ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering, Volume VII (XVII), 2008

Economically study regarding modernizing of the final working of the car radiators through implementation of an articulated robot in a flexible manufacturing cell

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Keywords: cell, manufacturing, flexible, cost, profitability.

Abstract. In this paper the authors purpose the conception and modeling of a possible application in a circular flexible manufacturing cell; this flexible cell is composed from five manufacturing points for realizing the final technological itinerary of an type of radiator. This flexible manufacturing cell is served by an industrial articulated robot, which possess in his cinematic chain three degrees of freedom, type RRT.

In virtue of real values of the functional parameters which are input data in the analysis of the flexible manufacturing cell, had been dignify the cost of the flexible manufacturing cell, determining the value of the included industrial robot in the system and the value of the entire flexible cell where the robot realize the manipulating process of the radiators.

1. INTRODUCTION

The flexible manufacturing cell (M.F.C.) represents a developed manufacturing system not only because is the last elaborated concept, in time, in the manufacture domain of intangible assets, but also, is determining a improve of the economy of the process to the necessary of real products and predominant of the society, that are products typological large diversified which are produced in reduced quantities.

This paper is proposing the designing of a possible application in a circular flexible manufacturing cell composed by five points of machining work, for final work of some car radiators, cell which is served by an industrial robot having the manipulator function.

2. THE CONCEPTION AND CALCULUS OF THE FLEXIBILE MANUFACTURING CELL

The robot allot for implementation possess three degrees of freedom (two rotations and one translation) and the clamping device, where:

- The rotation velocity on vertical: 0,75 [rad/s];
- The rotation velocity on horizontal: 0,75 [rad/s];
- The translation velocity of the clamping device: 0, 10 [m/s].

In the matter of the robot, the load grade of this is approximate to 85,5%, and the working space and the trajectory realized in the process time in cell been approximate 4 minutes. In virtue of the analysis of the production load is established the cell configuration.

In the cell is manufacturing one type of part, type water radiator, the manufacturing consist of:

- The carcasses of the radiators are fit in the fitting machine;
- The carcasses thus fit are welded to the welding machine;
- The water radiator thus welded is through to the test bed realized with a special device;
- The overspill material from the carcasses of the radiators is bended and brooked on the bender;

- The reception and the final check test are manually realized by the human factor;
- In final is realized the palletization of the radiators, process which is realized by the industrial robot included in the system.

The dimensions of the parts and the time of the each process are given in the table 1, respectively in the table 2.

Table 1- Parts value

Tip reper	L [mm]	l [mm]	$G_{brută}$ [Kg]	$G_{netă}$ [Kg]	SAF [buc/an]	Rigid. L/l
Radiator	247	200	3280	3050	24000	1235

Table 2. Manufacturing time on each process and annually

Operaţia	Potrivire	Sudare	Probe	Îndoire	Recepţie
Timpul de prelucrare [min/buc]	10	18	10.5	8	4
Timp de prelucrare total [min/buc]	50.5				
Timp de prelucrare anual	1212000				

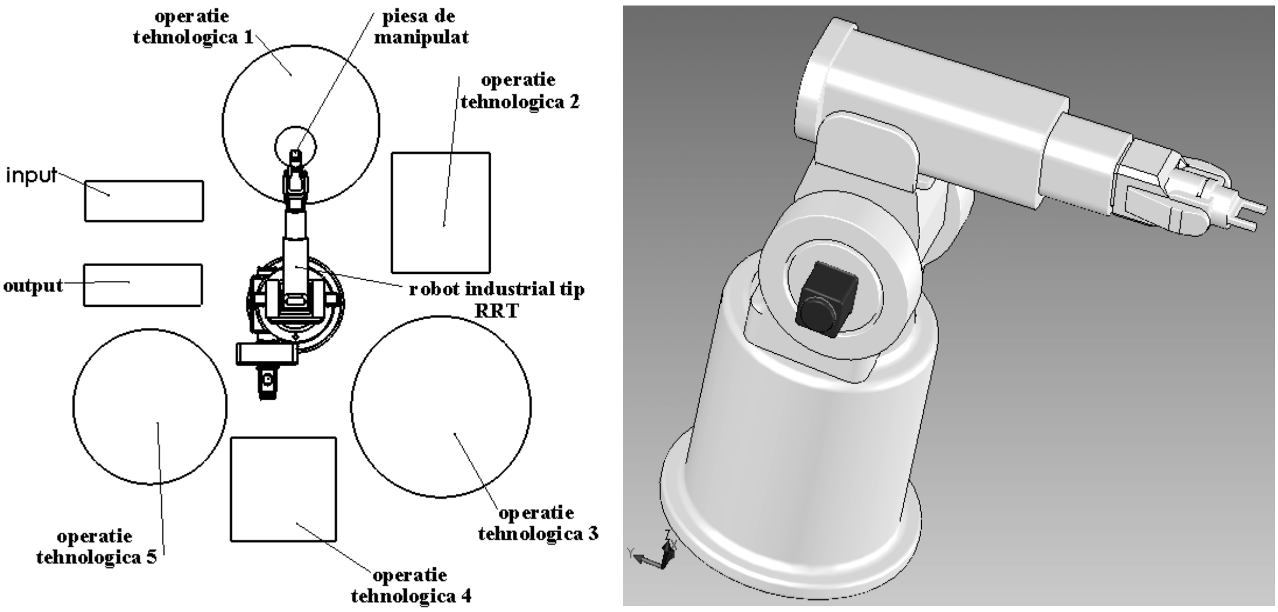

Fig. 1 The industrial robot RRT in the circular flexible cell

For the designing of the flexible manufacturing cell had been considered the next functional parameters:

- The price of the parts material P_m=5,74 [RON/kg];
- The lot of the costs of transport-provision T_{ra}=5%;
- The utilization degree of the material is in medium 95%;
- The basic wage of the workers is S_t=5 [RON/h];

- The lot of the welfare fund including the dole, health assurance and fund risk is CAS=30%;
- The price of the recovery resulted from the price of the material wherefore are made the parts is $P_{deş}$=40%*P_m;
- The fabrication account of the section is 40% and the fabrication account of the enterprise is 10%;
- Working fund time of an worker in one year is 1.880 [ore/an]; the productivity is 5.050 [RON/person*year] and the cost of 0, 1 RON realized production is 0, 08 RON;
- The preconize duration of recovery of the investment through introducing of the flexible manufacturing cell is 6 years;
- The prices of the machine tools from the flexible manufacturing cell are considered (1€ = 3, 70 RON):
  - Fitting machine- 20.000€;
  - Welding machine- 26.500€;
  - Testing device – 10.100€;
  - Bender machine – 17.800€;
- Set-up cost and the compatibly of the equipments in F.M.C. is 5.500 [RON /system];
- The character of service of the system is D=260 [working days/year], S=2 [shifts/day], h= 8 [hours/shift];
- The medium annually stopping time for revises and repairs represent 10% of annually fund time;
- Allowable minimal degree of utilization of the available time fund is 80%;
- The transition cost from the manufacturing of one part to another part is 7, 5 RON for each affinity point;
- The included robot in system possesses the next characteristics:
  - Three degrees of freedom;
  - The medium displacement velocity on trajectory - 0,3 [m/s];
  - Position accuracy – 1 [mm];
  - The capacity of the working space- 15 [m^3];
  - Electrical driving.
- Introducing the flexible manufacturing cell are obtained the annually saving of 90.000 [RON/year], without the calculated savings. This savings are making part from the category on the saving which can quantize, of type competitive increase.

In the table 3 are given the next values of the radiator part.

Table 3 Parts data

Tip reper	P_i [buc/an]	N_i [buc/an]	N_i/P_i	a_i [RON/lot]	c_i [RON/buc]	k^* [lot/an]	Q_i^* [buc/lot]
Radiator	195423	24000	0.122	68	171.93	72	333

$$k^* = \sqrt{\frac{\sum_{i=1}^{n} N_i \cdot c_i \cdot \varepsilon \cdot \left(1 - \frac{N_i}{P_i}\right)}{2 \cdot \sum_{i=1}^{n} a_i}}\ ;\ i = \overline{1,4}, \quad \text{[lot/year]} \qquad (1)$$

where: k^* – represent the optimum number of lots per year, which is the same for all the type of parts [lot/year]; P_i – production capacity [piece/year]; N_i – annually series of fabricated products [piece/year]; a_i – delivery cost in fabrication of an lot of parts type „i" [RON/lot]; c_i

– the cost of an part type „i” [RON/piece]; ξ- stockage rate [RON/year]; ξ= 0,2 [RON/year].

$$Q_i^* = \frac{N_i}{k^*} \quad \text{[piece/year]}, \tag{2}$$

where, Q_i^* - represent the optimum amount of the fabrication lot [piece/lot].

3. THE COST OF THE MANUFACTURING CELL

As a starter, will be determinate the value of the industrial robot included in cell knowing that the number of the robots included in system is given by relation:
$\frac{number\ of\ machine-tools}{4.38} = \frac{4}{4.38} = 0.91 \Rightarrow 1\,robot$, (considering that, generally, the flexible manufacturing cell has in medium one robot to 4.83 manufacturing points).

According to the characteristics possessed by the robot are given points, thus:

g_m = 3...1, 8 points
v_{med} = 0, 3 m/s..............................0,75 points
p_p = 1 mm.......................................4, 5 points
v_{sl} = 15 m^3....................................1, 25 points
m_p = 3.30 kg...................................0, 17 points
Total = 8, 35 points,

where: g_m – represents the number of the degrees of freedom of the robot; v_{med} – the medium velocity of displacement on trajectory [m/s]; p_p – the position accuracy [mm]; v_{sl} – the volume of the work space of the robot [m^3]; m_p – carrying capacity of the robot (the maximum weight of the manipulated parts) [kg].

The given points had been determinate thought rule of three based on the charts of analysis.

The actuating of the robot is electrical. The price of the robot is established thus:

Robot price = 12.822 · No. of points · EURO currency (RON)/2 = 212.774,679 RON. (3)

Supposing that the whole transfer system is assured by the robot, we can assess the cost of the flexible manufacturing cell thus:

1. Manufacturing points:

- 1 fitting module: 1 x 74000 = 74.000 RON
- 1 welding module: 1 x 98050 = 98.050 RON
- 1 testing module: 1 x 37370 = 37.370 RON
- 1 bending/breaking module: 1 x 65860 = 65.860 RON
- The cost of the compatibility of the manufacturing points: 1 x 5500 = 5.500 RON

TOTAL: **280.780 RON**

2. The transfer system:

- 1 robot: 1x212776 = 212.774.679 RON

TOTAL: **212.774.679 RON**

4. THE RECOVERY TIME OF THE INVESTMENT

The economy to the price cost on year (EPC) is calculated thus:

$$\mathrm{EPC} = \sum_i \sum_j S_j \cdot \frac{n_{tij} \cdot s_{tij}}{60}\left(1+\frac{CAS}{100}\right) = 120900\left[{RON}/{year}\right], \tag{4}$$

where: S_j – represent annual series o the part „j” [piece/year]; n_{tij} – manufacturing time of the part „j” to the process „i” [min/piece]; s_{tij} – the basic wage of the worker which realize the process „i” to the part „j”[RON/hour], s_{tij} = 3,4 [RON/hour].

The fund time of the machine tool type “i” (F_{tpi}) is calculated with relation:

$$F_{tpi} = D \cdot S \cdot h - D \cdot S \cdot h \cdot 10/100 = 224.640 \text{ [min/year]}. \tag{5}$$

Modules:

1) to fitting:

$$\sum_j s_j \cdot n_{t1j} = 24000 \cdot 10 = 240000 [\text{min}/\,year]; \tag{6}$$

2) to welding:

$$\sum_j s_j n_{t2j} = 24000 \cdot 18 = 432000 [\text{min}/\,year]; \tag{7}$$

3) to testing:

$$\sum_j s_j \cdot n_{t3j} = 24000 \cdot 10.5 = 252000 [\text{min}/\,year]; \tag{8}$$

4) to bending/breaking:

$$\sum_j s_j \cdot n_{t4j} = 24000 \cdot 8 = 192000 [\text{min}/\,year]. \tag{9}$$

Supplementary benefit (profit) (SB) is calculated with relation and has the value:

$$SB = \frac{\sum_i \sum_j S_t \cdot n_{tij}}{60 \cdot F_{tm}} \cdot W\left(1-\frac{C_{1000\ pm}}{1000}\right) = 9992{,}553\ [RON\ /\,year], \tag{10}$$

where: F_{tm} – represent the fund time of annually work of one worker [hours/year]; W- the productivity of realized work [lei/year·person]; C_{1000pm} – the cost to 1000 lei of production goods realized by enterprise [RON].
Then,

$$E_{an} = EPC + BS + EENC = 220.892{,}55 \text{ [RON/year]}. \tag{11}$$

The economy on year been 104.129,934 RON, the recovery of investment is making in:

$$\frac{493.554{,}579}{220.892{,}55} = 2{,}23\ years\ . \tag{12}$$

Through subject is proposed the investment recovery in six years. Through realization of the cell the investment is recovered with 3.77 years earlier, in this way our target is satisfied, in the same time, it is obtained an supplementary economy of 832.764,973 RON.

5. CONCLUSIONS

Such a robot equipped and designed can function in closed loop with a controller and can be introduced in a flexible manufacturing cell realizing with success any technological operation. The supply, robustness, the agreeable design, the performance of the constituent elements, the originality and the relative reduced gauge of the robot, make it a redoubtable concurrent on the marker.

The term which defines best the results of the implementation of this robot in a flexible manufacturing cell is profitability.

REFERENCES

[1] Abrudan, I., Cândea, D., ş.a., *Manual de inginerie economică. Ingineria şi managementul sistemelor de producție*, Editura Dacia, Cluj-Napoca, 2002.

[2] Ispas, Vrg., Petrişor, S.M., Arghir, M., Ispas, V., *Aspects regarding the conception, modeling and implementation of an articulated robot in space with noises and vibrations*, Annual Meeting of International Association of Applied Mathematics and Mechanics, University of Bremen, Gamm 2008, Germany.

[3] Petrişor, S.M., Oțel, C.C., *Prelucrarea în sistemul flexibil de fabricație a unei familii de piulițe olandeze cu ajutorul robotului industrial TTRTR1*, Revista de Management şi Inginerie Economică, vol. 5, nr. 3(19), 2006, Editura Todesco, Cluj-Napoca.