ELECTRICALLY ASSISTED MANUFACTURING

## WHY DOES MANUFACTURING MATTER?

Manufacturing plays an indispensable role in the global economy. It provides consumer goods and a significant portion of employment opportunities, community presence and economic strength. The U.S. manufacturing sector accounts for approximately 14% of the gross domestic product, however, it is responsible for over 30% of national energy consumption and consequently greenhouse gas emissions. Though there have been substantial improvements, there remain opportunities for increases in energy efficiency.

Consumers and investors have a favorable perception of environmentally sustainable products and practices. Though greenhouse gas emissions can be diminished by increasing the use of renewable resources in the electricity mix, manufacturing companies do not have sufficient control over the electricity mix when purchasing it from utility companies. The focus of the research is to improve the energy efficiency of manufacturing techniques through the use of electrically assisted manufacturing.

## DIFFERENT MANUFACTURING TECHNIQUES?

Rolling

The rolling process is defined as the process of plastically deforming metal by passing it between rolls. Metal rolling is often the first step in creating metal forms, it is a widely used forming process which provides high production and close control of final product. The metal is subjected to high compressive stresses as a result of the friction between the rolls and the metal surface. The forces act to reduce the thickness of the metal and affect its grain structure.

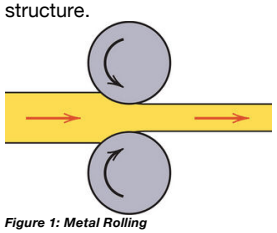

*Figure 1: Metal Rolling*

Forging

Forging is a manufacturing process that shapes a metal using localized compressive forces. It creates the desired geometric change to the material. The forging process is critical in the metal manufacturing industry as it can also alter the material properties. There are a variety of forging processes, such as closed die forging, cold forging and extrusion.

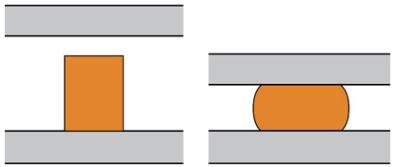

*Figure 2: Upsetting Die Forging*

## IS ELECTRICITY UTILIZED IN MANUFACTURING?

Induction Furnace

Induction begins with a coil of conductive material. As the current flows through the coil, a magnetic field in and around the coil is produced. The energy transfer to the metal work-piece occurs by the means of electromagnetic induction. Any electrically conductive material placed in a variable magnetic field is the side of induced electric currents, referred to as eddy currents. This eventually leads to joule heating, a process where the electric current through a conductor releases heat. Since heat is transferred to the product via electromagnetic waves, even though the part never comes into direct contact with any flame the inductor itself does not get hot and there is no product contamination.

Electron Beam Additive

The 3D model is created by computer-aided design (CAD) program. The design will be executed by the electron beam gun depositing metal layer by layer till the part reaches net shape. The technology utilized melted power or wire in the electron beam.

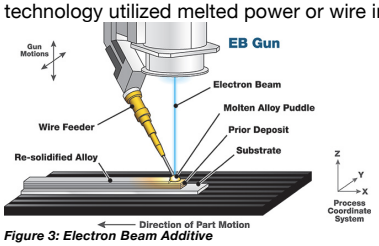


*Figure 3: Electron Beam Additive*

Electric Discharge Machine

Electrical discharge machining is a manufacturing process where a desired shape is obtained using electrical discharges. Material is removed from the work-piece by a series of rapidly recurring current discharges between a work piece and electrode. The dielectric or deionized water liquid separating the work piece and electrode creates a connectivity bridge and allows for electric sparks to be created. The spark is localized and controlled so it only affects the surface of the material. The conductivity of the dielectric or deionized water makes it an excellent environment for the EDM process. The water acts as a coolant and flushes away the eroded metal particles.

## WHAT IS ELECTRICALLY ASSISTED MANUFACTURING?

Electrically Assisted Manufacturing (EAM) is an emerging manufacturing technique where electricity is applied to a metallic work piece during deformation. The electric current reduces the flow stress of the material; it essentially softens the work piece in a specific area. It can be seen as a form of preheating. There are reduced losses as a specific area is being heated instead of the entire work piece.

Electrically Assisted Forming

Electrically assisted forming (EAF) is a specific type of electrically assisted manufacturing, where electricity is applied to metal-forming processes, for example for bulk deformation or sheet metal forming. The manufacturing process focused on is press forging as the work piece has minimal movement. The process can be modeled clearly and the energy outputs can be analyzed. To incorporate EAM for a moving work piece there are inevitable design barriers. The personnel and machine components must be insulated while the electric current is focused on the work piece.

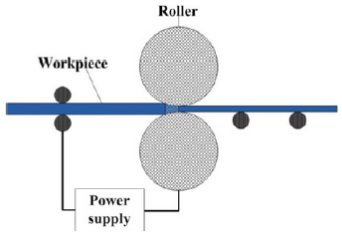


*Figure 4: Electrically Assisted Rolling*

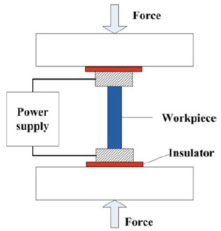


*Figure 5: Electrically Assisted Forging*

Press forging is where there is slow continuous pressure applied to the work piece. As the work piece is fed through the grooved portion of the roll's revolution, the compressive form the material into the desired shape. Studies illustrate EAM allows manufacturing processes such as die forging and sheet metal forming to be more efficient. The variables of time and temperature are better controlled in the EAM process; this can mitigate the problems associated to thermal stress and controllability of tolerance. The increased control on the variables illustrate improved quality in material, for example in die forging results show increased achievable part displacement and reduced spring back effects.