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A review: Challenges stand off for tooling material in AM field

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Abstract: *Direct metal laser sintering (DMLS) is one part of additive manufacturing (AM) emerges as rapid prototyping (RP)technique and it is making three dimensional product or parts directly from computer aided data (CAD) without intervening of tooling or human effort. Cl50WS material is hot tool steel material which widely accepted in additive manufacturing field. Nowadays, conventional cooling in die and mould manufacture have been shifted to new developing technique conformal cooling. Cooling is provided in die or mould by drilling in conventional method which provides uneven cooling, but now conformal cooling provide uniform cooling in cavities of die or mould. Die and mould has own special characteristic like high mechanical properties, wear resistance, dimensional accuracy and good surface finish. These characteristic can be fulfill when die and mould would be made by selection of proper parameter of machine. Hence, it is very essential to conducted optimization of DMLS machine for CL50WS material.*

I. INTRODUCTION

Direct metal laser sintering (DMLS) technology also called as layer based technology because of these technology are making parts with layer by layer. Nowdays, trend has been shifted from conventional and non conventional to direct metal AM to improve process parameter. Direct metal AM is one application for making metal parts form CAD, where using of conformal cooling in metal parts. The design phase of mould and die as well as manufacturing of mould and die plays major role in any production sector. Nowadays, Selective laser sintering (SLS)/ Selective laser melting (SLM) is widely accepted by industries for their unique capabilities to produce direct parts from a CAD file. DMLS is emerging technology amongst various Rapid prototyping (RP) methods. It is used to produce metal parts which are used as functional unit, end user application or tooling purpose. It is the fastest growing technology for direct production of metal parts or tool from computer aided data (CAD) (Jae-Ho Lee, 2009). The final qualities of product are being affected by quality of die or moulds. For any production of industrial goods, it requires several parts which can be assembled together and make the final product for customer. Dies and moulds are used for mass production of discrete parts that are used in processes such as casting, forging, injection moulding and stamping, like moulds used for injection moulding, or die used in precision parts of automotive components (Taylan Altan et al.). High carbon percentage in intermediate to high carbon steels are responsible for corrosion and cracking which results in unexpected or undesirable failure of parts. CL50WS material offers an attractive alternative, as it is not suffering from corrosion or cracking problem as it possess high nickel content and less carbon content, which provides good corrosion resistance and wear resistance (Yasa E. et al.,2010). The chemical composition of CL50WS material is very close to maragingsteel 18Ni300.

II. LITERATURE

G. Casalino et al., (2015) have shown that the energy density ranges from 1.29 J/mm2 low level to 2.78 J/mm2 high level while the surface roughness decreases from 22 µm to 15µm. They have suggested that good surface finish achieved at a high laser power and a low scanning speed because of it produced a high-energy density, which resulted in an effective melting of the particles. J .A.M. Ferrira et al., (2016) have revealed that porosities of part's increase with increasing scan speed (400 or 600 mm/s) which exert a worse effect on mechanical properties of maraging steel. Naiju C D et al., (2017) have been carried out experiment through varying effect of load (20 to 80 N), temperature (35 to 150 ^{o}C) and hardness (0.5 to 1.5mm) on the reciprocating wear testing of DMD components under lubricated condition. The load is main responsible parameter for wear rate for maraging material during DMD process. C. Sanz et al., (2013) have characterized the various material of Maraging Steel, Inconel 718 and Co Cr alloy by different thermal and finishing (shot peening and surface polishing) treatments. It has been seen that hardness of specimen increase in core of the specimen after heat treated. The non heat treated samples have a mean hardness of 410 HV10, which increases up to 450 HV10 after the heat treatment at 650◦C, and up to 500-510 HV10 for heat treatments at 850◦C and 1000◦C, respectively. In case of heat treatment process, high thermal gradient in cooling provides maximum hardness in parts. Similar work has studied by Snehashis Pal et al., (2016). Nan Kang Pierre et al., (2016) showed that maximum wear resistance of parts up to laser power of 210W and micro hardness also increase up to this value of laser power. They also present the lowest wear rate (7.0×10-4 mm3 N-1 m-1) among all SLM processed sample at this

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laser power. Naiju C D. et al., (2017) have varied coating thickness, applied load and temperature for wear rate. They showed that as the load increases the coefficient of friction decreases. G. Casalino et al., (2015) explored study to varying effect of laser power (57W, 86W, 100W) and scan speed (180mm/s, 200mm/s, 220 mm/s) on relative density. The laser power bigger than 90W and the velocity smaller than 220 mm/s gives more relative density. E. Yasa et al., carried out experiement to determined effect of building axis as well as of various heat treatments on titanium alloy Ti-6Al-4V, stainless steel 316L and maraging steel 300 matrial. They have revealed that building axis does not effect on mechanical properties if connection between two successive layer is in proper way. The strength of Impact test is decrease in case of heat treated specimen.
From the past literature, it can be seen that very limited work has been explored on tooling material. All these research related to surface roughness, wear rate and effect of process parameters on characteristic. But their research doesnot included comprehensive full study on specific material. Most of research has been addressed for maraging steel 18 Ni 300 which is one tooling material. However, very limited work has been studied for tool material CL50WS which is developed by concept laser company for tooling industries.

III. FUTURE RESEARCH DIRECTION

1. Part quality of DMLS
   Several researches has been done on several material for part quality of DMLS made part. However, part quality of die and mould is very significant for those parts which are molded by same die and mould. There is still lacking of research for tooling material. research toward tooling material may be worshiped for those industries whose are using AM technique for making die and mould with conformal cooling.
2. Optimization of parameter
   Several parameters have been affect the mechanical properties and other aspect like surface roughness, wear rate and metallurgical aspect. These parameters have been discussed for various material by several researcher because of it was very essential to discussed and set that parameter where desired characteristic can be meet. Similarly, process parameters may affect the mentioned aspect for tool material CL50WS which area is still not addressed. Thus, It can motivated to conducted research in that direction.
3. Thermal modeling of DMLS
   Very limited research conducted in direction of thermal modeling and provide very less information of prediction of thermal stress and temperature distribution in real application of of die and mould. Thus, in this direction research can be explored to provide useful information for reduced thermal stress and give systemic way to provide even temperature distribution on powder bed of machine.
4. Metallurgical characteristic
   Density and porosity of parts are directly affect the mechanical properties as well as wear resistance, and higher mechanical properties and wear resistance are very essential for die and mould. Thus, in this direction, research can be carried out on tool material are very fruitfull for tooling industries.

IV. CONCLUSION

From literature review, it can be seen that several research have been done on various material like titanium, aluminum, stainless-steel and nickel base alloy which are including category of aerospace, automobile and biomedical. but, it can be seen from past literature that very limited work has been carried out on tooling material. Hot tool steel CL50WS material is belongs to category of tooling material CL50WS widely used in tool application like tool insert, die, mould and other tooling application. Many tool insert or die and mould making industries use AM technology for conformal cooling which increase efficiency of production. However, from past literature, it can be said that research has not been done on hot tool steel material. Hence, it is very essential to explore research on hot tool steel material CL50WS material. Die and mould manufactures does not know the proper selection of process parameters of AM machine, hence some of mechanical properties of parts and part quality of parts have been poor which affects the life of die and mould. Thus, it is essential to set process parameter where mechanical properties and quality of parts are get to achieve higher.

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