Direct Metal Laser Sintering Technology Applications on Conformal Cooling System Development

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Introduction of Direct Metal Laser Sintering (DMLS) Technology

With increasing product complexity but shorter development time, how to improve mold cooling efficiency to reduce cycle time has been an important issue in injection molding process. One crucial factor to reduce cooling time is a high efficiency cooling channel design. And conformal cooling is the solution. In addition, conformal cooling is also helpful in improving some product defects such as sink mark and warpage. By using some non-conventional methods such as laser sintering, cooling channels can get closer to the cavity surface than using traditional method. This resolves local heat accumulation problems and provides a more efficient cooling channel. Manufactured by EOS GmbH, the direct metal laser sintering (DMLS) machine can be utilized to compensate the insufficiency of traditional CNC and EDM tooling method. It can easily manufacture cooling channels with any geometry.

Cooling efficiency comparison - conformal cooling channel vs. conventional cooling channel

The geometry of a conformal cooling channel is more complex than a conventional cooling channel. Thus, it is more difficult to manufacture through traditional tooling method. However, by using non-traditional manufacturing method such as DMLS, cooling system layout is not restricted. Conformal cooling channel offers a better cooling efficiency to lower the cycle time. In addition, due to the lower mold temperature difference, some product defects such as warpage and sink mark can be avoided. Product quality is thus improved effectively.

EOSINT M series is the DMLS equipment manufactured by EOS GmbH. The procedures of laser sintering start from melting metal powder by laser beams. Follow by that is a layer-by-layer additive forming step. At the end, the sintered part will be harden and milled to the final tool insert. The metal powder developed by EOS can be fully reused. And there are several options of the powder for each specific use.

As to cooling channel design, there are many research works related to optimization theory. Basically, cooling channel should be as close to the cavity as possible; however, mold strength is a great concern. There exist some experimental rules for cooling channel design. Figure 1 shows the relation among the three important design parameters.

Figure 2 shows a case from PEP. A conventional and a conformal cooling channel were compared with a 20 ℃ mold temperature drop and 20 seconds cycle time reduction. The product in Figure 3 is a give-away golf ball. It needs to be produced in large quantity (20 millions) with a low cost. Through DMLS tooling method, this four cavity tool took only 50 hours to build up while the productivity increased 20%.

Moldex3D Molding Simulation on Conformal Cooling Channel Design Validation

DMLS is only a technique in manufacturing conformal cooling channels. The cooling system design itself is the crucial factor for success. But how can we validate the design? Molding simulators such as Moldex3D can help with an efficient and economic way. Through molding simulations, we can quickly understand the effects of cooling systems on cycle time and product quality. The simulation results provide useful indices for cooling system re-design. Using this kind of computer-assisted mold trial method can save mold development cost most effectively.

Figure 4 is a children cup case provided by EOS GmbH. In this case, a conventional baffle design was compared with a conformal cooling design (as shown in Figure 5).

Through Moldex3D simulation (Figure 6), we can see the mold temperature distribution range drops from 79~91℃ (conventional) to 79~84℃(conformal). Since conformal cooling design keeps the same distance between cooling channel surface and cavity surface, the cooling rate differences at the part surface can be much smaller than a baffle design. Also, the heat spot can be relief further. According to the data from EOS, cycle time can be reduced by 42% if conformal cooling design was applied.

Conclusion

The concept of conformal cooling is getting popular nowadays since its effect is significant. DMLS method can compensates the insufficiency of traditional CNC and EDM tooling method and manufacture complex cooling channels which traditional tooling method cannot reach.

Through molding simulators such as Moldex3D can effectively reduce actual mold trial times. It provides a quick tool for design validation in purposes of design optimization and cost reduction.

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References

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Keyword: DMLS, conformal cooling, injection molding.

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Wall thickness of molded product (in mm)	Hole diameter (in mm) b	Centerline distance between holes a	Distance between center of holes and cavity c
0 - 2	4 - 8	2 - 3 x b	1.5 - 2 x b
2 - 4	8 - 12	2 - 3 x b	1.5 - 2 x b
4 - 6	12 - 14	2 - 3 x b	1.5 - 2 x b

Figure 1 Conformal cooling design rules

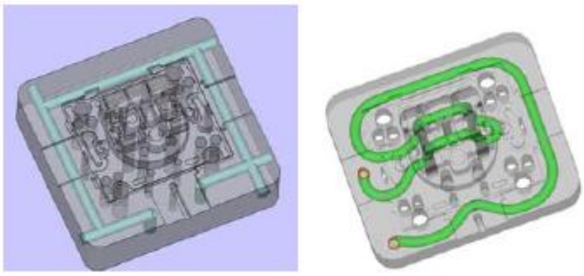
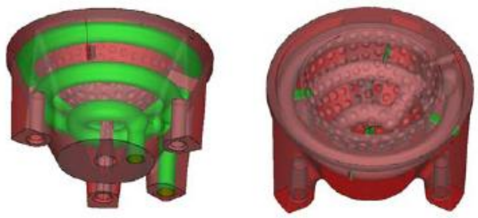


Figure 2 PEP case: conventional cooling design (left) and conformal cooling design (right)



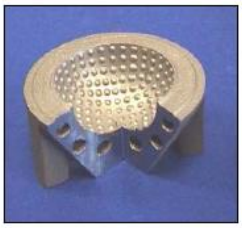


Figure 3 Golf ball mold insert with a conformal cooling channel design

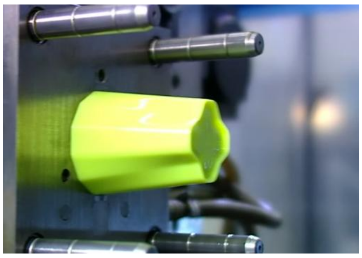
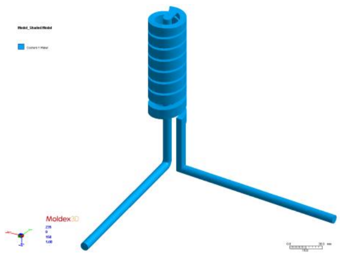


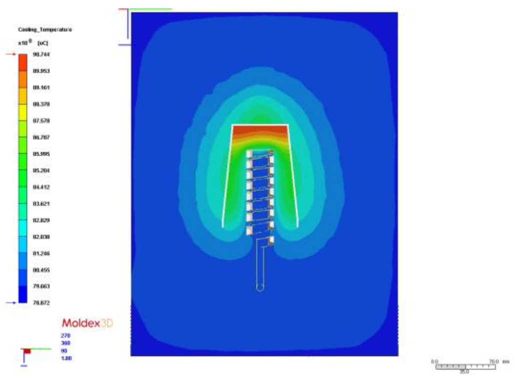
Figure 4 EOS children cup case



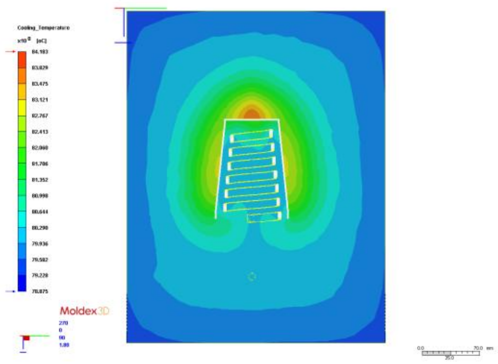
(A)

(B)

Figure 5 Baffle design (A) and conformal cooling design (B)



(A)



(B)

Figure 6 Mold temperature distributions at the end of cooling (A) baffle design (B) conformal design