Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
3rd DAAAM-ICAT

SELECTIVE LASER SINTERING OF COMPOSITE MATERIALS TECHNOLOGIES

KRZNAR, M[atic] & DOLINSEK, S[lavko]

Abstract: *During the last years, a lot of different machines for additive technologies processes have emerged on the market; there has been a great progress in development of new materials. For each type of additive technologies it is now possible to use more different materials which lead to the fact that machines for this type of technology are becoming more and more universal. In our research, we used a composite material that is still in a testing phase. It is necessary to conduct analyses of this material, which are important for a customer, from the strength of a material to its hardness. It is also necessary to determine a right shrinkage of the material.*
Key words: *additive technologies, selective laser sintering, composite materials*

1. INTRODUCTION

From a viewpoint of a state of matter, selective laser sintering technology belongs to powdering procedures, while from a viewpoint of additive manufacturing; it belongs to selective sintering processes. In selective laser sintering technology, fine granular powders are used that later form a model with the help of a laser. A selection of materials for selective laser sintering technology is rather wide. A local melting and coagulation method enables us usage of many materials. These are polyamide; polyamide, fulled with glass; elastomers; polisterin as well as other polymers. A material for selective laser sintering is in a form of a powder and is sticked together with the help of CO2 laser energy, so that at the end it forms a model.

Selecting a right powdering material is the most important factor in selective laser sintering technology. It is necessary to know whether a product or a prototype is designed for functionality testing or only for visual control. If SLS process for functional prototyping is used, then it is important to produce samples of quality external look as well as products with good mechanical properties. External look of a product is mainly defined by a dimensional precision and roughness of a surface, while mechanical properties are defined by tensile strength, surface hardness and density. In our centre, we currently use two materials: polyamide 12 and polyamide 12, filled with 30% of glass balls (Dolinsek 2007).

2. COMPOSITE MATERIAL SINTERING

We made experiments on the above mentioned machine for selective laser sintering EOSTIN P385 of a German manufacturer EOS GmbH, where a broad spectrum of powder materials can be used (***,2010). The majority of materials are based on a polyamide, but also some other material can be added, for example glass balls, aluminium or carbon powder. At the market for this machine, there is no polyamide powder to which ceramic powder would be added yet (EOS, 2008).

For the investigation we used test specimens (Figure 1). Based on these, we have determined optimal manufacturing parameters when conducting research. A shape of the cross is such that by already a minimal deviation of parameters from their optimal value deformations occur (Picture 2) and because of this also some minor problems in the future when products are being manufactured.

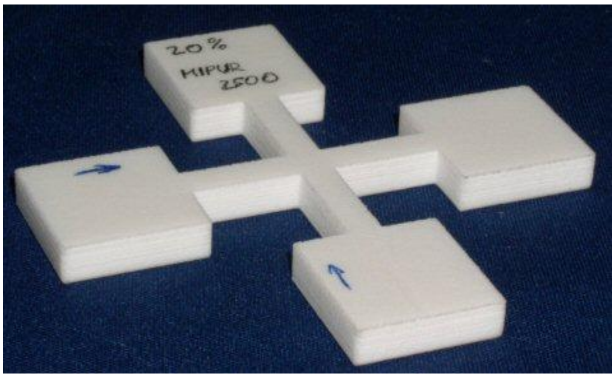

Fig. 1. Test specimen

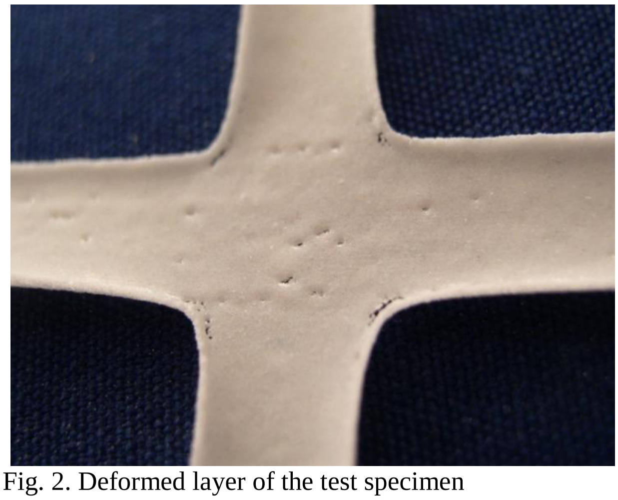
Fig. 2. Deformed layer of the test specimen

A very important thing that caused many problems at the beginning was humidity of a powder. A ceramic powder has a great hygroscopicity, so that at the beginning we did not even notice, that humidity content in the powder was too big. In the following experiments, we dried every lot of ceramics in a drying chamber prior to preparing a mixture. A ceramic powder was being dried for four hours at 80°C in a drying chamber.

3. RESULTS OF ROUGHNESS MEASURING

On an EOSINT P385 machine for selective laser sintering of polymers we made test specimens on which measurements of roughness have been conducted. Pieces were made from a composite material as well as from materials that are being used in out centre from the very beginning. In the following, tables of measurements with average roughnesses and diagrams of measurements are presented.

	X direction	Y direction	Z direction
Ra average [μm]	8.042	8.146	12.555
Deviation σ	0.338	0.440	0.469

Tab. 1. Results of measurements for material PA 2200

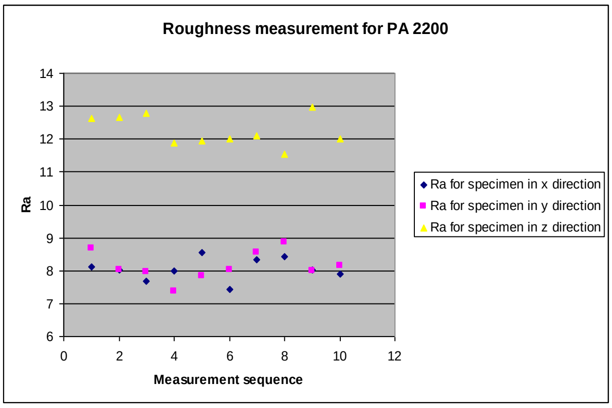

Fig. 3. Roughness distribution for all three directions

	X direction	Y direction	Z direction
Ra average [μm]	9.439	9.476	19.461
Deviation σ	0.392	0.509	0.664

Tab. 2. Results of measurements for material PA 3200GF

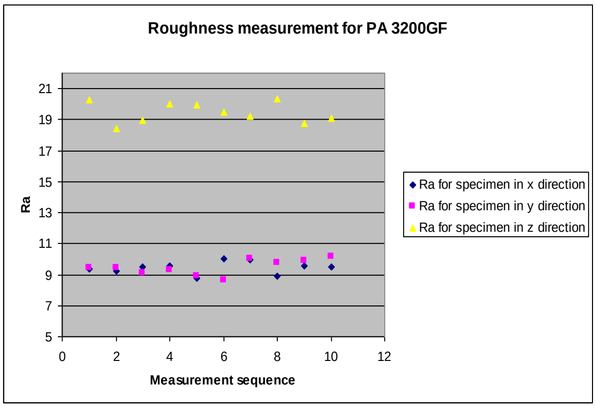

Fig. 4. Roughness distribution for all three directions

	X direction	Y direction	Z direction
Ra average [μm]	6.678	6.600	11.140
Deviation σ	0.371	0.372	0.420

Tab. 3. Results of measurements for material PA 2200 (20 % ceramic powder)

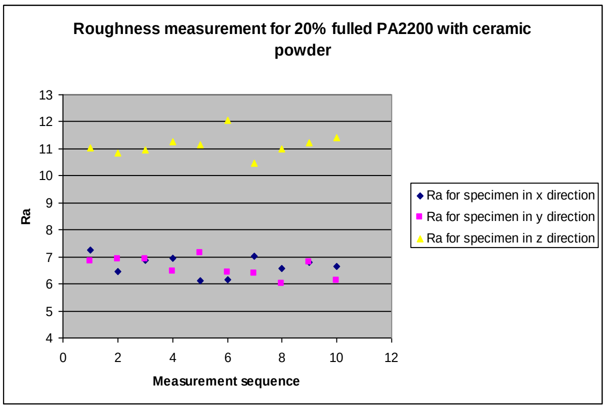

Fig. 5. Roughness distribution for all three directions

Results show that deviations between measurements of a particular material are rather small in directions x and y. Since selective laser sintering is an additive technology with, we had planned already prior to testing greater deviation in direction z, and was later shown also on results. In PA 3200GF material that is fulled with 30% glass balls, visible deviations occur in roughness measurements of all directions in comparison with all other tested materials. Also, a new composite material is fulled with 20% of ceramic powder, yet deviations do not occur.

On the contrary, roughness of sinters with fulled material with ceramic powder is still a little smaller than in the PA 2200 material. Of course this refers to average measurement values; however, this is a very encouraging result, since smoothness of a surface is very important for subsequent use and refinement of prototypes and products.

Much more interesting information for a customer is whether we can manufacture products of the same roughness all the time. This is shown by a measurement scatter. Scatter or standard deviation (statistically considered) is in a theory defined as a concentration of statistical units around an average value. In our case, we could define scatter by ''homogeneity'' of manufacturing, under presupposition of measurements being totally accurate.

By smaller deviation of measurements among themselves, there is greater accuracy and scatter is smaller. In an ideal case, a standard deviation would be null. That would mean that all measurements are the same, and from this it further follows that by using this machine, products of completely same roughness for a particular material can be manufactured.

In our case, no greater scatter of measurements has occurred. The lowest result of deviation occurred exactly in products that were made with a polyamide powder, to which 20% mass fraction of ceramic powder was added. A result shows that by using this material we can sinter products of roughly the same roughness which is very important for a supplier of services, since it can guarantee a specific roughness with a minimal deviation to a customer.

5. CONCLUSION

Selective laser sintering is one of additive technologies, where a user can offer to his customer functional products with good mechanical properties, yet sometimes this is not enough for a customer to decide for such manufacturing technology. Surface quality of products, made by laser sintering technology, is currently the biggest insufficiency in comparison to other additive technologies.Further research on selective laser sintering of composite materials is still needed.

In this way, better results regarding surface quality can be achieved, yet for this purpose close cooperation with machine manufacturers is needed, since only they know in detail background of a machine and its equipment. Our research has proved that by using addiive technologies, products can be produced from any type of material that is available on the market in a powder form, and also that powder particles sinter (stick together) by adding energy.

6. REFERENCES

Dolinšek S., Kert R., Krznar M. (2007), Direct production of final products with laser sintering of polimers, IRT 3000, Vol 2, No. 11, pp. 46-49

*** (2010), http//www.eos.info – EOS Manufacturing Solutions, Accessed on: 2010-06-10

EOS (2008), Basic Training for EOSINT P385 V3.2