UDC: 621.867(047)=20
COSATI: 13-03, 13-09, 15-05

A contribution to the dependence of conveyor transport on automation level of manufacturing equipment

Dragan Živković, PhD (Eng)[1)]
Milan Bukumirović, PhD (Eng)[2)]

Analysing how a transport system works leads us to the conclusion that there is a certain dependence of conveyor transport, on one side, and the automation level of manufacturing equipment, that is supplied by the transport device analyzed, on the other side. This paper presents the results from the *Zmaj* factory of agricultural equipment in Belgrade, where the dependence of conveyor transport on the automation level of manufacturing equipment was a subject of an analysis. The results show that the dependence of conveyor transport on automation level of manufacturing equipment is stronger in the section where the automation of manufacturing equipment is based on integration of selected manufacturing operations.

Key words: **transport of material, automation level, manufacturing equipment, supply, supply factor.**

Introduction

THE automation level of manufacturing equipment and the transport of material are two variable quantities, frequently encountered in manufacturing. The economics of a manufacturing process often depends on how accurate these two variables are defined. Supposing that a relation between the automation level of manufacturing equipment and conveyor transport exists, it is necessary to determine the form of their dependence. It is of great practical importance to determine the relation between the automa-tion level of manufacturing equipment and conveyor transport, in order to enable us to compute the value of one feature based on the value of the other feature.

Conveyor transport

Conveyors are mostly used in mass and large series production, in the transport of work pieces. Modern overhead conveyors (transporters) feature a wide range of parameters. They are used to transport parts having a mass ranging from a few grams to 2.5 tons, where the dimensions of the workpiece range from a few centimeters up to 6-12 meters. The speed of the conveyor may range from 0.1 to 30 m/s. The length of the conveyor ranges from 500 to 600 meters in a single-drive facility, i.e. from 2 to 3 kilometers in a multi-drive facility.

One of the first conveyors was designed and taken into exploitation in 1928-29 at the *Dukat* tobacco industry in Moscow. The conveyor was 500 meters long and working at a speed of 10.2 meters per minute [1].

The essential advantage of overhead conveyors over other types of transport lies in their capacity to transport work pieces following a wide variety of complex paths in all directions. For this to be possible, the driving element of overhead transporters should be flexible in all directions and should also enable flexibility in two orthogonal planes.

Automation level of the production equipment

Automation of the production equipment, i.e. of the production system, has the task:

- to reduce physical effort of a man,
- to increase productivity,
- to increase product quality,
- to increase economical efficiency.

As a measure of automation for production equipment--machine, production process, and production system a measure named: level of automation is most frequently used. The automation level represents the relation of the number of automated functions to a total number of functions and can be determined by means of the formula [3]

$$A^{o} = A_f \,/\, A_u \qquad (1)$$

where

$A°$ - automation level
A^f - number of automated functions
A_u - total number of functions

The minimum automation level refers to the production equipment with manual machining and the maximum automation level to the computer integrated production equipment with automatic designing of product, technology and planning (CIM).

The automation level is a relative measure of the automation, which shows the development phase of managing information to which all changes are automated. For example: the automation level would be as follows: for

[1)] Higher Technical School, Đorđa Stratimirovića 22, 23000 Zrenjanin
[2)] The Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, 11000 Beograd

a radial drill 0.12, for a radial drill with a circular table 0.15, for a horizontal drilling and milling machine 0.17, and for a machining center 0.48.

Determining the dependence of conveyor transport on the automation level of manufacturing equipment

Some of the main parameters of a conveyor are:

– ***Capacity:***

$$Z_p = P_1/m_1 + P_2/m_2 + ... + P_n/m_n \text{ (in hours)} \quad (2)$$

where

$P_1, P_2, ... P_n$ - amount of annual production (modified annual production),

$m_1, m_2, ..., m_n$ - amount of parts (details) being transported by an overhead device-brackets.

– ***Computational capacity of a conveyor***

$$Z_R = K_R\, K_a\, Z_p \quad (3)$$

where

K_R - coefficient describing production reserves, K_R=1.2-1.3

K_a - disturbance (non-rhythmicity) coefficient, shows an amount of devices-brackets, i.e. stands for placing material that has passed through a point observed, in a computational rhythm. For a strictly rhythmical work, K_a=1.

Analyzing the situation at the *Zmaj* factory, Belgrade, we came to the results shown in Table 1. K_R=1.25 and K_a=1.

Table 1

A^0	0.12	0.15	0.17	0.48
Z_p	574500	595500	620700	614100
Z_R	718125	744375	775875	767625

On the basis of Table 1, we can establish a dependence of a specified conveyor capacity on the automation level of manufacturing equipment, and a dependence of computational conveyor capacity on the automation level of manufacturing equipment [2].

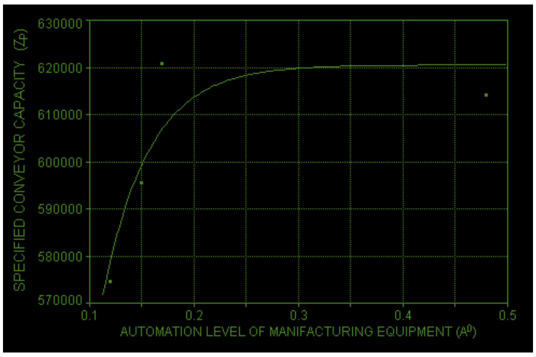

Figure 1. Dependence of conveyor capacity on the automation level of manufacturing equipment

With the help of "Tablecurve" software, we can approximate the resulting curve that describes how a specified conveyor capacity depends on the automation level of manufacturing equipment, by a curve that is mathematically described as

$$y = a/(1+\exp(-(x-b)/c)) \quad (4)$$

where the parameters in the previous equation are

$$a=617339.76; \quad b=0.0547; \quad c=0.0253$$

i.e., the dependence of the computational conveyor capacity - Z_R on the automation level of manufacturing equipment.

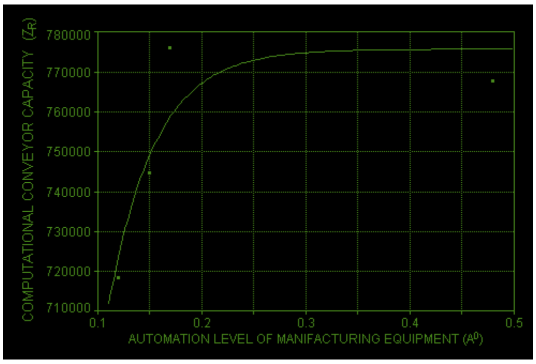

Figure 2. Dependence of the computational conveyor capacity on the automation level of manufacturing equipment

We can approximate the resulting curve that describes how the computational conveyor capacity depends on the automation level of manufacturing equipment, by a curve that is mathematically described as

$$y = a/(1+\exp(-(x-b)/c)) \quad (5)$$

where the parameters in the previous equation are

$$a=771663.71; \quad b=0.05487; \quad c=0.02534$$

– ***Specified movement rhythm***
can be determined as:

$$R_0 = 60\; t \,/\, Z_p \;\text{ (minute/rhythm)}, \quad (6)$$

where

t - available amount of time per year, in hours.

– ***Computational movement rhythm***
can be determined as

$$R_R = 60\; t \,/\, Z_R \;\text{ (minute/rhythm)}. \quad (7)$$

For the example previously considered, we obtain the resulting specified, i.e. computational rhythm of the movement dependence on the automation level of manufacturing equipment (Table 2) [2]

Table 2

A^0	0.12	0.15	0.17	0.48
t	2700	2650	2700	2600
R_O	0.282	0.267	0.261	0.255
R_R	0.2253	0.2136	0.2088	0.2032

The dependence of the automation level of manufacturing equipment on a specified conveyor movement rhythm, can be shown in a form of a chart.

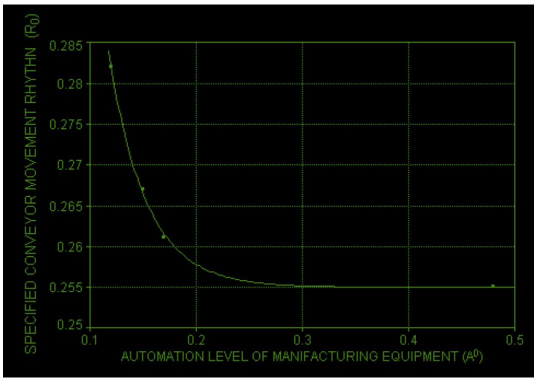

Figure 3. Dependence of the specified conveyor movement rhythm/-/conveyor capacity on the automation level of manufacturing equipment

We can approximate the resulting curve that describes how a specified conveyor capacity/conveyor movement rhythm depends on the automation level of manufacturing equipment, by a curve that is mathematically described as

$$y^2=(a+cx) / (1+bx) \quad (8)$$

where the parameters in the previous equation are

a=0.06137; b= - 9.8087; c= - 0.6302

i.e.

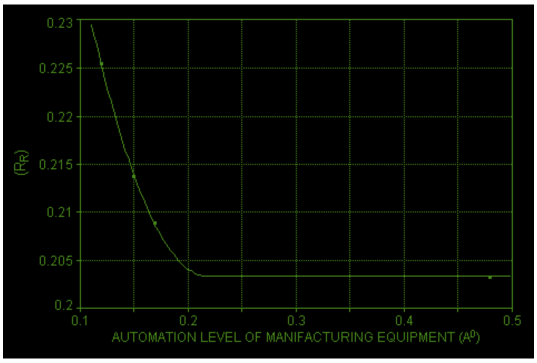

Figure 4. Dependence of the computational conveyor capacity/conveyor movement rhythm (R_R) on the automation level of manufacturing equipment

We can approximate the resulting curve that describes how the computational conveyor capacity/conveyor movement rhythm depends on the automation level of manufacturing equipment, by a curve that is mathematically described as

$$y^2=(a+cx^2) / (1+bx^2) \quad (9)$$

where

a=0.035178; b= - 108.73; c= - 4.46299

– ***Determining the conveyor speed***

The conveyor speed is calculated as follows

$$V= S/R_R \text{ (m/min)} \quad (10)$$

We can calculate the conveyor movement speed as a function of the automation level of manufacturing equipment, and for the example considered, we can take S=1.5m (Table 3) [2]

Table 3

A^0	0.12	0.15	0.17	0.48
V	6.65	7.02	7.18	7.38

i.e. as a chart shown in Fig.5

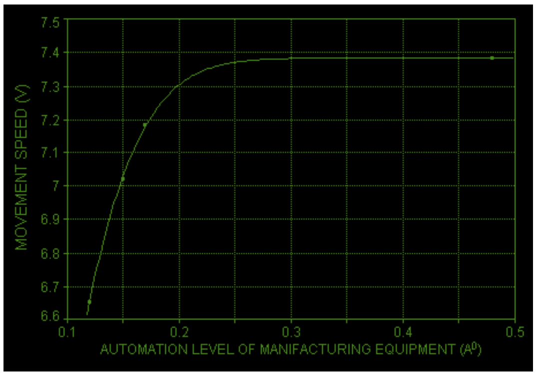

Figure 5. Dependence of conveyor movement speed on automation level of manufacturing equipment

We can approximate the resulting curve that describes how the conveyor movement speed depends on the automation level of manufacturing equipment, by a curve that is mathematically described as

$$y^2=a/ (1+\exp(-(x-b)/c)) \quad (11)$$

where the parameters in the previous equation are

a=7.38187; b= 0.0364; c= 0.0379.

In manufacturing practice, we can determine mass and size of material being transported as a dependence of conveyor speed. Naturally, the opposite is also the case:

– Conveyor speeds: V=12 to 14 m/min, used for round material, with dimensions of 1.5x1.5 meters and more (car cockpits, containers, tractors, etc.) or large mass (over 400 kg).
– Conveyor speeds: V=14 to 18 m/min, used for parts of medium size and medium mass.
– Conveyor speeds: V=24 to 26 m/min, used for light material (up to 150 kg) and compact material not bigger in size than 500x400 mm. [1]

Conclusion

From the research described in this paper and conducted in the framework of modern methods used in designing manufacturing and transport systems and optimizing their characteristics, it can be seen that a certain dependence of conveyor transport on the automation level of manufacturing equipment exists. Defining the automation level of manufacturing equipment dependence on material transport allows a more economical application of technology and an optimum automation level of manufacturing equipment.

Reference

[1] IVANOVSKIJ,K.E., OBOLENSKIJ,A.S. *Peregruzochnyj ustrojstva konvejerov shtychnykh gruzov.* Mashinostroenie, 1996, Moskva.

[2] ŽIVKOVIĆ.D. *Međuzavnost unutrašnjeg transporta i stepena automatizacije proizvodne opreme.* Doktoral thesis, Faculty of Mechanical Engineering, 2001, Kraljevo.

[3] BUKUMIROVIĆ,M. *Automatizacija procesa rada u poštanskim sistemima.* Faculty of Transport and Traffic Engineering, 1999, Belgrade.

[4] ŽIVKOVIĆ,D. *Dependence analyze for some parameters of transport system in dependence on automation level of equipment being superintended.* XV ECPD International conference on material handling and warehousing, 1998, Belgrade, pp.2.7 -2.11.

Received: 19.5.2003

Prilog zavisnosti unutrašnjeg transporta konvejerom i stepena automatizacije proizvodne opreme

Analizom rada transportnog sistema došlo se do zaključka da postoji određena zavisnost između unutrašnjeg transporta i stepena automatizacije proizvodne opreme koju opslužuje razmatrani transportni uređaj. U radu se prezentuju rezultati dobiveni u fabrici poljoprivrednih mašina *Zmaj* - Beograd, gde je vršena analiza međuzavisnosti unutrašnjeg transporta konvejerom i stepena automatizacije proizvodne opreme. Dobiveni rezultati pokazuju da je zavisnost između unutrašnjeg transporta konvejerom i stepena automatizovanosti proizvodne opreme više izražena u onom delu gde je automatizacija proizvodne opreme zasnovana na objedinjavanju određenih proizvodnih operacija.

Ključne reči: **unutrašnji transport, stepen automatizacije, proizvodna oprema, opsluživanje, faktor opsluživanja.**

Contribution à la dépendance entre le transport intérieur par convoyeur et le degré de l’automatisation de l’équipement de production

L'analyse du fonctionnement du système de transport a relevé qu'il y a une certaine dépendance entre le transport intérieur et le degré de l’automatisation de l’équipement de production qui alimente ce système de transport. Le papier présente les résultats obtenus dans l’usine de machines agricoles *Zmaj* où cette analyse était effectuée. Les résultats obtenus démontrent que la dépendance entre le transport intérieur par convoyeur et le degré de l’automatisation de l’équipement de production est plus accentuée là où l’automatisation de l’équipement de production est basée sur le groupement des opérations de production particulières.

Mots-clés: **transport intérieur, degré de l’automation, équipement de production, alimentation, facteur d’alimentation.**