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PRODUCTION CAPACITY AND WORKSTATIONS LOAD IN THE ANIMAL FEED PRODUCTION PROCESS[1]

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ABSTRACT

Production capacity is the amount of production with the determined assortment structure possible to achieve by a particular production unit in a determined time at the optimal use of production factors and at maintaining the products quality corresponding to standards. The objective of the paper was to determine the production power and output of particular workstations which constitute an assembly line of dry animal feed. The scope of research covered an assembly line in the establishment which produces dry feed for pet animals. Based on information and documentation obtained from the company manager and on the work schedule determined for particular workstations, the operation time of a machine, human work time (operation of a machine) and operation time of the entire station with its working surface was determined. Research showed that workstations which constituted the assembly line of dry animal feed were loaded within 76 to 86%. The lowest loading was reported in the mill and LP02 assembly line and it was respectively 76 and 78%. Whereas loading of the remaining devices was comparable and was at the level within 84 to 86%.

Introduction

A production structure is a manufacturing cells system of a basic and auxiliary nature along with their internal cooperation relations which occur in the production process (Mazurczak, 2002). A technological and group trend to create a technological production structure can be distinguished (Dohn, 2012; Duda and Wojakowski, 2013). In the group production a particular product is an element which combines cell workstations and in the technological production – a similarity of workstations (Baruk, 2006; 2012). When choosing an appropriate option of the production structure one should take into consideration the following factors i.e.: information included in the construction and technological documentation, characteristics of the manufactured goods, production size, programme variability, specialization and production cooperation degree, production processes nature, products evolution nature, characteristics of workstations and their role in the production process and characteristics of technical measures applied in auxiliary processes (Feld, 2013). These

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factors, related to the work environment and technical capabilities of machines, must cooperate and complete mutually (Duraj, 2004; Radziszewska-Zielina et al., 2013).

Present market requirements force enterprises to constantly minimize the production time at maintaining a high quality of a product (Zemczak, 2013). The use of machines and devices, namely production capacity understood as possibly the highest number of products manufactured within specific time has a great impact on production results (Waters, 2001). Appropriate use of workstations decides on the course of the entire production. Thus, workstations should be suitably adjusted to operation which they are to perform. They should have a precise objective of operation and manner of performing work. However, finally the work results of particular workstations depend on a man, who carries out a number of actions and functions in the work process (Szeloch, 2004).

Objective, scope and methodology

The objective of the paper was to determine the production power and output of particular workstations which constitute the assembly line of dry feed for pet animals. The scope of research covered the assembly line in the establishment which produces dry feed for pet animals. This line comprised a raw material storage, mill, two extruders, packing floor and ready products storage.

Tests consisted in observation and recording of treatments on particular workstations and in reporting the operation time of a specific station. Simultaneously, a guided survey was carried out among employees who operate workstations and information on treatments carried thereon was provided. A monthly report on the production size and work time structure i.e. available time, production time, duration of stoppages, duration of faults and set ups and references changes were used for analysis.

Production capacity and its use were calculated with the use of the following formulas.

$$Zp = Wtch \cdot Te \tag{1}$$

where:

Zp – production capacity,
Wtch – performance of machines or devices in production units referred to the assumed time unit,
Te – effective work time during a year (days, days and nights).

$$Wzp = \frac{P}{Zp} \cdot 100\% \tag{2}$$

where:

Wzp – production capacity use,
P – production,
Zp – production capacity.

Research results

Among devices which constitute the assembly line of dry feed for pet animals the highest data sheet performance at the level of 30 $t \cdot h^{-1}$ was reported for a mill (table 1).

The remaining devices had a considerably lower performance. It should be emphasised that extruders performance differed by 5 $t \cdot h^{-1}$. Also in case of packing lines, performance differed strongly. The highest was in case of LP02 line for packing the biggest bags and logically the lowest in case of LP01 line for packing samples of the weight of 20-120 g. The biggest number of bags of the weight of 0.5 to 4 kilo (563051 pcs.) was filled in during the investigated period and the lowest number (249321 pcs.) in case of the biggest bags. The production size was within 7513.95 t processed in a mill to 19.55 t on the packing line of a sample. Because of the big assortment of products offered by the company, the selected workstations must be set up or the references must be changed. In the investigated month, extruders were set up 188 and 185 times respectively the first one and the second one and packing lines were set almost two times more often. The change of reference concerned the packing line of the biggest and the smallest bags where this activity was carried out respectively 371 and 100 times.

Table 1.
Technical and exploitation parameters

Station		Data sheet performance ($t \cdot h^{-1}$)	Production size (t)	Number of packed bags	Number of set ups	Change of references
Mill		30.00	7513.95	–	–	–
Extruder I		7.00	2963.97	–	188	–
Extruder II		12.00	4115.58	–	185	–
Packing lines	LP01	0.24	19.55	391000	–	100
	LP02	8.10	3695.95	249321	–	371
	LP03	6.34	2174.21	329365	353	–
	LP04	2.52	679.35	563051	314	–

The fund of operating time of particular working devices expressed in days and hours was presented in tables 2 and 3.

In the investigated period, the general time fund was 30 days i.e. 720 hours. On the other hand, the nominal time fund which describes availability of devices on working days was at the level from 584 to 600 hours which corresponds to 24 or 25 days. Thus, the operating time, during which one could dispose devices, was comparable. Among the detailed measures, one may distinguish three groups of devices, for which the nominal time was similar or was the same, i.e. of extruders and samples packing line, LP02 and LP04 packing line and mill and LP03 packing line.

In the investigated time the highest number of stops as a result of faults was in case of a mill (6 days) and LP02 line (4 days). The remaining devices did not work in total 1, 2 or 3 days.

Table 2.
Funds and losses of working time on particular workstations (days·month^{-1})

Workstation		Work days funds					
		Disposition	Holidays	Production	Stops	Set ups	Changes of references
Mill		25	5	19	6	–	–
Extruder I		24	6	21	1	2	–
Extruder II		24	6	21	2	2	–
Packing lines	LP01	24	6	20.5	3	–	0.5
	LP02	25	5	19	4	–	1
	LP03	25	5	21	1	1	2
	LP04	25	5	21	2	1	1
Total		172	38	142.5	19	6	4.5

Table 3.
Funds and losses of operating time on particular workstations (h·month^{-1})

Workstation		Work time funds					
		Free	Nominal	Fault	Stops	Set ups	Changes of references
Mill		120.00	600.00	26.18	116.19	–	–
Extruder I		136.00	584.00	9.58	23.67	47.00	–
Extruder II		134.28	585.72	11.53	27.27	46.25	–
Packing lines	LP01	134.57	585.43	12.77	63.60	–	6.43
	LP02	124.00	596.00	1.58	91.85	–	35.18
	LP03	120.00	600.00	4.58	28.14	21.58	36.70
	LP04	128.00	592.00	1.75	42.37	17.22	30.83
Total		896.85	4143.15	67.97	393.09	132.05	109.14

For all nominal stations the operating time was in total 4, 143.15 h, i.e. 82.2% of the total operating time fund. From among the listed sources of work time losses, considerably the highest were the losses related to stoppages. In total they were 393.09 h which constituted as much as 9.5% of the nominal time fund. Stoppages resulted mainly from the awaiting time for the product, machine regulation, changes of production materials, no packages, no production plan, no free silos, no raw material, control etc.

On particular stations the time of stoppages was varied. The highest was on the mill station, where it was 116.9 H and on the LP02 packing line where it was 91.85 h. It was respectively 19.4% and 15.4% of the nominal time fund. The lowest time of stoppages was reported on the extruder I station where it was 23.67 h which constitutes 4.1% of the nominal time fund. The stoppages time on the extruder II station – 27.27 h was a little bit higher and on the LP03 packing line station – 28.14 h. In both cases it was 4.7% of the nominal time fund.

The remaining work time losses were considerably lower in comparison to the awaiting time. In case of set-ups they were in total 132.05 h which was 3.2% of the nominal time fund. On the other hand, on account of changes of references the operating time losses were in total 109.14 h i.e. 2.6% of the nominal time fund. On the other hand, on account of a fault, these losses were in total 67.97 h. i.e. 1.6% of the nominal time fund.

From among the listed sources of work time losses, these losses should be analysed in detail which affect the effective time fund. Work time losses incurred because of set ups and changes of references i.e. operating time losses which are technologically justified are included in this group.

Set up of extruders lasted 46-47 hours and on the packing lines they were 17-22 hours. In case of extruders it was 8% of the nominal time fund. In case of packing lines it was approx. 3-4% of the nominal time fund.

Change of references on the packing lines was at the average 30 hours except for LP01 line for which this activity was only 6.5 hours in the investigated time. It was respectively 5-6% and 1% of the nominal time fund.

Set ups require work inputs both of the operator and an assistant and the set up procedure is strictly complied with.

The mill had the highest technical performance – table 4. This performance at the level of 16.4 $t \cdot h^{-1}$was several times higher than the performance of the remaining devices. Performance of extruders was at the level of 5.9 and 8.2 $t \cdot h^{-1}$and packing lines from 0.1 $t \cdot h^{-1}$ to 7.9 $t \cdot h^{-1}$. Comparing this performance to the data sheet performance we may notice that only in case of LP02 packing line these are comparable values and technical performance constitutes 97.5% of the data sheet performance. Moreover, nominal performance of extruder I – 84.3% is highly used. On the other hand, the nominal performance of LP01 packing line was used in the lowest degree – 41.7% and a mill – 54.7% and LP04 packing line –55.6%. It might have been caused by a significant change of work parameters of these machines or a small efficiency of auxiliary processes which significantly limits the basic process efficiency.

Effective time fund includes only justified and scheduled work time losses, resulting from the need of changes of production technology course. The production time fund is formed after the effective time fund is decreased by the non-scheduled losses which most often result from incorrect work organization or random factors (fault). On the analysed stations the effective time fund was 539.47 h in case of extruder II to 600.0 h in case of a mill. On the other hand, the production time was 457.63 h in case of a mill and 509.00 h in case of the packing line LP03. Thus, for the mill, the production time was only 76.3% of the effective time fund and for extruders it was 93-94% of the effective time fund (at the average 93.3%). Such a high use of the effective time also defines the packing line LP03-94%. Taking into consideration the total packing time, we will notice that the production time constitutes at the average 89% of the effective time fund. Thus, at the extrusion and packing stage the participation of the production time is respectively by 19.0% and 12.5% higher than at the defragmentation stage. It indicates significantly high reserves of the operating time for the stand equipped in the mill.

Table 4.
Production capacity and production reserves

Workstation		Technical efficiency	Work time fund		Production capacity	Production	Production reserves
			effective	production			
		($t \cdot h^{-1}$)	(h)	(h)	(t)	(t)	(t)
Mill		16.4	600.00	457.63	9840.0	7514.0	2326.0
Extruder I		5.9	537.00	503.75	3168.3	2964.0	204.3
Extruder II		8.2	539.47	500.67	4423.7	4115.6	308.1
Packing lines	LP01	0.1	579.00	502.63	57.9	19.6	38.3
	LP02	7.9	560.82	467.39	4430.5	3696.0	734.5
	LP03	4.3	541.72	509.00	2329.4	2174.2	155.2
	LP04	1.4	543.95	499.83	761.5	679.4	82.1
Defragmentation		16.4	600.00	457.63	9840.0	7514.0	2326.0
Extrusion		14.1	1076.47	1004.42	7592.0	7079.6	512.4
Packing		13.7	2225.49	1978.85	7579.3	6569.2	1010.1

Production capacity is a product of the effective time fund and technical efficiency and production reserves are a difference between the production capacity and the production size. Degree of use of the production capacity reflects the relation of the production size to the production capacity - figure 1.

The highest and the lowest value attract the attention when analysing the production capacity. The highest production capacity at the level of 9,840.0 t was reported for a mill and the lowest of 57.9 t for LP01 line which packs the samples with the weight of 2-120 g. Production capacity of the second extruder and the LP02 packing line was comparable and was approximately 4 430 t. In the remaining cases these were considerably different values.

When analysing particular production stages we may notice that the total production capacity of extruders was 7592.0 t and was comparable to the total production capacity of packing lines – 7579.3 tones which indicates high balancing of this part of production lines. In comparison to the production stages, production capacity of a mill was higher by 1/4. Inter alia, this output stock justified a greater number of stoppage days of this workstation.

The production capacity was the best used in case of LP03 packing lines and both extruders. In these cases the level of production capacity use was respectively: packing line LP03 – 93.3%, extruder I – 93.6% and extruder II – 93%. In the remaining cases it was considerably lower and the lowest was reported for the station equipped with LP01 packing line – 33.9%.

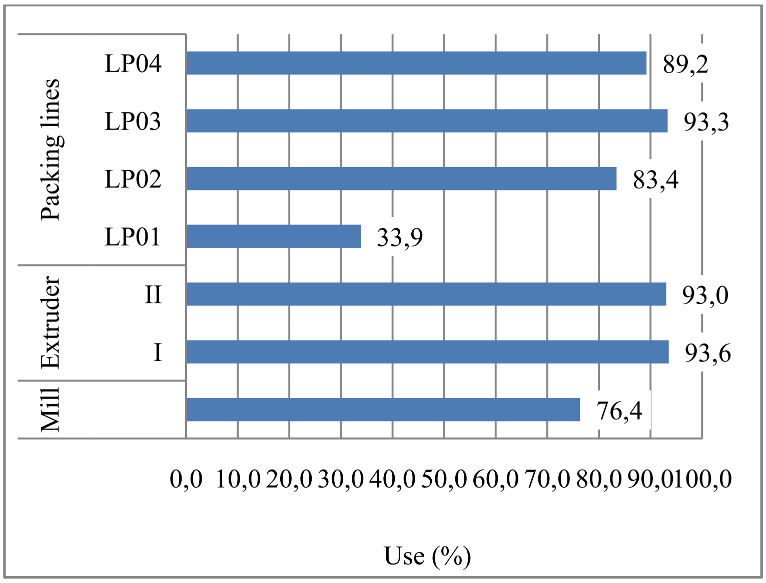

Figure 1. The use of production capacity of devices

When analysing the total use of the production capacity we may notice that at the defragmentation stage it is 76.4%, at the extrusion stage – 93.3% and at the packing stage – 86.7% (fig.2).

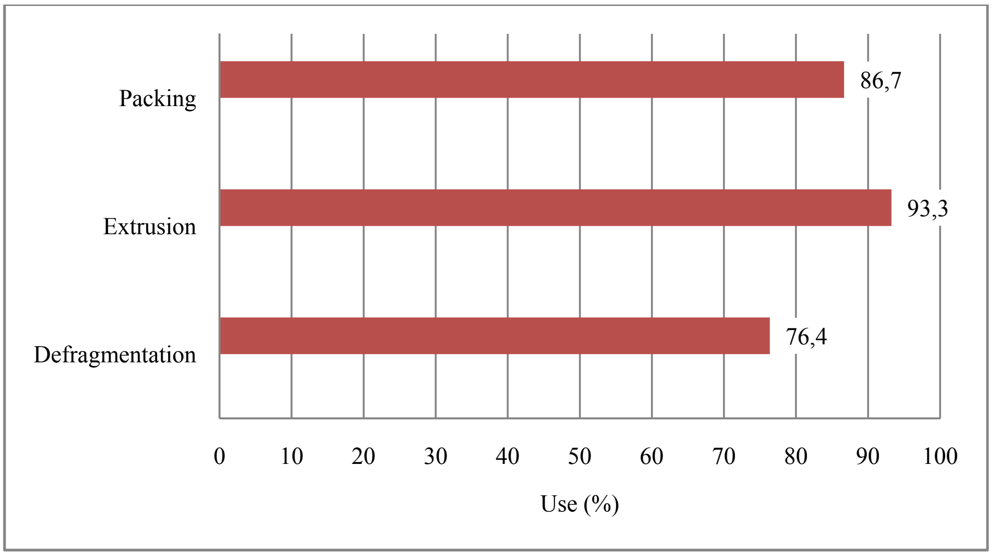

Figure 2. Total use of production capacity

The above analysis indicates that for the increase of the production capacity of the establishment it is necessary to implement technical or organizational changes concerning extrusion processes. Nominal performance of extruders higher by 1/4 than the technical performance achieved in the establishment indicates that the increase is possible without the need of purchase of new, more efficient machines.

Loading workstations which constitutes the ratio of the production time to the nominal time fund is 76.3% to 86.3% – fig. 3. The lowest is related to the mill station and the highest to the extruders stations and LP01, LP03 and LP04packing lines. In case of the last it is within 84.4% to 86.3% which indicates high mutual relations between particular stations. Such stiff relations are characteristic for downstream lines. For such lines any stoppages and periodical shutdowns must be closely synchronised with each other.

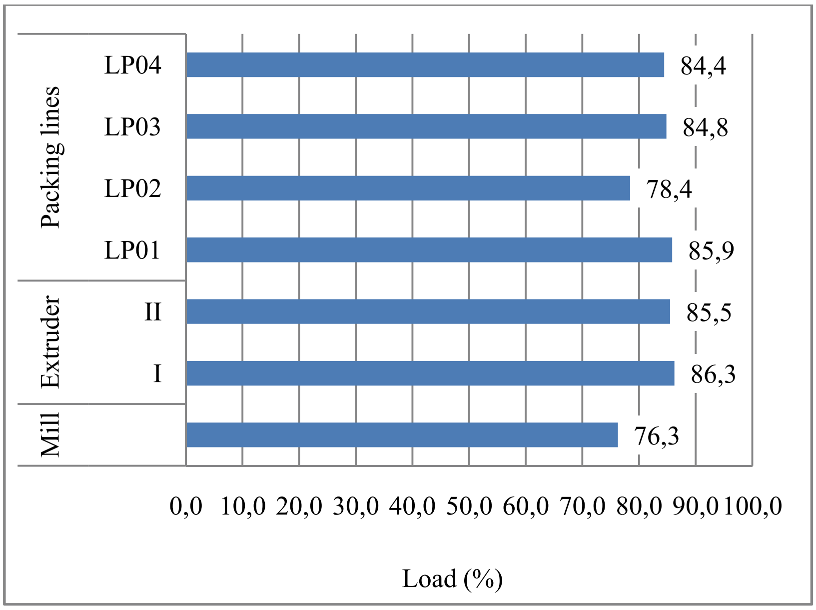

Figure 3. Loading workstations

Summary and conclusions

In the analysed establishment a downstream work system on assembly lines with a high level of balancing are used. In the investigated period in total 6,569.2 tons of animal feed were produced. It was packed in varied packaging.

1. On particular production stages, production capacity was respectively: defragmentation – 9,840.0 t, extrusion – 7,592.0 t and packing – 7,579.3 t. Thus, the extrusion stage is highly synchronised and balanced on the packing stage. In comparison to the production stages, production capacity of the mill was higher by 1/4 and enabled performance of a considerably higher production schedule.

2. The highest use of the production capacity was reported at the extrusion stage where it was 93.3%. The use of the production capacity at the defragmentation stage was 76.4% and at the packing stage – 86.7%. In order to increase the production capacity of the establishment, it is necessary to implement technical and organizational changes including mainly such that will increase technical performance of extruder II. For this device technical performance constitutes only 68.3% of the data sheet performance.
3. Low variability of loading of particular workstations indicates high mutual relations between particular stations characteristic for downstream lines. For such lines any stoppages and periodical shutdowns must be closely synchronised with each other, which reduces threats to the production schedule performance.

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ZDOLNOŚĆ PRODUKCYJNA I OBCIĄŻENIE STANOWISK ROBOCZYCH W PROCESIE PRODUKCJI KARMY DLA ZWIERZĄT

Streszczenie. Zdolność produkcyjna to ilość produkcji o określonej strukturze asortymentowej, możliwa do osiągnięcia przez daną jednostkę wytwórczą w określonym czasie, przy optymalnym wykorzystaniu czynników produkcji oraz przy zachowaniu jakości produktów odpowiadającej normom. Celem pracy było określenie wykorzystania mocy produkcyjnych i przerobowych poszczególnych stanowisk roboczych stanowiących linię do produkcji suchej paszy dla zwierząt. Zakresem badań objęto linię produkcyjną w zakładzie wytwarzającym suchą karmę dla zwierząt towarzyszących. Na podstawie informacji i dokumentacji uzyskanej od menedżera firmy oraz harmonogramu pracy ustalonego na poszczególnych stanowiskach roboczych, określono czas pracy maszyny, czas pracy człowieka (obsługi maszyny) oraz czas pracy całego stanowiska, z uwzględnieniem jego powierzchni roboczej. Badania wykazały, że stanowiska robocze stanowiące linię do produkcji suchej karmy dla zwierząt obciążone były w zakresie od 76 do 86%. Najmniejsze obciążenie odnotowano na młynie oraz linii pakującej LP02, odpowiednio 76 i 78%. Natomiast obciążenie pozostałych urządzeń było porównywalne i kształtowało się na poziomie od 84 do 86%.

Słowa kluczowe: stanowisko robocze, zdolność produkcyjna, obciążenie robocze, wydajność techniczna