Introduction

In this research category, I try to analyze the process by developing an Analytical and/or Numerical Model to predict the desired output like thermal residual stresses, transient thermal stresses, etc. Also the results obtained by the Analytical/Numerical model are verified by FEM and also by the actual experimentation. In present there is great need of optimization of the process through not only design-of experimentation method but also considering the process as a thermal process and applying the entire basic fundamentals. This is because still there are some problems left out which can be only solved by analyzing the process through development of an accurate Analytical and Numerical Model which will be helpful to describe the process output with respect to the process parameters. The field of laser material processing has recently faced new directions owing to reduced cost of new laser systems as well as development in high speed computers and consequently computer aided design (CAD), laser technologies, and layered/additive manufacturing techniques. As a result, many sectors including automotive, defense and aerospace have started employing this emerging technology in different fields of welding, cutting and surface treatment. Amongst diverse applications of laser material processing techniques, Selective Laser Sintering Layer Manufacturing (SLSLM)[1, 2] utilizes the advantageous features of additive manufacturing methods and laser technology which itself has had tremendous impacts on many different fields of science and engineering within the last few decades. The common advantages and disadvantages of these techniques over the conventional methods are briefly pointed out in order to provide a basic picture of the fundamental challenges in their further developments. In the selective laser sintering manufacturing technique a pre-heated layer of material powder undergoes a laser radiation in a selective way to produce three dimensional metallic or polymeric solid parts. The phase transformation in this process involves the material heat transfer which is strongly affected by the material sintering phenomena. A transient three dimensional finite element model is developed to simulate the phase transformation during the selective laser sintering process. This model takes into account the heat transfer in the material (powder and solid), the sintering and the transient nature of this process. The numerical simulation of the set of equations, describing the problem, is made possible by means of the commercial finite element software. Layer manufacturing techniques give a physical identity to a virtual concept. Physical models, although normally not capable of functioning in their real operating conditions, can assist in refining a physical design during the development process prior to mass production. However, in today’s highly competitive and fast-changing world, emerging advanced technologies, such as LSLM, demonstrate capacities that exceed existing boundaries and barriers. Rapid manufacturing has defined a new meaning besides rapid prototyping which was fostered and
mastered over the last few decades. Rapid manufacturing has shown a wider range of applications whereby fabrication of production quality parts is also possible under rapid manufacturing protocols. This has had an influential effect on the transition from mass production to flexible low-volume-production manufacturing strategies, in which complex structures capable of functioning in a multidisciplinary environment are prevalent. LSLM as a layered/additive manufacturing technique has shown tremendous potential for these types of applications. The flexibility of LSFF and its other promising features offer solutions to limitations of comparable methods. However, despite all inherent and demonstrated advantages, like other new techniques, LSLM also has several drawbacks and consequently faces challenges in utilizing its full manufacturing potential. The main drawbacks of LSLM stem from the same sources as its advantages, the additive nature and the laser beam characteristics [9, 10]. In LSFF, besides the layer-by-layer material deposition, the process domain undergoes cyclic heating and cooling. In addition, the heat source (i.e., laser beam), which is highly concentrated and moves across the fabrication domain, develops an uneven temperature distribution throughout the structure. This process characteristic makes LSLM vulnerable to thermal stresses which are the primary source of potential delimitation and crack formation. The heat source characteristics can also play a crucial role in poor bonding and porosity. On the other hand, one of the most important criteria for rapid manufacturing is fabrication of the parts with accurate geometries and desired mechanical and metallurgical properties. LSLM as a multidisciplinary technology is governed by a large number of process parameters, interrelated and highly sensitive to disturbances. These sensitive and interrelated parameters determine the circumstances of the involved physical phenomena such as heat conduction, melting, phase transformation, and solidification. Accordingly, final mechanical/metallurgical qualities of the fabricated parts using LSLM are highly dependent on the process parameters. Therefore, any disturbances or sudden changes of these parameters may compromise the geometrical accuracy as well as the final structural qualities. Thus, controlling these parameters is critical during the fabrication of an object to maintain desired physical accuracies. In order to bring all variations effectively under the control, it is necessary to understand the relationships between these parameters and their effects on the final build-up. Based on this knowledge, it is possible to design a control plan as well as a path planning and external disturbances efficiently. Developing the full potential of this emerging manufacturing technique is being investigated.

**Laser sintering (LS)**

Laser sintering (LS) is an additive manufacturing process which uses laser surface heating to induce
consolidation of powdered materials. This work investigates some of the process-structure-property relationships for LS of viscoelastic polymers. A one-dimensional closed-form analytical solution for heating of a semi-infinite body, with a convective boundary condition, by a moving surface heat flux was developed. This solution approximates the shape of the Gaussian energy distribution of the laser beam more accurately than previous solutions in the literature. A sintering model that combines the effects of viscoelastic deformation driven by attractive surface forces and viscous flow driven by curvature-based forces was developed. The powder-bed temperature was approximated using the thermal model developed herein. The effect of the enthalpy of melting for semi-crystalline polymers was accounted for using a temperature recovery approach. Time-temperature superposition was used to account for the temperature dependence of the tensile creep compliance. The results of the combined-mechanism sintering model will be compared to the classic Mackenzie-Shuttleworth sintering model. A lab-scale LS unit was constructed to fabricate test specimens for model validation and to test the applicability of materials to LS. In this work, sintering four materials, polycarbonate (PC) and three molecular weights of polyethylene-oxide (PEO) was predicted using the aforementioned thermal and sintering models. Samples were fabricated using the lab-scale LS unit and the sintered microstructures were investigated using scanning electron microscopy. The rheologic, thermal and physical properties of the materials were characterized using standard methods and the relevant properties were used in the models. The choice of an amorphous polymer, PC, and a semi-crystalline polymer, PEO, affords comparison of the effects of the two material forms on contact growth during LS. The three molecular weights of PEO exhibit significantly different tensile creep compliances, however, the thermal and physical properties are essentially the same, and therefore the effect of molecular weight and subsequently the rheological characteristics on contact growth during LS will be investigated. The effects of particle size, laser power, and bed temperature were also investigated.

WHAT IS LASER?
Laser rapid prototyping of engineering components is one of the evolving technologies. This report tells a brief note about the lasers, CO2 lasers, Rapid prototyping and parameters affecting the laser rapid prototyping for the engineering component manufacturing. Here, insight of laser cladding process is included.

WHAT IS LASER?
The word laser is a acronym for "Light Amplification by the stimulated emission of radiation". Hence, stimulated emission is the key to laser operation. A photon with definite energy under certain condition can stimulate an excited atom to the ground state. During this process, the atom emits an additional photon, which is alike to the stimulating photon. This process is called stimulated emission. The energy of the photon is related to its wavelength by the formula:

\[ E = \frac{hc}{l} \]

- \( E \) is the energy of the radiation
- \( h \) is the plank's constant
- \( c \) is the velocity of light
- \( l \) is the wave length of light or laser

When laser is produced, the number of photons emitted should be more than the number of photons absorbed. This implies that the number of ground state atoms is less than the number of atoms in the excited state this condition is known as Population inversion. Population inversion cannot be achieved by heating.

WHAT ARE THE PROPERTIES OF LASERS?
1) Highly monochromatic
2) Highly coherent
3) Highly directional
4) Can be sharply focused

CO2 GAS LASER
Dr. C.KN Patel invented this laser in 1964.
The CO2 gas laser wavelength is 10.6 mm i.e. CO2 lasers in the infrared region. In this laser a mixture of three gases viz. Carbon-di-oxide (CO2), Helium (He) & Nitrogen (N2) is the medium in which lasing occurs. In the medium the ratio of CO2:N2: He = 1: