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ROBOTICS IN THE PROCESS OF PACKING GREENHOUSE TOMATOES

Stanisław Lis, Michał Czech, Henryk Juszka, Marcin Tomasik
Department of Power Engineering and Automatization of Agricultural Processes
University of Agriculture in Kraków

Summary. A robotic research stand with a vacuum gripper for analysis of the tomato packing process was presented. On the basis of the research for the applied vacuum cup, the following parameters of the process of moving tomatoes were determined: operational negative pressure, conditions for picking and releasing vegetables. Properties of tomatoes were determined in regard to the research and the impact of the selected packing method on their condition was assessed - they were checked in regard to damages. It was proved that using a vacuum gripper with a vacuum cup BX 52P in the process of packing tomatoes is possible. It was found that operational negative pressure of the value 0.2 bar ensures a correct realisation of the packing process and does not cause any damages to vegetables. It was determined that releasing tomatoes during packing should take place at the height which enables their free slip into a packaging under the influence of gravity.

Key words: Robot, vacuum gripper, package, packing tomatoes

Introduction

Tomato is one of the most widespread vegetables in Poland, priced by consumers for its taste and dietary qualities. Due to popularity of this vegetable, the Authors were encouraged to carry out research concerning possibility of using robots in the process of packing. The analysis of using a vacuum gripper for this purpose was carried out. Difficulty of applying robotics in the process of packing results from considerable diversity of features of the packed products, which is characteristic for the food industry. During tests, the purpose of which was to determine inhomogeneity of properties of the used vegetables, their shape, size and mass were analysed.

The reasons for implementation of automatic machines and robots, and consequently for limiting the human interference in the process of packing are as follows: improvement of work safety, lowering costs and increasing efficiency and elasticity of the process. Possibility of obtaining and keeping high quality standards, difficult to obtain in case of traditional packing is also significant [Barczyk 2007].

The objective and the scope of the study

The objective of the study was to analyse the use of a vacuum gripper in the process of packing tomatoes.

The scope of work covered:

– analysis of the process of packing tomatoes,
– determination of tomatoes properties in regard to the research,
– usefulness analysis of a vacuum cup,
– determination of the negative operational pressure for the analysed process,
– identification of damages in tomatoes which were made during packing.

A research stand

The research was carried out on the robotics stand for packing and palletization in the Laboratory of Technological Processes Robotics in The Department of Production and Power Industry of the University of Agriculture in Kraków (fig. 1) [Juszka et al. 2010].

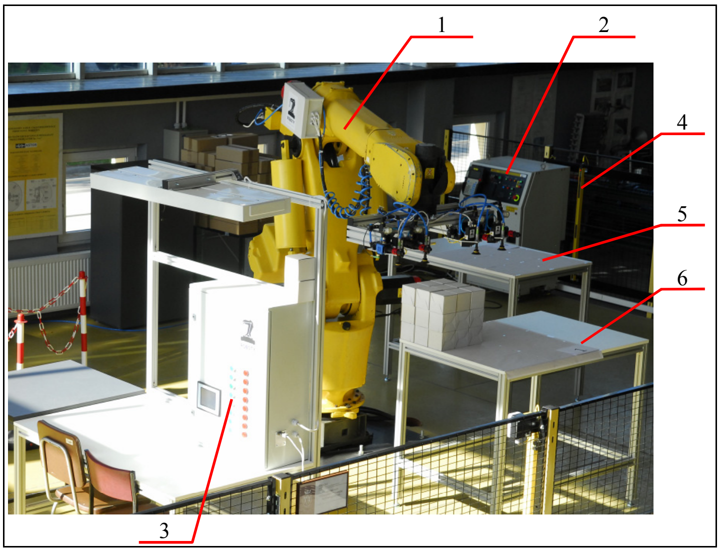

Photo: St. Lis

Fig. 1. The research stand 1– kinematic chain of GM FANUC S420iF robot, 2 – controller along with suspended manual programmer (Teach Pendant), 3 – operator panel with programmable controller PLC HORNER HE-QX351, 4 – light barrier element, 5 – table "2", 6 – table "1"

Rys. 1. Stanowisko badawcze: 1 – łańcuch kinematyczny robota GM FANUC S420i F, 2 – kontroler wraz z zawieszonym ręcznym programatorem (Teach Pendant), 3 – panel operatorski ze sterownikiem programowalnym PLC firmy HORNER HE-QX351, 4 – element bariery świetlnej, 5 – stół „2", 6 – stół „1"

The basic element of the stand is FANUC S420i F industrial robot with a controller R-J2. PLC HORNER HE-QX351 programmable controller integrated with an operator's panel cooperates with this machine. Communication between a robot and a controller is carried out through Profibus network. Safety of work at the stand is ensured by the safety system with a light curtain controlled by a controller. Objects for packing are placed on two tables made of aluminium profiles.

A vacuum gripper installed on the robot's arm is equipped with 4 vacuum cups, supplied with negative pressure by an ejector (fig. 2).

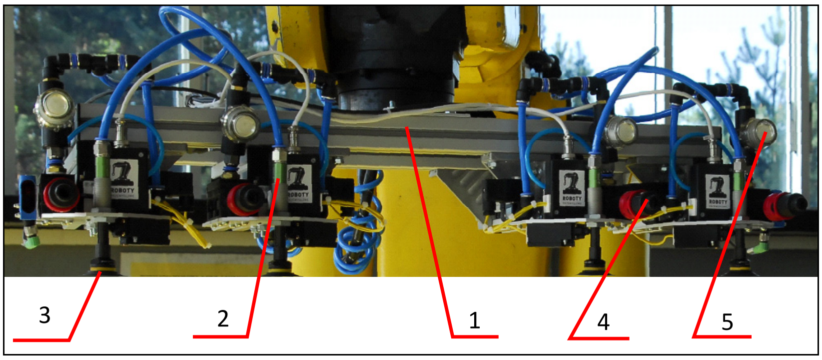

Photo: St. Lis

Fig. 2. General view of the pneumatic gripper: 1 – aluminium profile, 2 – level compensator, 3 – vacuum cup, 4 – ejector, 5 – vacuum filter

Rys. 2. Widok ogólny chwytaka pneumatycznego: 1 – aluminiowy profil, 2 – kompensator poziomu, 3 – przyssawka, 4 – eżektor, 5 – filtr próżni

Structure of this gripper, made of aluminium profiles allows for fast reconstruction/ modification in order to adjust to varying conditions of the process. The gripper is divided into 4 sections with separately controlled negative pressure. From the bottom it is protected from damages caused by collision with elements of the surroundings with level compensators with vacuum cups [Juszka 2006, Kost 2001, Instrukcja robota przemysłowego 1995]. Tests were carried out with the use of Piab BX 52P gripper (fig. 3).

Fig. 3. Gripper Piab BX 52P

Rys. 3. Przyssawka Piab BX 52P

Photo: St. Lis

Gripper BX 52P is made of two types of materials of varied hardness. In this structure, soft bellows and an elastic lip may be distinguished. It is distinguished by elasticity and good sealing properties protecting from dropping an object which is carried.

Botanic properties of tomatoes and the used packaging

From the point of view of realisation of the packing process on the robotics stand, such properties of tomatoes as their shape, size and mass should be found crucial. For determination of the mentioned parameters, it is possible to use the existing methodology (selection of tomatoes according to their shape is used both in trade as well as in botany). In trade, on account of shape, tomatoes are divided into 4 types, i.e. round, ribbed, oblong and elongated – "cherry" (small round) or cocktail (small lightly elongated). For description of the shape of tomatoes in the botanical description the so-called shape coefficient is used which is a ratio of the vertical diameter to horizontal diameter. It allows distinction of 10 types of fruit, which are divided into flat, slightly flat, round, rectangular, cylindrical, heart-shaped, egg-shaped, reverse egg-shaped, pear-shaped and strongly pear-shaped. Tomatoes size and mass according to the generally accepted classification are related to each other in the following way: very small tomatoes are those fruit of the mass less than 50 g, small are those which are within the range of 50–80 g, average fruit are those fruit,which are within the range of 80–110 g, big tomatoes are those of mass within the range of 110–140 g, very big are those whose mass exceeds 140 g [Borowiak 2007; Buchter-Weisbrodt 2009].

Beside the issue concerning parameters of the packed tomatoes, types of the used packages are an essential issue concerning robotics of the packing process. Vegetable protection from damage is a crucial issue while selecting a packaging. Packaging, which is the most frequently used for tomatoes: cartoon cases, which can contain 6 kilo of tomatoes, one (7 kg) or two-layer (14 kg) cartoon cases with pressings, plastic cases, small boxes made of hard polyethylene foil with a cover containing 250 g or 500 g tomatoes and trays wrapped with plastic foil to which the whole bunch of tomatoes is packed [Jankowski 2007; Jarczyk, Płocharski 2010; Lisińska-Kuśnierz, Ucherek 2003].

The research object

The research was carried out with the use of Marissa F1 tomatoes. Their shape, size and mass were described. As it was noticed above, these features influence the packing process. The shape coefficient, which is used in botany, was applied to describe the shape. In order to determine the size of tomatoes, their volume was measured. Moreover, vegetables were weighed. The shape coefficient, which is a ratio of vertical and horizontal diameter of tomatoes used in the research, was within the range of 1.05−1.21. Therefore, these were fruit, which, according to the above presented classification may be treated as rectangular. Tomatoes volume was measured by soaking them in distilled water – the amount of displaced liquid constituted information on the volume of a vegetable. The volume of tomatoes used in the research was within the range of 69.3–110.9 ml. A laboratory scale was used to weigh vegetables.

Experimental research

The methodology accepted for the research assumes the following course of the packing process. Sorted tomatoes are collected by a robot from a feed with a vacuum cup of a vacuum gripper, then it transports them and releases to packagings. Collecting tomatoes from a feed may be carried out separately or in a group.

In order to check if the applied vacuum cup meets the requirements of the tomatoes packing process, its usefulness was analysed. Then, negative pressure was determined for a vacuum cup. Finding such a value, which would ensure that a tomato does not fall of a vacuum cup and at the same time is not be damaged, was the objective function. Moreover, it was analysed whether at the applied negative pressure, the acceleration value and delay of the gripper movement would not result in falling off a tomato from a vacuum cup. Negative pressures of values reaching 0.2 bar, 0.4 bar and 0.6 bar were accepted during the research. It was found that at the value of negative pressure under 0.2 bar, tomatoes fell off the vacuum cup. Negative pressure was measured with Wika DG-10 manometer. Further, conditions for correct picking and release of tomatoes during packing were determined.

The stage of collection and transport of tomatoes after the selection of the process parameters were presented in figures 4 and 5.

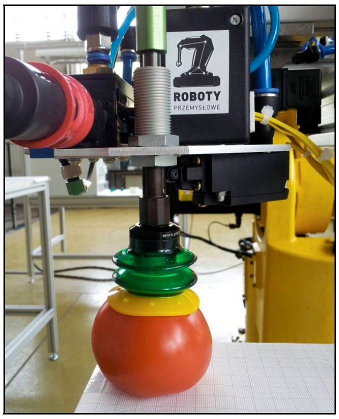

Photo: St. Lis

Fig. 4. The packing process of tomatoes with a pneumatic gripper – picking

Rys. 4. Proces pakowania pomidorów chwytakiem pneumatycznym – pobranie

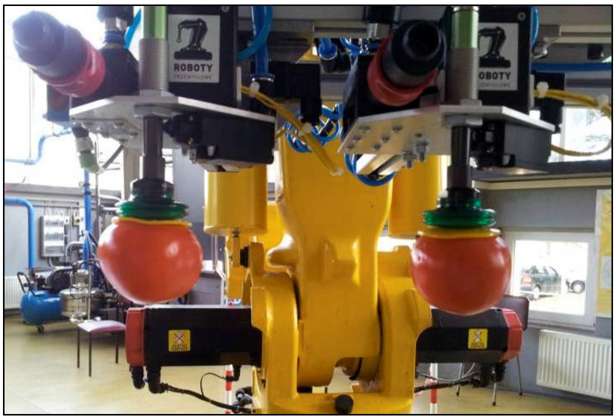

Photo: St. Lis

Fig. 5. The packing process of tomatoes with a pneumatic gripper – transport

Rys. 5. Proces pakowania pomidorów chwytakiem pneumatycznym – transport

The final stage of the analysis of the packing process was the assessment of the condition of tomatoes used for the research. Damage survey was carried out. Fig. 6 presents a cross-section of one of the vegetables used in the research.

Fig. 6. A cross-section of a tomato after moving it with a vacuum cup BX 52P

Rys. 6. Przekrój pomidora po przeniesieniu przy użyciu przyssawki BX 52P

Photo: St. Lis

As it may be noticed on the exemplary cross-section of a tomato, the vegetables used in the research carried no traces of damages. Due to the above, it may be assumed that the process parameters were correctly selected in the course of research, inter alia, resulting from the properties of a vacuum cup, such as: operational negative pressure, conditions for collecting and releasing tomatoes.

Conclusions

1. It is possible to use a negative pressure gripper in the process of packing tomatoes.
2. BX 52P gripper when set with a level compensator allows a correct performance of the tomatoes packing process.
3. Value of the operational negative pressure, which would ensure that a vegetable is held by a vacuum cup and would not cause its damage, is 0.2 bar.
4. It was determined that releasing tomatoes during packing should take place at the height which enables their free slip into a packaging under the influence of gravity.

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ROBOTYZACJA PROCESU PAKOWANIA POMIDORÓW SZKLARNIOWYCH

Streszczenie. Przedstawiono zrobotyzowane stanowisko badawcze z chwytakiem podciśnieniowym do analizy procesu pakowania pomidorów. Na podstawie badań dla zastosowanej przyssawki ustalono parametry procesu przenoszenia pomidorów: podciśnienie robocze, warunki pobierania i uwalniania warzyw. Określono cechy pomidorów w aspekcie badań i oceniono wpływ wybranej metody pakowania na ich stan – sprawdzono czy nie zostały uszkodzone. Dowiedziono, że zastosowanie chwytaka podciśnieniowego z przyssawką BX 52P w procesie pakowania pomidorów jest możliwe. Stwierdzono, że podciśnienie robocze o wartości 0,2 bar zapewnia poprawną realizację procesu pakowania nie powodując uszkodzeń warzyw. Ustalono, iż uwalnianie pomidorów podczas pakowania powinno odbywać się na wysokości umożliwiającej ich swobodne wsunięcie się do opakowania pod wpływem siły grawitacji.

Słowa kluczowe: robot, chwytak podciśnieniowy, opakowanie, pakowanie pomidorów

Contact details:
Stanisław Lis; e-mail: stanisław.lis@ur.krakow.pl
Katedra Energetyki i Automatyzacji Procesów Rolniczych
Uniwersytet Rolniczy w Krakowie
ul. Balicka 116B
30-149 Kraków