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ADDITIVE MANUFACTURING OF SAND CORE BY USING CO_2 GAS

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ABSTRACT

Additive manufacturing is the rapidly emerging field or technology in today's world. It works on the principle of addition of material layer by layer to make 3D object. This paper presents the methodology to make CO_2 coresby using combine approach of conventional CO_2 moulding process and 3D printing method. It uses silica sand (raw material), sodium silicate (hardener) and CO_2 gas (curing gas) in appropriate proportion to make cores. CO_2 cores most preferred cores in the foundry. This methodology involves the spreading of silica sand and sodium silicate mixture layer by layer and then passing of controlled CO_2 gas over the layer as per cad data. CO_2 gas cures the mixture within 20 to 40 seconds depending on the size of cores. This methodology overcomes the limitations experienced by traditional approach in making of cores and mould box by using patterns and core box such as draft angle.It has proven that more complex core and mould box can easily print by Three d printing.

Keywords: CO_2 moulding process,Parametric Optimization of Carbon - Dioxide Moulding Process,Rapid manufacturing, three dimensional sand printing, Rapid castings.

I. INTRODUCTION

Additive manufacturing [1] is a process of adding material layer by layer to form final object. Innovations are going on in 3D printing by using different raw materials, hardeners and binders to make 3D object athigh accuracy and low cost.The concept of Three D sand printing is developed from the Selective laser sintering printing process [5] and traditional method of CO_2moulding [2]. The core difference in Three D Sand printing, which makes it different from other manufacturing processes, is its printing process. It works on the same principle as SLS but the difference is it uses CO_2gas jet as a binderinstead of laser. Outcome of this process is sand cores and mould box, used in foundry to make castings.

Foundry uses pattern to make mould box and cores are produced from core box [6][8]. Making of pattern and core box is costly and time consuming. There are limitations in the designing of patterns and core boxes. CO_2 moulding process is used in the foundry since long time to make cores [2]. Methodology mention in this paper uses CO_2 moulding process to 3D print the cores. Proposed method in this paper doesn't use patterns and core box to make sand core and mould box, so the related limitations also eliminated. Proposed method gives freedom to the designer to design the cores and mould box as per requirement. The CO_2 cores mostly preferred to make large castings for the aerospace industries, automotive industries and heavy equipment and in the

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research and development fields. Three D sand printings by CO2 gas have following advantages over traditional CO_2 moulding process are:It Eliminates many manufacturing steps such as materials-machine planning, man-machine interaction, intermittent quality checks, assembly and related human errors etc., reduced production time, better process control, incorporating the changes instantly, no need of extra support to produce overhanging shapes, complex part can produce easily [11], pattern less process offers design freedom, improved efficiency and eliminates storage.

II.METHODOLOGY

This technique takes a CAD file of the part as input and prints it into 3D Part.It works on the principle of depositing a first layer of mixture of silica sand [7] and sodium silicate [9], on the print bed and then depositing CO_2 gasas binder material to the selected regions as per cad data on the layer of mixture to produce a layer of bonded sand material at the selected regions. Such steps are repeated a selected number of times to produce successive layers of selected regions of bonded sand material so as to form the sand cores. The unbounded sand material is then removed. In some cases the component may be further processed as, for example, by heating it to further strengthen the bonding thereof [1] [5].

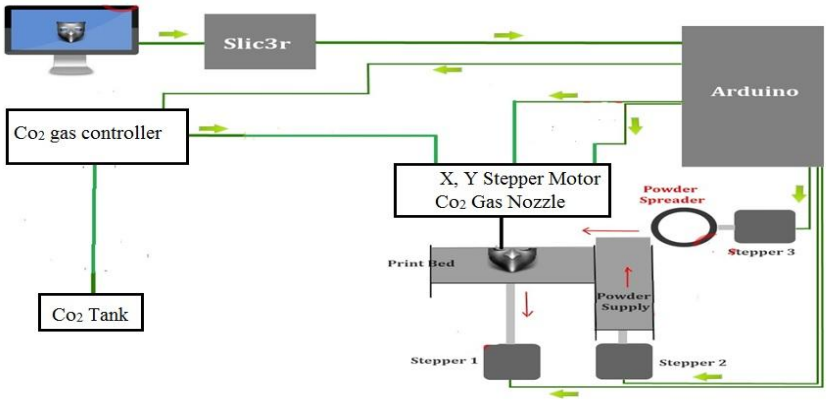

Fig1.Three Dimensional CO_2 sand core making process.

Dr. M.VenkataRamana, in his journal ofmodelling of CO_2 moulding process[2] and Parametric Optimization of Carbon - Dioxide Moulding Process for Maximum Mould Hardness [3], describes the complete CO_2 moulding process and parametric optimization of process. The chemical reaction between silica sand, sodium silicate and CO_2 process is shown at equation 1. The sand mixture used in this process is pure silica and sodium silicate. The molding mixture thus obtained is gassed with carbon dioxide (CO_2). The molding mixture gets hardened due to the formation of silica gel. And finally mold box or core is form [2].

$$Na_2\ Si_2\ O_5\ .H_20\ _{(l)} + CO_{2\ (g)} = Na_2CO_3.\ H_20 + SiO_{2\ (gel)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Properties of silicates vary according to the silica (SiO_2)-soda (NaO) ratio of the sodium silicate base that is used to formulate the binder. Considerable care must be used when gassing with CO_2 since overgassing and undergassing adversely affect the properties of the cured binding system [4]. The amount of silicate binder used

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for cores and molds varies from 3% to 6%, depending on the type of sand, grain fineness, and degree of sand contaminants [3]. CO_2 gas used to cure silicate is depending on the quantity of silicate. For maximum mould hardness CO_2 gas used should be 40 % of weight of sodium silicate [3].

CO_2 gas flow mechanism:

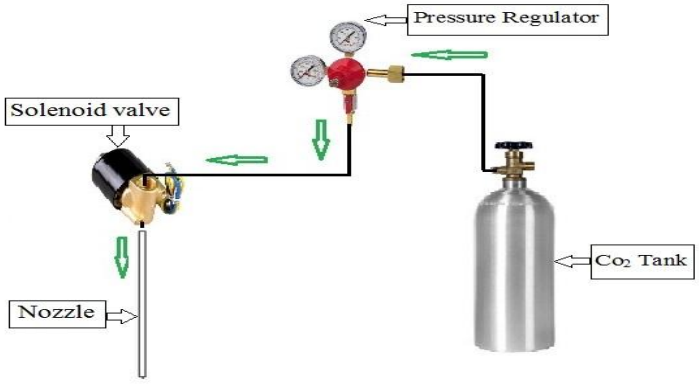

Fig2. CO_2 gas flow mechanism.

To make sand cores as per cad data, the parameters needs to control are the depth of penetration of CO_2 gas in the silica sand and sodium silicate mixture, quantity of CO_2 gas passing over the bed as per cad data and CO_2 spreading thickness. Those parameters can control by solenoid valve, to on off the flow of CO_2 gas, design of nozzle to control the flowof gas, and scanning speed.

Properties such as collapsibility, hardness, surface finishing, porosity are depends on the type of sand [7], sodium silicate and CO_2 proportions [10]. CO_2 cores are difficult to brake after solidification of metal. Collapsibility properties of CO_2 cores are poor but by adding some ash will overcome this limitation. Surface finishing by this method may be poor but can improve by post processing.

III.CONCLUSION

Three dimensional CO_2 core making process uses principle of additive manufacturing, thus the process of making cores can control more efficiently and effectively. This process gives design freedom to the designer. More complex sand cores can print easily within less time with this technology. Better control of properties of sand cores can achieve by this method. Man-machine interaction, intermittent quality check reduced thus human errors gets reduced. It gives freedom to incorporate changes instantly. Like other additive manufacturing processes, to produce overhanging shapes it doesn't require any extra support, as unbounded sand particles provides support to the bonded sand particles.

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