INFLUENCE OF INJECTION PARAMETER IN THE POLYPROPYLENE DIMENSIONS AND MASS

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Abstract. *The product development of plastics injection molding has increased, giving significant importance. The purpose of this work is with Design of Experiments - DOE analyze the influence of injection parameters in the dimensions and mass of Polypropylene - PP. The DOE will help to determine the injection parameters that must be changed during the injection process of the sample that can influence this properties.*

Keywords*: Design of Experiments, Injection parameters, Polypropylene.*

1. Introduction

The injection molding of thermoplastics is the most common process by which plastics compounds are converted to useful products. (Ress, 1995)

Because of high investment in mold, injection machine, and human resources, the industries are looking for higher productivity with quality. (Beaumont, Nagel, Sherman, 2002)

*Design of Experiment*s - DOE has been a very useful tool to design and analyze industrial problems[3]. Due to the ability of this technique to derive large amounts of information on the process from minimal experimentation, the result is quality improvements, variation reduction, and lower costs. Many works with DOE have been made in injection molding, because it can help to determine the optimal conditions of the process. (Park and Ahn, 2004), (Launsby *et al*, 1999), (Viana, Kearney and Cunha, 1999)

The DOE procedure consists of: i) Planning with the definition of the problem; ii) Screening, i.e, reduction of the number of variables; iii) Optimization through the determination of the optimal values for various experimental factors and iv) Verification. (Montgomery, 1983)

The DOE approach can be divided into a full factorial experiment and a fractional factorial experiment. This work uses the DOE full factorial to determine which injection molding parameters (injection pressure, speed and temperature, injection and cooling times) influence the part mass and thickness as well the part dimensions of a Polypropylene – PP sample.

2. Experimental

This experiment used a mold ISO 294-1 of steel with two cavities and one injection machine Sandreto Micro 65. The material used is a commercial grade of Polypropylene, PP XM 6150K from Polibrasil Company.

The parameters analyzed during the injection molding were: injection pressure, temperature and speed, screw rotation and cooling time.

The Table 1 shows the maximum and minimum parameters used, and the others injection parameters such as mold temperature and clamp force were maintained constant during the test. The interactions were determined setting the maximum and minimum parameters in the software Minitab and making a $2^5 = 32$ the full factorial experiment as show the Tab. 2.

Each experimental run was repeated 3 times; i. e. the total number of runs in the experiment was 96. After the injection the samples were measured to obtain the results of the part mass and thickness as well the dimensions. With this results the software Minitab was used to compare which changes of the parameters influence this property. The experiment was constructed a 95% confidence interval.

Table 1. Parameters used.

	Injection			Screw Rotation	Cooling time
	Pressure (bar)	Speed (cm³/s)	Temperature (°C)	(rpm)	(s)
Minimum (-1)	200	38	180	90	10
Maximum (1)	800	70	210	200	20

Table 2. Parameters vs run used

Run	Injection			Screw Rotation (rmp)	Cooling Time (s)
	Pressure (bar)	Temperature (°C)	Speed (cm³/s)		
1	-1	-1	-1	-1	-1
2	1	-1	-1	-1	-1
3	-1	-1	-1	1	-1
4	1	-1	-1	1	-1
5	-1	-1	1	-1	-1
6	1	-1	1	-1	-1
7	-1	-1	1	1	-1
8	1	-1	1	1	-1
9	-1	1	-1	-1	-1
10	1	1	-1	-1	-1
11	-1	1	-1	1	-1
12	1	1	-1	1	-1
13	-1	1	1	-1	-1
14	1	1	1	-1	-1
15	-1	1	1	1	-1
16	1	1	1	1	-1
17	-1	-1	-1	-1	1
18	1	-1	-1	-1	1
19	-1	-1	-1	1	1
20	1	-1	-1	1	1
21	-1	-1	1	-1	1
22	1	-1	1	-1	1
23	-1	-1	1	1	1
24	1	-1	1	1	1
25	-1	1	-1	-1	1
26	1	1	-1	-1	1
27	-1	1	-1	1	1
28	1	1	-1	1	1
29	-1	1	1	-1	1
30	1	1	1	-1	1
31	-1	1	1	1	1
32	1	1	1	1	1

2. Results

To organize the results, the samples were divided in 3 different points as shows the Fig. 1 to facility the measured that are part A (points: A1, A2, A3) the part B (points: B1, B2, B3) and the runners of the samples.

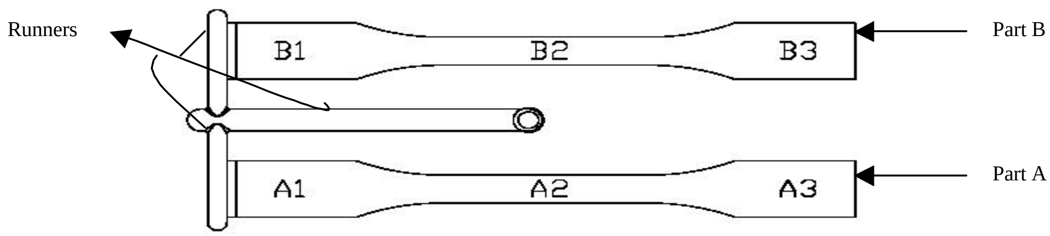

Figure 1. Points classification of the sample part A (A1, A2, A3) and part B (B1, B2, B3).

The Fig. 2 shows the means of the results of total part mass (A+B+runner), part mass A, part mass B and part mass runners.

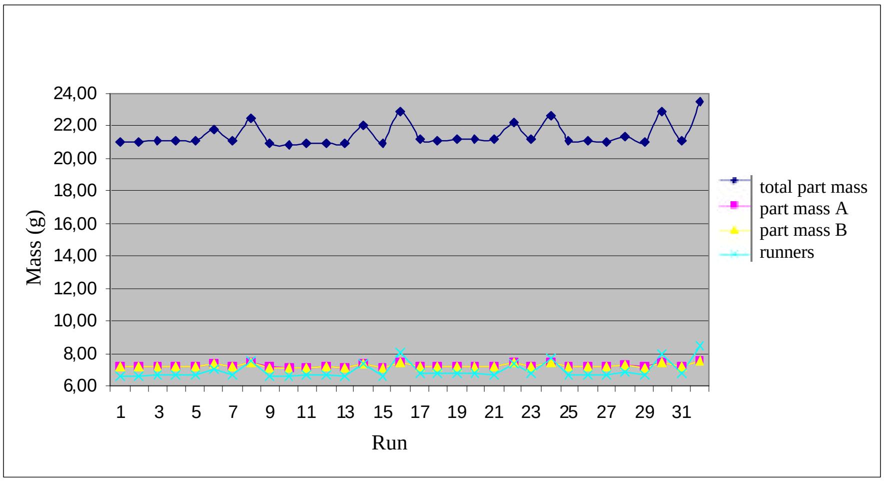

Figure 2. Analyze of mass of the sample.

The Fig. 3 shows the means of the results of large dimensional divided in 3 points for each parts, A (A1, A2, A3) and B (B1, B2 e B3).

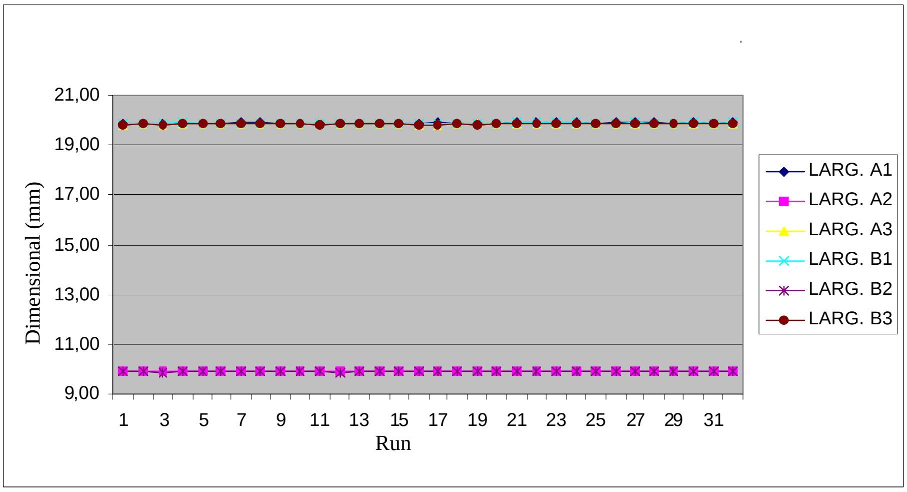

Figure 3. Analyze of dimensional of the sample

The Fig. 4 shows the means of the results of the thickness in the 6 points of the samples.

2.1. Part Mass

The Fig. 5 presents the Pareto Charts results of contribution for each selected response along the significant factors. The injection pressure and the injection speed were the main important parameters that influenced the results of the total part mass. The cooling time and screw rotation also influences.

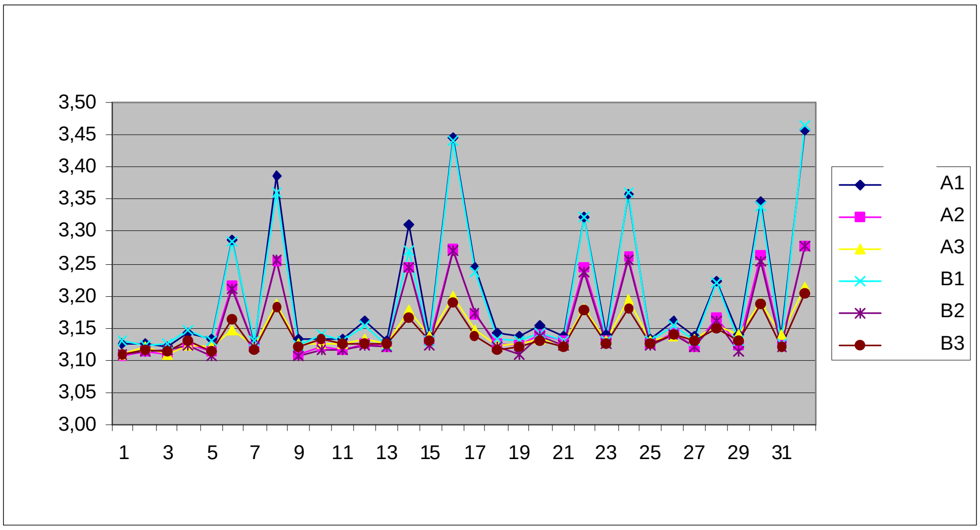

Figure 4 – Analyze of thickness of the sample

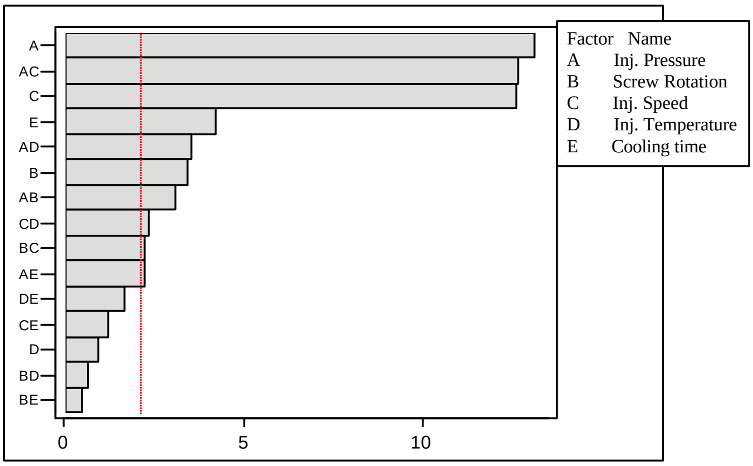

Figure 5. Pareto charts results of DOE for total mass.

In the Fig. 6 shows the influence of the machine parameters, where the injection pressure and speed were the parameters that most influenced.

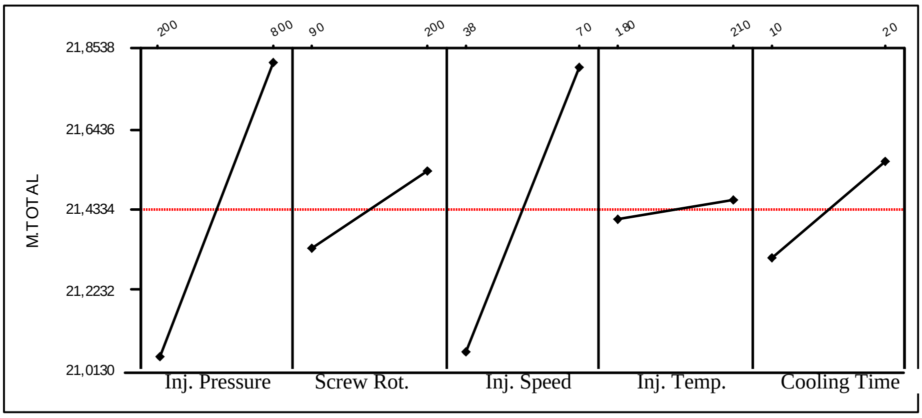

Figure 6. Effect results for the Total Mass

2.2. Part Mass A

In the Fig. 7 the parameters injection pressure and injection speed were the parameters that most influenced in the results of the part mass A. The injection temperature, cooling time and the screw rotation did have big influence.

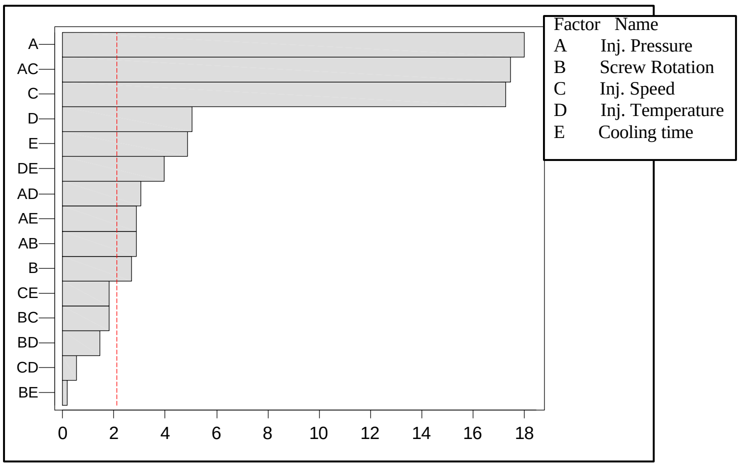

Figure 7. Pareto charts results of DOE for the sample mass A

The Fig. 8 shows the influence of the parameters in the part mass A, where the injection and pressure and speed were the parameters that most influenced the change of the part mass A

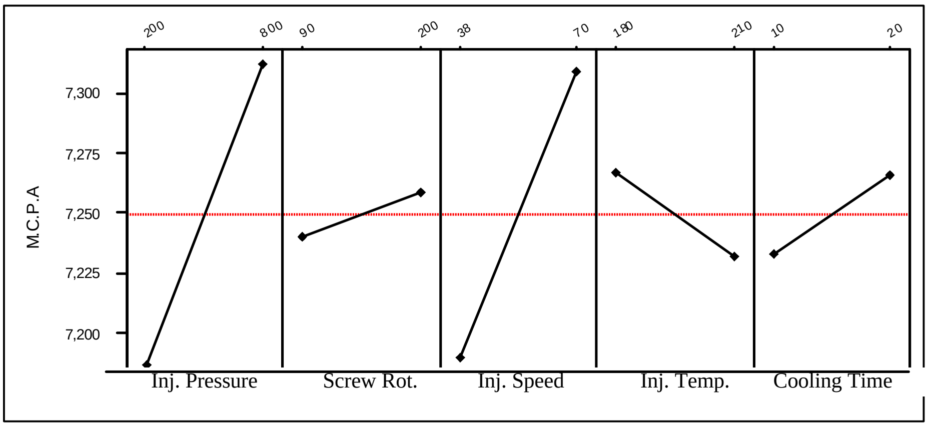

Figure 8. Effect results for the sample A mass.

2.3. Part Mass B

The Fig. 9 shows that the injection pressure and the injection speed have the bigger influence in the mass result. The injection temperature, cooling time and screw rotation does not present a significant.

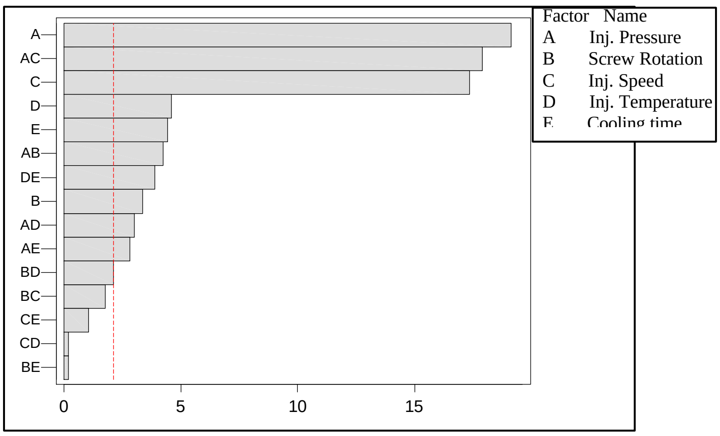

Figure 9. Pareto charts results of DOE for sample mass B.

2.4. Runners

The Fig. 10 shows that injection pressure and the injection speed were the most important parameters.

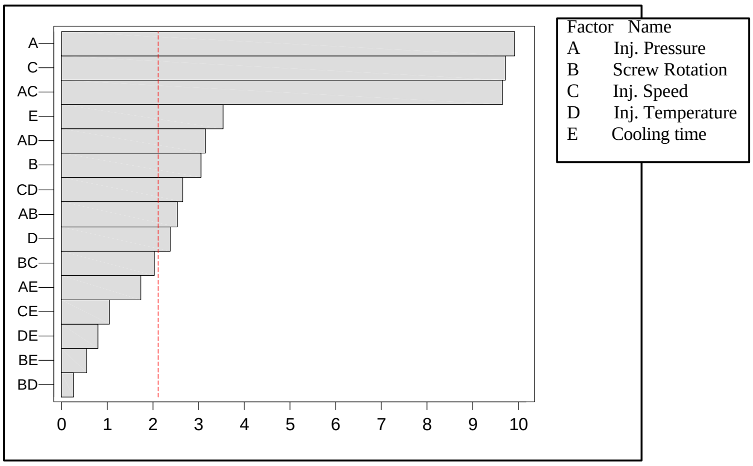

Figure 10. Pareto charts results of DOE for runner mass.

The injection pressure and speed injection compare to the other parameters has the most important influence as show the Fig. 11.

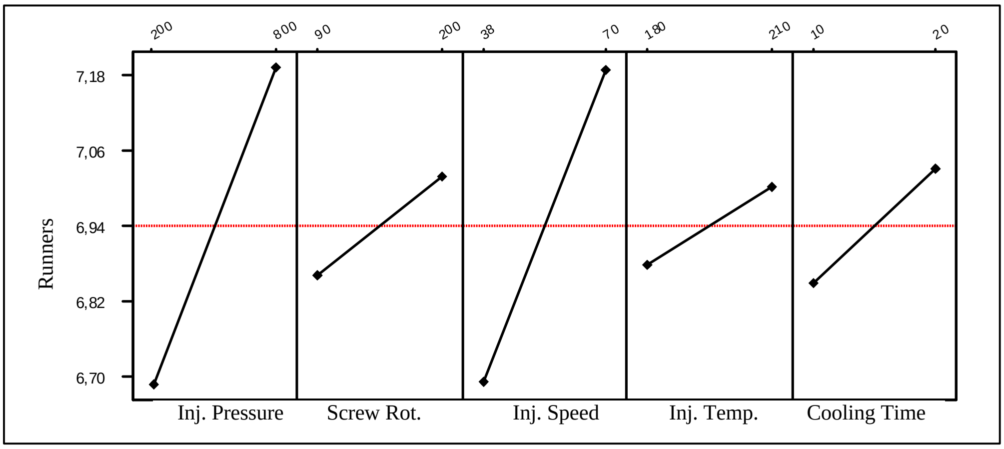

Figure 11. Effect results for the Runner Mass.

In the Tab. 3 show that the injection pressure, speed and time, screw rotation and cooling time were the parameters that influence the part mass A the part mass B and the runners mass but the injection temperature didn't influence the total mass.

Table 3. Parameters that influenced the mass.

Total Part Mass	Part Mass A	Part Mass B	Runner Mass
ECAB	ECABD	ECABD	ECABD

2.5. Dimensional

To the dimensional analyzed was just considered the large dimensional and the thickness in the same points (A1, A2, A3, B1, B2 and B3). As the example for this analyzed the point B1 it will be describe.

The Fig. 12 shows the cooling time and injection speed has the most important influence in the measure the point B1.

In the Fig. 13, we can see the speed injection and the cooling time are the parameters that most influence the point B1.

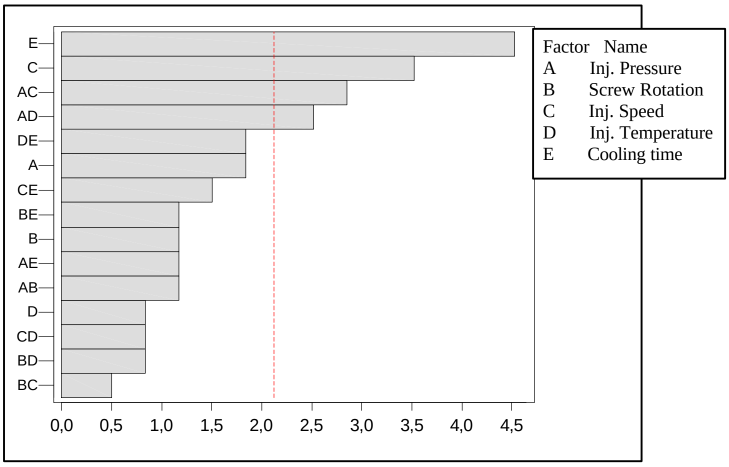

Figure 12. Pareto charts results of DOE for dimensional B1.

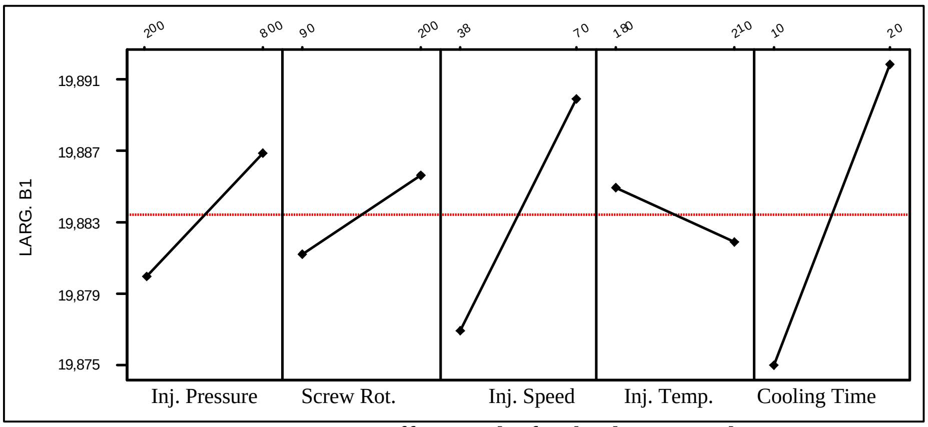

Figure 13. Effect results for the dimensional B1.

The other points B2, B3 and A1, A2 and A3 also were analyzed and the results as shows in the Tab. 4. The results point at the injection speed and the cooling time were the parameters that most influence the all dimensional point A and B. But this analyzed point at that for different points in this samples A and B, other parameters it will influence.

Table 4. Parameters that influenced the large dimensional.

Points					
B1	**B2**	**B3**	**A1**	**A2**	**A3**
EC	ECA	ECA	ECD	EC	ECA

3.6. Thickness

The Fig. 14 shows the injection pressure and the injection speed were the parameters most important that influenced the results in the point B1.

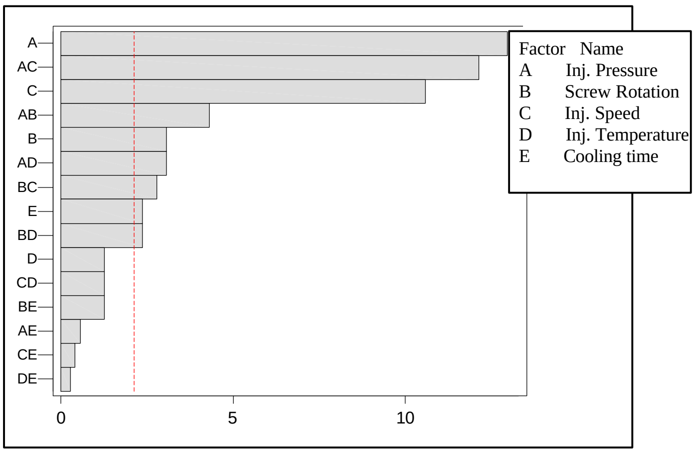

Figure 14. Pareto charts results of DOE for thickness B1.

In the Fig. 15 the influence of injection pressure and injection speed were the parameters that most influenced.

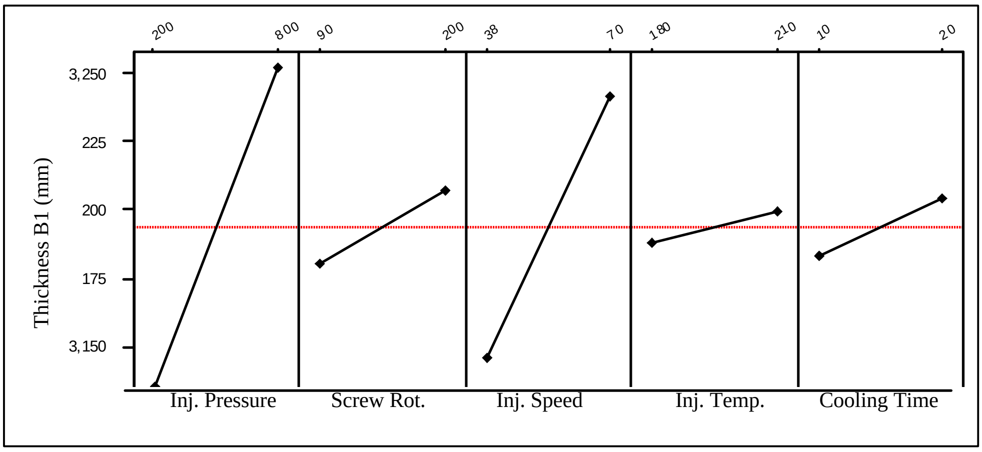

Figure 15. Effect results for the thickness B1.

The other points B2, B3 and A1, A2 and A3 also were analyzed and the results as shows in the Tab. 5. In this table, we can see the injection speed and the cooling time were the parameters that most influence the dimensional of the sample A and B. The point B1, B2 has the same influence like the points A1 and A2.

Table 5. Parameters that influenced thickness dimensional.

Points					
B1	**B2**	**B3**	**A1**	**A2**	**A3**
ECAB	ECAB	ECAD	ECAB	ECAB	ECABD

4. Conclusion

The performed tests have shown that through DOE it is possible to determine the influence of a variety of the processing parameters and their interactions in injection molding. This method can be used to increase the productivity and quality of this process.

The experiment with the full factorial experiment shows that injection pressure and the injection speed are the parameters, which most influenced in the mass and dimensional of the samples for Polypropylene – PP.

5. Acknowledgements

Instituto Superior Tupy – IST

6. References

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