], composed for simulation of the working process of the virtual manipulator, driven by two dependent drivers, in one working cycle.

Heinloo, Leola have designed also multiparametric optimization of the manipulator in Fig. 3 (a), when in solution of the above mentioned problems of optimization not only δ and ρ_{AO} but also the distances ρ_{AB}, ρ_{OE} between points A and B, O and E were determined (Fig. 3, b) [13]. Increasing the number of the optimizing parameters gave additional possibilities for solution of the problems of optimization.

Novel virtual manipulator

Heinloo, Leola have optimized also a novel manipulator in Fig. 12 [14]. Different from the previous manipulators, this manipulator turns from the working position to the return position counterclockwise and from the return position to the working position – clockwise. In solution of the above mentioned problems of optimization δ and distances ρ_{AO} ρ_{AB}, ρ_{OE}, ρ_{AC}, ρ_{CE}, were determined that determine the shape of the novel manipulator in Fig 12.

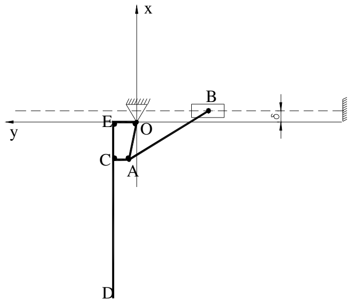
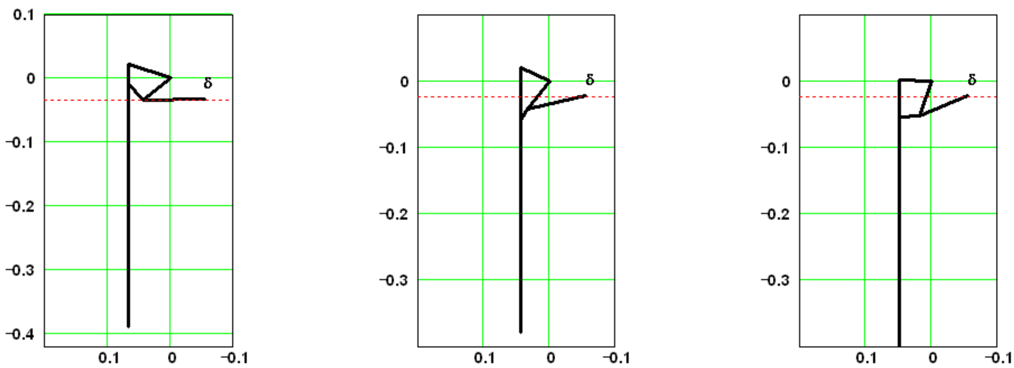


Fig. 12. **Novel manipulator**

Fig. 13 shows some generated shapes of the novel optimal manipulator in Fig. 12.



(a) (b) (c)

Fig. 13. **Different generated shapes of optimal virtual manipulator (Fig. 12)**

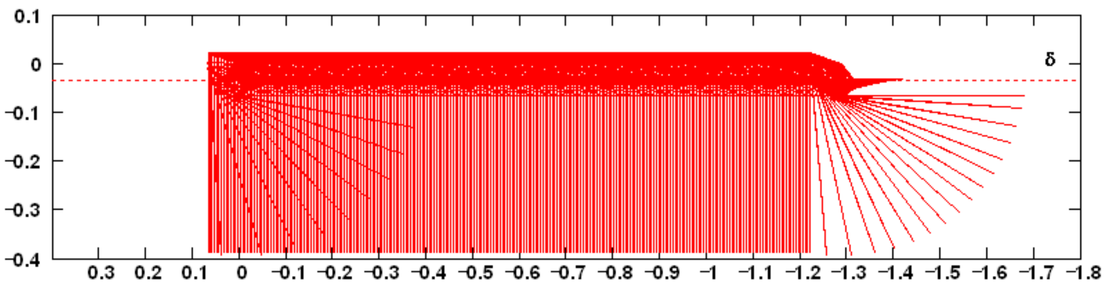


Fig. 14. **Video frames from the composed video clip that simulates the working process of the virtual manipulator in Fig. 13 (a) in one cycle**

Fig. 14 shows the frames from the video clip [15], composed for simulation of the working process of the virtual manipulator in Fig. 13 (a).

It is possible to study also dynamics of the considered virtual manipulators. In future papers we will present the results of study dynamics of the virtual manipulator in Fig. 3 (a) in turning from the working position to the return position.

Conclusions

Before to make a physical model of a machine element nowadays, it is reasonable to make, if possible, detailed analysis of the correspondent virtual model that may give important information for composing a physical model. This paper gives an overview of experimental and theoretical studies in 2001-2007 of press manure removal and its parts at the Estonian University of Life Sciences. The results of this paper can be useful for the designers of manipulators for press manure removals and for users of the Computer Package Mathcad.

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