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SIMULATION MODEL FOR PET BOTTLE PRODUCTION

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ABSTRACT
In this paper is describe simulation model for PET (polyethylene) wrapping materials production. Here is give description of multicompressor plant for production compressed air in PET bottle production. The procedure of determined compressor and blower combination is present to get optimal production process. For compressors and blowers working optimization is used software ARENA to determine optimal period of compressor turning on or turning off.
Keywords: compressor, blower, module, puffer tank, PET, mechatronic system

1. INTRODUCTION
The research in this paper is consider control model of "Knjaz Milos" (mineral water and drink factory) in Arandjelovac in Serbia. This model is based on complex mechatronic system used for leading and control centralize plant for compress air production in function of technological consumer-PET bottle blower.
Simulation model is based on dynamic process parameter in which is defined differential pressure increase in buffer tank as compressor work result with simultaneous pressure decrease. The pressure decrease as result of blower work. Simulation model is made of several module which present four compressor, reservoir with volume V= 10m ^{3} and four blowers.

The list of compressors are:		The list of blowers are:	
	capacity		capacity
1. ABC Spain	Q= 1198 Nm^3/h	1. SIDEL SBO 10	Q= 1047 Nm^3/h
2. AF 46B Belgioum	Q= 1320 Nm^3/h	2. BLOMAX 10 Krupp	Q= 1247 Nm^3/h
3. B&M England	Q= 1800 Nm^3/h	3. SIDEL SBO 12	Q= 1800 Nm^3/h
4. CE 24A Belgioum	Q= 510 Nm^3/h	4. SIPA 8/3	Q= 415 Nm^3/h

2. DEFINING SIMULATION MODEL
Pressure air who appear as compressor working result is store in reservoir and later is take in different direction on blowers which are used for PET wrapping material production. Simulation model define optimal schedule of compressors work for planning air consume on blowers. The pressure necessary in puffer tank is p=38 bars. The main scheme of simulation model is give on figure 1.
The main unit for simulation flow is time in seconds. Input data for compressors and blowers are length of acting in seconds.
The referent value is air pressure in reservoir. The start pressure in reservoir is 39 bar. The main function goal is to decrease total production of compressed air accord to blower usage (decrease total time of compressor idle speed and save consumption of electrical energy). The pressure in reservoir

must be in range of 38 to 40 bars. It also must be known data of air flow in seconds form compressor and in blowers. In experiment can be included all possible combination of blower and compressor usage and procedure for determination combination of compressors depend on blowers.

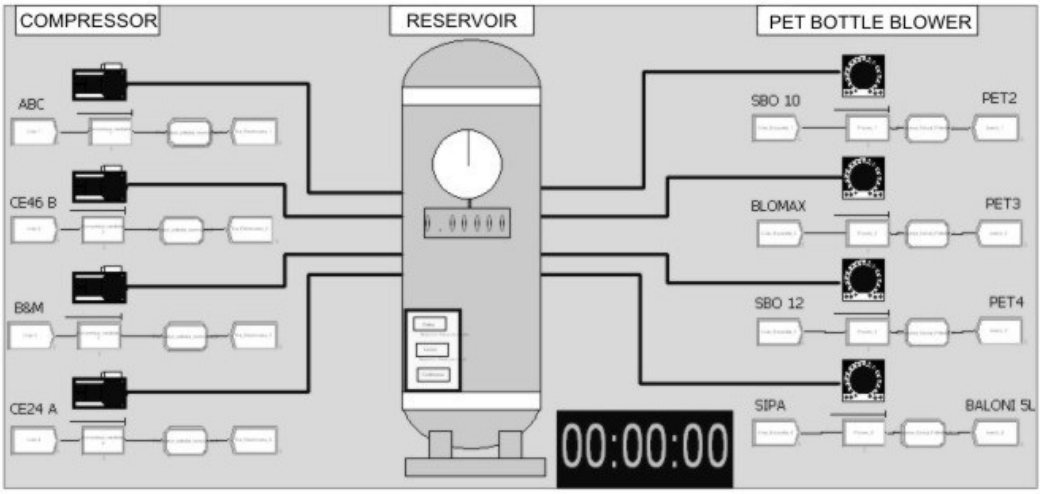

Figure 1. The main scheme of simulation model

3. DETERMINE COMBINATION PROCEDURE OF COMPRESSORS WITH BLOWERS

3.1 Calculation of increase air pressure in reservoir

Here is showing air pressure increase in reservoir for one second depending on combination of turn on compressor (table 1). In table is present all possible combination of compressor work. There are 16 possible combination: when work all or none of them, four combination with three turn on compressors, six combination with two turn on compresors and four combinations with one turn on compressor. All combinations are marked with K_{XY} (X – present number of turn on compressors, and Y number of certain combination for giving number of compressors).

Table 1. The review of air pressure increase with different combination of compressors work

Compressor	**+Δp**	**all**	**K41**	**none**	**K40**	**three**	**K31**	**three**	**K32**	**three**	**K33**	**three**	**K34**
ABC	0.032454	1	0.032454	0	0.000000	0	0.000000	1	0.032454	1	0.032454	1	0.032454
CE46B	0.035753	1	0.035753	0	0.000000	1	0.035753	0	0.000000	1	0.035753	1	0.035753
B&M	0.048754	1	0.048754	0	0.000000	1	0.048754	1	0.048754	0	0.000000	1	0.048754
CE24	0.013812	1	0.013812	0	0.000000	1	0.013812	1	0.013812	1	0.013812	0	0.000000
		∑ Δp	**0.130773**	**∑ Δp**	**0.000000**	**∑ Δp**	**0.098319**	**∑ Δp**	**0.095020**	**∑ Δp**	**0.082019**	**∑ Δp**	**0.116961**
Compressor	**+ Δp**	**two**	**K21**	**two**	**K22**	**two**	**K23**	**two**	**K24**	**two**	**K25**	**two**	**K26**
ABC	0.032454	1	0.032454	1	0.032454	1	0.032454	0	0.000000	0	0.000000	0	0.000000
CE46B	0.035753	1	0.035753	0	0.000000	0	0.000000	1	0.035753	1	0.035753	0	0.000000
B&M	0.048754	0	0.000000	1	0.048754	0	0.000000	1	0.048754	0	0.000000	1	0.048754
CE24	0.013812	0	0.000000	0	0.000000	1	0.013812	0	0.000000	1	0.013812	1	0.013812
		∑ Δp	**0.068207**	**∑ Δp**	**0.081208**	**∑ Δp**	**0.046266**	**∑ Δp**	**0.084507**	**∑ Δp**	**0.049565**	**∑ Δp**	**0.062566**
Compressor	**+ Δp**	**one**	**K11**	**one**	**K12**	**one**	**K13**	**one**	**K14**				
ABC	0.032454	1	0.032454	0	0.000000	0	0.000000	0	0				
CE46B	0.035753	0	0.000000	1	0.035753	0	0.000000	0	0				
B&M	0.048754	0	0.000000	0	0.000000	1	0.048754	0	0				
CE24	0.013812	0	0.000000	0	0.000000	0	0.000000	1	0.013812				
		∑ Δp	**0.032454**	**∑ Δp**	**0.035753**	**∑ Δp**	**0.048754**	**∑ Δp**	**0.013812**				

3.2. Calculation of air pressure decrease in reservoir

Here is show decreasing air pressure in reservoir for one second depending on appropriate combination of using blowers (table 2). Thera are all possible combination of blower work: when work four blower, all combination with tg=hree, two or one turn on blower. Every combination is

marked with D_{XY} (where X – present number of turn on blowers, and Y - number of certain combination). For every combination of blowers is give optimal schedule of turn on compressors. The criteria for selection is: *the choose compressor combination must give bigger pressure level in reservoir from blower combination in one second.*

Table 2. The reviw of air pressure decreas with different combination of blowers work

Blower	**- Δp**	**all**	**D41**	**none**	**D40**	**three**	**D31**	**three**	**D32**	**three**	**D33**	**three**	**D34**
SBO 10	0.029852	1	0.029852	0	0.000000	0	0.000000	1	0.029852	1	0.029852	1	0.029852
BLOMAX	0.035554	1	0.035554	0	0.000000	1	0.035554	0	0.000000	1	0.035554	1	0.035554
SBO 12	0.039828	1	0.039828	0	0.000000	1	0.039828	1	0.039828	0	0.000000	1	0.039828
SIPA	0.012838	1	0.012838	0	0.000000	1	0.012838	1	0.012838	1	0.012838	0	0.000000
		-Σ Δp	**0.118072**	**-Σ Δp**	**0.000000**	**-Σ Δp**	**0.088220**	**-Σ Δp**	**0.082518**	**-Σ Δp**	**0.078244**	**-Σ Δp**	**0.105234**
			K41		**K40**		**K32**		**K24**		**K22**		**K34**
Blower	**- Δp**	**two**	**D21**	**two**	**D22**	**two**	**D23**	**two**	**D24**	**two**	**D25**	**two**	**D26**
SBO 10	0.029852	1	0.029852	1	0.029852	1	0.029852	0	0.000000	0	0.000000	0	0.000000
BLOMAX	0.035554	1	0.035554	0	0.000000	0	0.000000	1	0.035554	1	0.035554	0	0.000000
SBO 12	0.039828	0	0.000000	1	0.039828	0	0.000000	1	0.039828	0	0.000000	1	0.039828
SIPA	0.012838	0	0.000000	0	0.000000	1	0.012838	0	0.000000	1	0.012838	1	0.012838
		-Σ Δp	**0.065406**	**-Σ Δp**	**0.069680**	**-Σ Δp**	**0.042690**	**-Σ Δp**	**0.075382**	**-Σ Δp**	**0.048392**	**-Σ Δp**	**0.052666**
			K21		**K22**		**K23**		**K22**		**K13**		**K26**
Blower	**- Δp**	**one**	**D11**	**one**	**D12**	**one**	**D13**	**one**	**D14**				
SBO 10	0.029852	1	0.029852	0	0.000000	0	0.000000	0	0				
BLOMAX	0.035554	0	0.000000	1	0.035554	0	0.000000	0	0				
SBO 12	0.039828	0	0.000000	0	0.000000	1	0.039828	0	0				
SIPA	0.012838	0	0.000000	0	0.000000	0	0.000000	1	0.012838				
		-Σ Δp	**0.029852**	**-Σ Δp**	**0.035554**	**-Σ Δp**	**0.039828**	**-Σ Δp**	**0.012838**				
			K11		**K12**		**K13**		**K14**				

4. SIMULATION OF OPTIMAL COMPRESSOR WORK FOR CERTAIN SCHEDULE OF BLOWER WORK IN SOFTWARE ARENA

This simulation depends on blower and compressor working time control. The control of turn on or turn of compressor is determine by time with calculating and then expreimenal with fine regulation of compresor woriking period. The working reservoir pressure is bring in allow limits. As start simulation condition is adopted resevoir pressure of 39 bars. Here is choos any combination of compressors of certain blowers schedule in any choosing period. The pressure is allow to oscilate one bar over or under start referent value of 39 bars. The gain solution must be optimized. After that must be balanced compressor and blowers work. The input working values are blowers and can be change only schedule of compressor work. Compressors can be turn on earlyer or later, or can be defined 50% of nominal working load insted of 100%.

The compressor and blower work in simulation model can be define by time with option *Schedule-Basic Process.* On figure 2 is shown view of main window for defining compressor and blower schedule working process.

Schedule - Basic Process

	Name	Format Type	Type	Time Units	Scale Factor	Durations
1	Schedule_1	Duration	Capacity	Seconds	1.0	2 rows
2	Schedule_2	Duration	Capacity	Seconds	1.0	2 rows
3	Schedule_3	Duration	Capacity	Seconds	1.0	1 rows
4	Schedule_4	Duration	Capacity	Seconds	1.0	3 rows
5	Schedule_K1	Duration	Capacity	Seconds	1.0	6 rows
6	Schedule_K2	Duration	Capacity	Seconds	1.0	4 rows
7	Schedule_K3	Duration	Capacity	Seconds	1.0	5 rows
8	Schedule_K4	Duration	Capacity	Seconds	1.0	5 rows

Figure 2. Defining working schedule

After this simulation are concluded that in certain time become pressure deviation out of permit limits. The reason of that is criteria of compressor choosed (the best combination of compressors is

that which supply enough air in blowers). So, the compressors work must be optimized again. The final schedule of compressors work is show on time diagram on figure 3. On figure 4 is shown diagram of reservoir pressure change. The pressure satisfied start limits between 38 and 40 bars. With this simulation is gained optimal solution for certain blower working schedule.

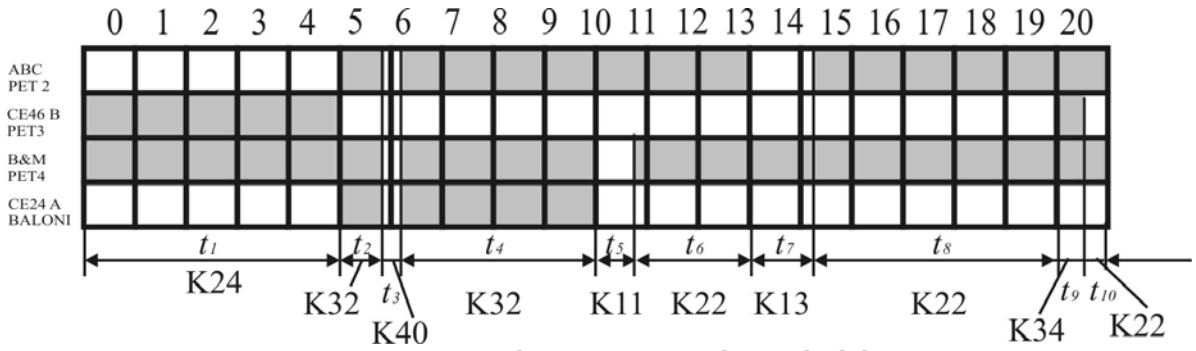

Figure 3. Optmal compressor working schedule

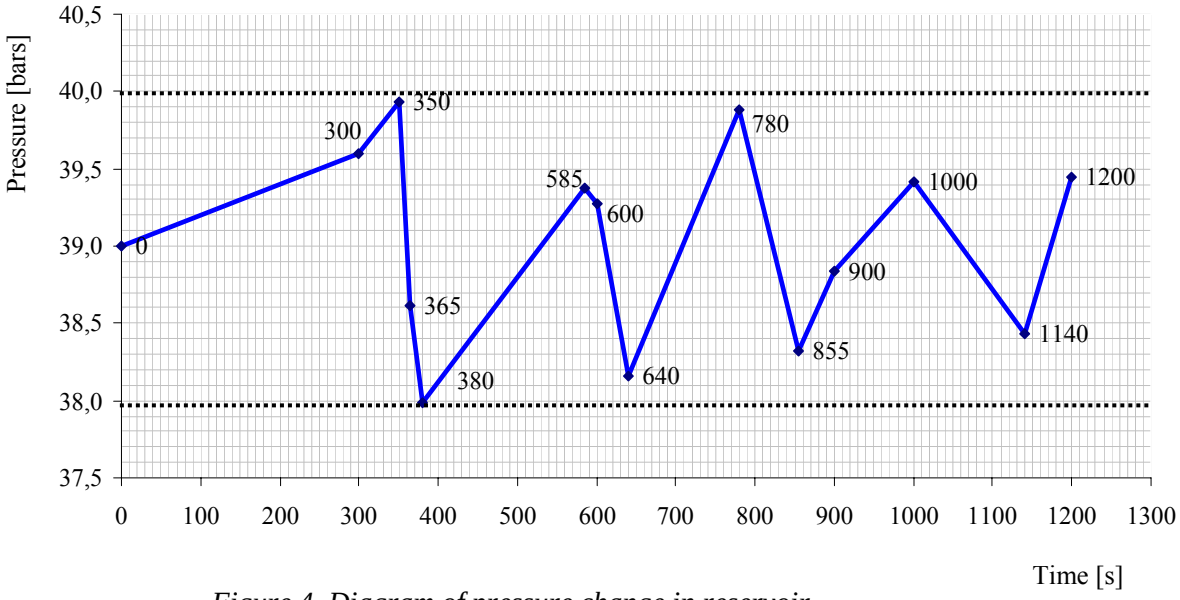

Figure 4. Diagram of pressure change in reservoir

5. CONCLUSION

The attended goal with optimization of dynamics parameter centralized compressors for air production (with pressure p=36 bars) in function of blower technological requirement are:

1. The efficient energetic control
2. Integration of decentralized generators in unique system
3. Increase hole system reliability
4. Elimination of time of big power generator idle speed
5. Optimization of big pressure air production processes costs

6. REFERENCES

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