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Defining the machining process for complex parts made from aluminium alloy extruded profiles by correcting raw material deviations

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Abstract. In this paper we present technical solutions to define the machining process to create good products specific for aerospace industry made of aluminium alloy extruded profile. Those parts have very tight tolerances and it is necessary to create a robust system to ensure repeatability of machining processes.
The major factor which affects our machining process is internal stress effect of the aluminium alloy extrusions. To determinate this influence were made several tests, using parts for aerospace industry, those parts were measured through coordinate measuring machine and all data was recorded for statistical analysis. Based on input data was determinate a technical solution to eliminate deviations caused by raw material internal stress for obtaining parts in tolerance.
Through several tests and recording all dimensions changes during the milling process, was obtained good products and was ensured repeatability of the machining process.

1 Introduction

The major concern for our production is to maintain the production repeatability. In aerospace industry it's not space to make mistakes for this reason we need to create a robust system to can ensure our products quality. Starting a new project on S.C. Universal Alloy Corporation Europe S.R.L. factory, were determined a machining strategy to can machine parts made from aluminium alloy extrusions. Through several tests which was measured on the coordinate measuring machine and all data was recorded for statistical analysis. Creating the Ishikava diagram was determined all factors which affect the machining process in this factory (Figure 1). The aim for this research is to track and control the extrusion internal stress using input data's to determinate the proper machining strategy [1].

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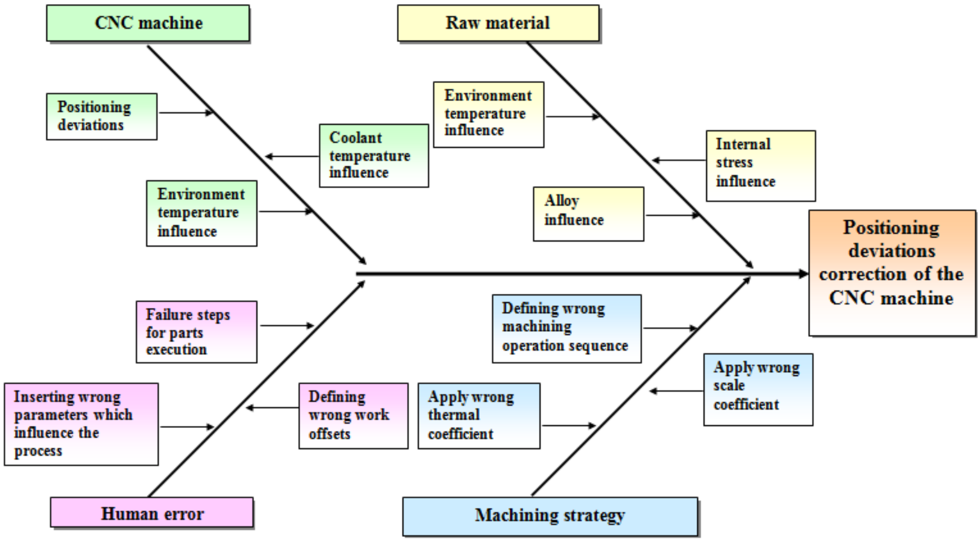

Fig. 1. Ishikawa diagram.

2 Manufacturing methodology

The machining process is performed in a normal processing unit, with climate control and the CNC (computer numerical control) machine used is Handtmann PBZ HD 600 (Figure 2). The CNC machine provides temperature compensation based on environment temperature fluctuation and also it is equipped with chiller system to maintain constant the coolant temperature [2].

Fig. 2. Handtmann PBZ HD 600.

Developing optimum machining results with best accuracy, high material removal rates with 63 kW spindle power a maximum 30000 rpm. As well as short machining times and reduced cost per part are the outcomes. The HD machine provides full 5-axis simultaneous machining [3]. All machined parts specific for aerospace industry are validated by CMM (coordinate measuring machine), placed in a room without temperature control environment.

CMM is a device for measuring the physical geometrical characteristics of an object. The typical 3 "bridge" CMM is composed of three axes, X, Y and Z [4]. These axes are orthogonal to each other in a typical three-dimensional coordinate system. Each axis has a

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scale system that indicates the location of that axis. The machine will read the input from the touch probe, as directed by the operator or programmer. The machine then uses the X, Y, Z coordinates of each of these points to determine size and position with micrometre precision typically.

The research was conducted on extruded aluminium alloys work pieces with 5600 mm length, used in aerospace industry, with a wide range of alloys and treatments. In Figure 3 is showing the test part placed inside the subassembly. With thin walls and the section represents a high resistance to shock and breakage, develop from advanced alloys tailored for specific applications to help find the right balance of strength, damage tolerance, and corrosion resistance.

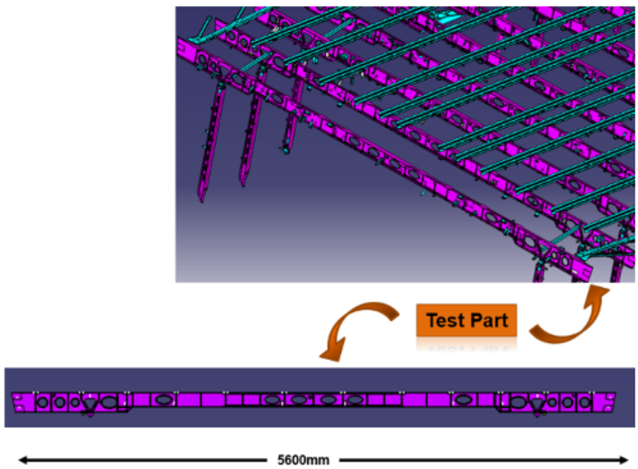

Fig. 3. Aerospace part assembled view.

The problem appears after machining process for those parts on the holes position, which have deviation out of tolerance on X-axis based on the datum reference (Figure 4). The tolerance for the all holes is ± 0.2 mm.

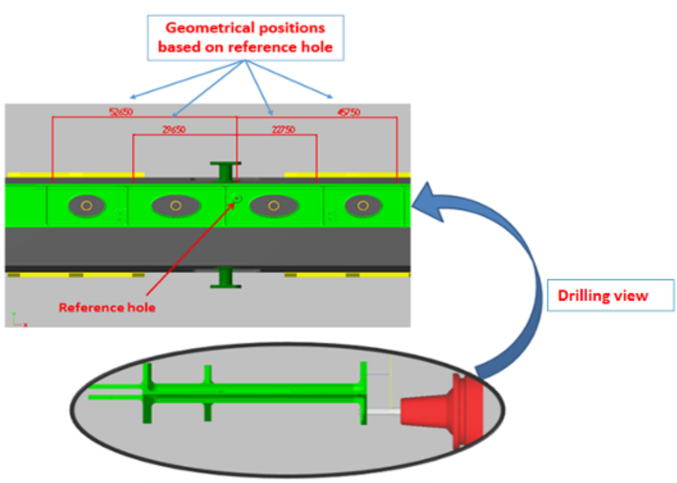

Fig. 4. Machined part view.

3 Machining results

The parts geometry is constrained by one middle hole. After machining four identical pieces, were measured in CMM. In Table 1 are represented the measurement values of the holes geometrical position based on reference hole.

Table 1. First four identical parts machined results.

Hole position on X-axis [mm]	P1	P2	P3	P4
-2316.7	-0.157	-0.275	-0.302	-0.277
-2162.5	-0.190	-0.255	-0.292	-0.265
-1991.5	-0.139	-0.244	-0.280	-0.255
-1727.5	-0.125	-0.196	-0.224	-0.233
-1585.0	-0.114	-0.173	-0.202	-0.208
-1503.7	-0.096	-0.163	-0.201	-0.200
-1261.5	-0.077	-0.137	-0.185	-0.169
-787.5	-0.058	-0.081	-0.111	-0.092
-457.5	-0.024	-0.040	-0.066	-0.048
-227.5	0.007	-0.009	-0.018	-0.023
296.5	-0.093	-0.066	-0.056	-0.067
526.5	-0.121	-0.097	-0.084	-0.104
856.5	-0.143	-0.131	-0.116	-0.136
1330.5	-0.239	-0.193	-0.172	-0.199
1572.7	-0.213	-0.235	-0.205	-0.211
1654.0	-0.220	-0.237	-0.219	-0.226
1796.5	-0.287	-0.258	-0.246	-0.248
2060.5	-0.306	-0.283	-0.282	-0.286
2231.5	-0.327	-0.303	-0.296	-0.309
2385.7	-0.354	-0.330	-0.314	-0.302

By analysing the results it is visible a material contraction to the middle of the part. The maximum deviation value which is on the ends of the part is -0.354 mm, on chart analysing is visible a polynomial growth (Figure 5).

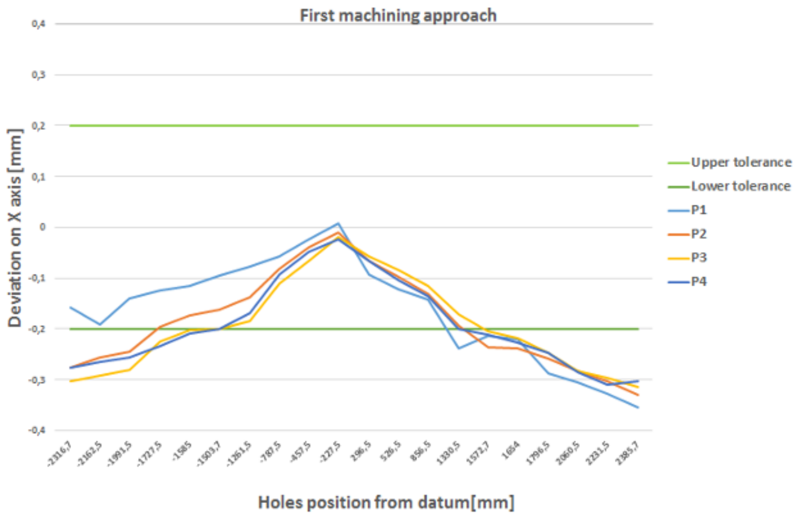

Fig. 5. First four identical parts machined results.

It is visible the final part contraction at both ends. Through elimination of other factors from Ishikava diagram, which can influence the holes position, was determinate the root cause to by internal stress (Figure 6).

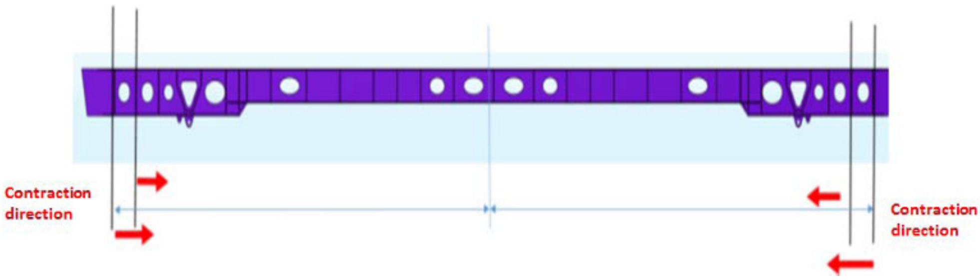

Fig. 6. Part contraction.

The solution for this issue is to eliminate the material stress before drilling operation, that means is to release the part to be on the free state from the clamping device and clamped again after that. Using this approach was made other four identical pieces. In Table 2 are represented the measurement values of the holes position based on the reference hole.

Table 2. Second four identical parts machined results.

Hole position on X-axis [mm]	P5	P6	P7	P8
-2316.7	0.006	0.008	0.022	0.007
-2162.5	0.013	0.008	0.002	-0.009
-1991.5	0.011	-0.001	-0.018	-0.017
-1727.5	0.093	0.004	-0.021	-0.021
-1585.0	0.004	-0.001	-0.023	-0.018
-1503.7	0.001	-0.003	-0.021	-0.026
-1261.5	0.032	-0.014	-0.021	-0.027
-787.5	0.032	0.006	-0.015	-0.020
-457.5	0.032	0.035	0.004	0.009
-227.5	0.033	0.045	0.010	0.017
296.5	-0.060	-0.054	-0.033	-0.032
526.5	-0.078	-0.057	-0.040	-0.037
856.5	-0.082	-0.054	-0.029	-0.030
1330.5	-0.074	-0.035	-0.028	-0.026
1572.7	-0.088	-0.046	-0.034	-0.045
1654.0	-0.084	-0.047	-0.037	-0.044
1796.5	-0.09	-0.054	-0.039	-0.042
2060.5	-0.087	-0.066	-0.030	-0.034
2231.5	-0.084	-0.057	-0.015	-0.022
2385.7	-0.085	-0.069	-0.007	-0.020

It is visible an improvement on the holes positions. If the internal stress from extrusion is eliminated by releasing the part, the holes are in tolerance (Figure 7).

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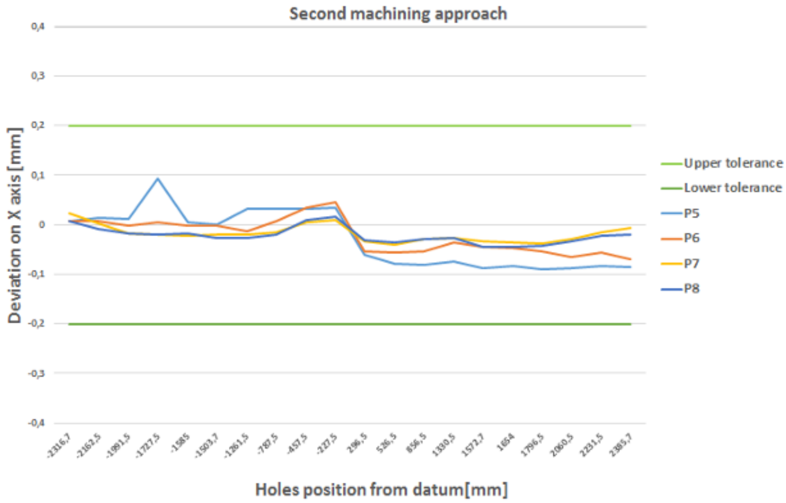

Fig. 7. Second four identical parts machined results.

4 Conclusions

This experimental research bring a solution using a simple procedure by releasing the part to be on free state before drilling operation, through this was eliminated the deviations created by internal stress of the extruded profiles. This methodology improves the machining process control and creates a manufacturing repeatability.

Future improvement which creates better precision on the final part will be to apply a temperature coefficient to eliminate the environment temperature fluctuation [5].

The original contribution for this research is: creating a solution to solve the deviations problem.

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