RESEARCH ON THE IMPLEMENTATION OF INDUSTRY 4.0 IN INTEGRATED MANUFACTURING SYSTEMS

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ABSTRACT

In the context of Industry 4.0, manufacturing systems are being upgraded to a smart level. Intelligent manufacturing takes advantage of advanced technologies, information and manufacturing to achieve flexible, intelligent and reconfigurable manufacturing processes in order to address a dynamic and global market. It allows all physical processes and information flows to be available, when and where they are needed across supply chains, multiple industries, small and medium enterprises (SMEs) and large companies.

Smart manufacturing requires certain core technologies to activate devices or machines in order to vary their behaviors in response to different situations and requirements based on past experiences and learning abilities. The technologies allow direct communication with the production, thus allowing the solution and adaptation of problems and decisions that must be taken in a timely manner.

INTRODUCTION

The phrase Industry 4.0 is used to describe the trend of digitization and automation of the production environment (Oesterreich and Teuteberg, 2016; Brettel et al., 2014). Companies do this to shorten development periods, to facilitate customization ("lot-size-one"), to improve flexibility, but above all to decentralize the decision-making process and increase efficiency. [8]

Industry 4.0 has its origins in Germany, but the concepts are in line with global initiatives, including smart factories, the industrial Internet of Things, smart production and advanced production. [15]

Industry 4.0 is an integrating factor of automation that by providing information significantly influences the business and execution architecture of parts production, and by integrating all aspects sends trade beyond the company's borders for greater productivity. Industry 4.0 thus relies on advances in automation and digital technologies to collect, analyze and provide useful information in real time.[3]

In this context, Industry 4.0 can be considered the implementation of the concept of intelligent factory, ie another form of organization of production, in which complex cybernetic-physical systems are responsible for controlling physical processes [10], and the activities undertaken are of an automated nature, allowing the complete or partial replacement of human physical and intellectual work.

Industry 4.0 is a model that shows how industrial production follows the latest developments and adapts to changes over time. Thus, man, machine, and production itself constitute the force in a single intelligent and independent production.

In Industry 4.0, smart digital devices are networked and communicate with raw materials, raw products; semi-finished products, machines, tools, robots and humans. This is characterized by flexibility, efficient use of resources and integration of customers and partner companies in the business process. [4]

The laser is a coherent beam amplified by electromagnetic radiation. The key element in making a practical laser is the amplification of light achieved by stimulated emissions due to high-energy incident photons. A laser comprises three main components, namely, a gain medium, a device for exciting the addition medium (amplification state) and the optical delivery system (feedback).

For example, the CO2 laser is an optical resonator or two-lens cavity (one is fully reflective and the other partially reflective) and has an energizing or pumping source that provides energy to the additive environment to activate CO2 in the amplified state. Additional lens cooling provisions, beam guidance and target handling are also important. The laser medium may be solid (e.g., Nd: YAG or yttrium-aluminum-garnet-doped neodymium), liquid (dye), or gas (e.g., CO2, He, Ne). [12]

For all the processing processes nowadays it is important to obtain exact dimensions, together with good surface finishes, and the high removal rate of the materials being the most important. The processing process involves various parameters that can indirectly affect the surface roughness and the rate of removal of materials. Feeding, cutting speed and depth are very important parameters by which surface roughness and MRR can be affected for the most part.

A good knowledge of parameter optimization can help reduce processing costs, improve product quality and reduce processing time. Extensive studies are performed to optimize the parameters, so that a better product is achieved. [6]

In this paper we have made a synthesis based on the implementation of the idea of Industry 4.0 and a brief classification of the optimal processing parameters of machine tools for their use.

MATERIAL AND METHOD

Laser cutting is a non-contact thermal process, capable of cutting complex contours with a high degree of precision. It involves the process of heating, melting and evaporating the material in a well-defined small area and capable of cutting almost all the materials shown in Figure 1.

The quality of the cut depends on many control factors or parameters, such as the parameters of the laser beam (laser power, pulse width, pulse frequency, operating modes, pulse energy, wave length and focal position); material parameters (type, optical and thermal properties and thickness); gas parameters (type and pressure) and processing parameters (cutting speed).

Laser cutting is a very complex and non-linear process due to the involvement of many process parameters. Many researchers have investigated the effect of these process parameters on various quality characteristics, such as material removal rate (MRR), kerf quality characteristics (kerf width, kerf deviation and conical edging), surface quality (surface roughness of the cut edge). , surface morphology), metallurgical quality characteristics (reformed layer, heat affected area, oxide layer and slag inclusions) and mechanical properties (hardness, strength). **[14]**

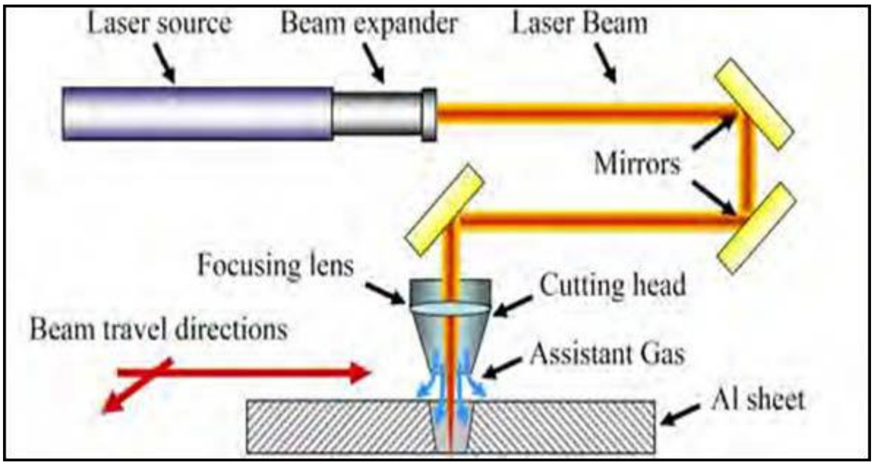
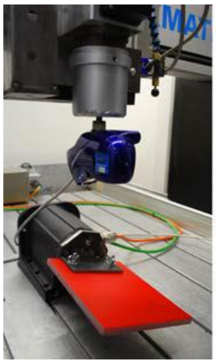


Fig. 1. Simple laser cutting process

Laser measurement systems are normally based on the principle of optical laser triangulation. This is based on the geometric conditions of the light beams; in particular with regard to the information on the angle and distance between the light source and the light image reflected on the sensor coupling device (CCD). When scanning these complex or larger shapes, it is often necessary to move the measurement sensor relative to the object shown in Figure 2. [5]



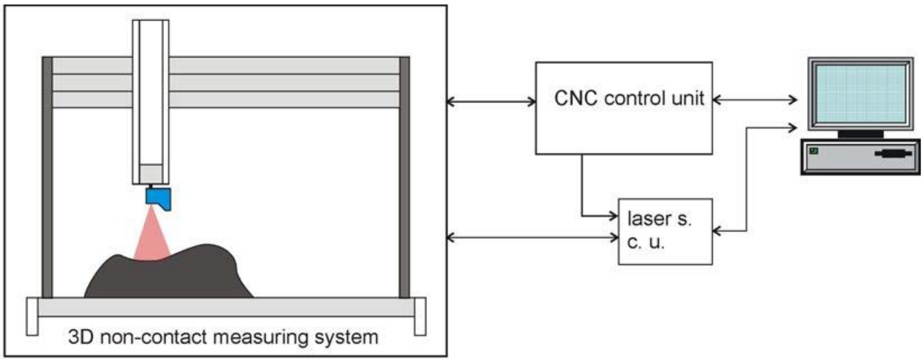


Fig. 2. Measurement configuration for laser triangulation scanning with CNC platform

The simplest way to determine the relationships is done by measuring the reflection properties, because they are connected with the optical properties of the surfaces and depend on several parameters (chemical composition of the microstructure and roughness, etc.) shown in Figure 3. Depending on properties of the material, some penetrate into the material, or can be absorbed by it or on its surface.

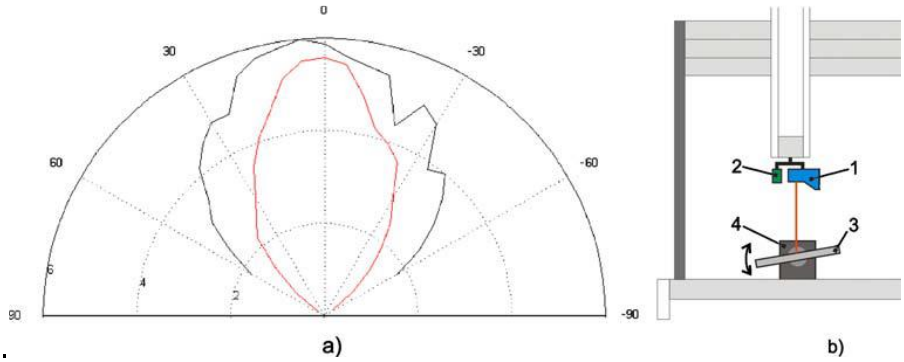


Fig.3. a) Measured relative intensity of surface reflection (radial value) as a function of angle (angular value): red line painted red represents the measured area (three average measurements), the surface of the black line covered with white powder (one measurement); b) Measurement configured for surface reflection: 1 laser scanner module, 2 CCD sensor for measuring the reflected intensity, 3 samples, 4 motorized rotary table.

An IPGYLR-10000 fiber laser operating at maximum power with a delivery system consisting of a 200 mm diameter fiber is shown in Figure 4. In the cutting head, the optics consisted of a 120 mm Collimator and five lenses with different focal lengths (starting at 250 mm). Using spacer rings, the nozzles were arranged to produce different combinations of FD and FPs to promote different assistance gas behaviors. Without defocusing the laser beam, seven sets of parameters were tested, all with the same nozzles.

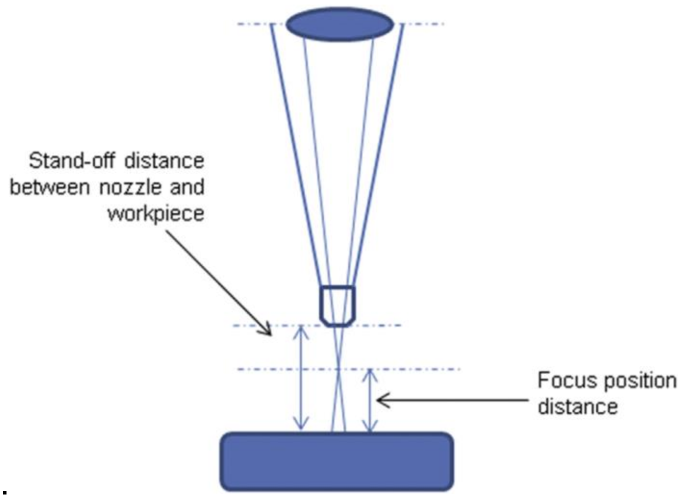


Fig. 4. Definitions of standby distance and focus position distance.

RESULTS AND DISCUSSIONS

The CNC parameters of machine tools are created by their manufacturers. However, the adjustment of parameters by the operator must have a lot of knowledge in the field, including the most basic theories, such as static, dynamic, kinematic, mechanism, motion control, etc. More advanced knowledge also includes the quality of computer aided production (CAM), interpolation, machine performance, tool geometry, cutting conditions, etc.

Figure 5 shows the architecture of the motion processing sequence within the commercial CNC machine tools in this study. First, the CAM generates the corresponding numerical control (NC) code. The NC position command (Sg) is interpreted by the CNC controller for planning the instrument path in the interpolator and then generates the motion path based on the CNC parameters.

Therefore, CNC parameters include speed, acceleration, and vibration for path directions, such as straight, corner, and arc paths.

An algorithm for planning the trajectories of the instruments produced the kinematic profiles of their relevant position, speed, acceleration and vibration based on the NC code and CNC parameters. According to the profiles, each servo axis moves along the path of the trajectory that has been defined as (Sc).[2]

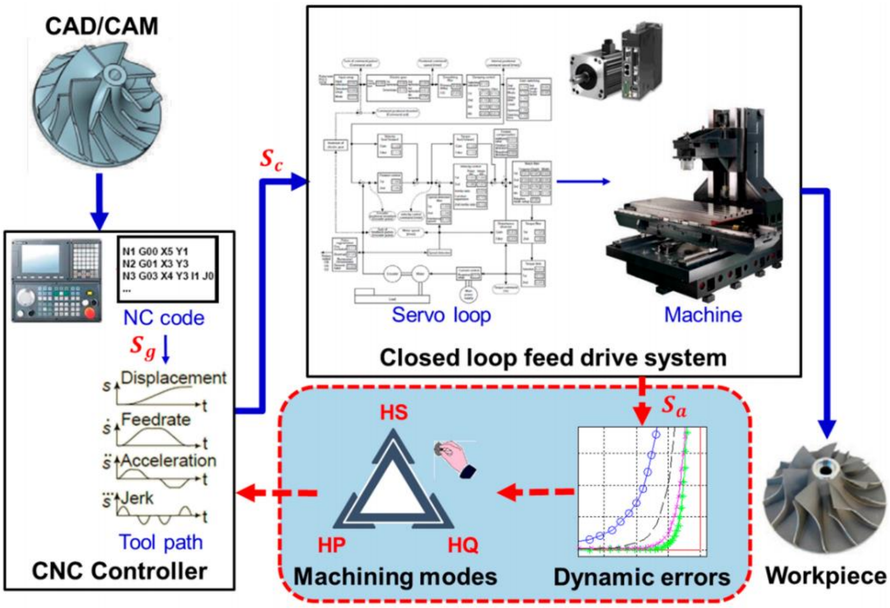


Fig. 5. The architecture of the processing sequence objective

J. Wang, (2000) worked on an experimental analysis and optimization of the CO2 cutting process for metal-coated sheet steels. An experimental analysis of the CO2 laser cutting process for metal-coated sheet steels, ie 0.55, 0.8 and 1.0 mm GALVABOND, was presented. It has been shown that these materials can be cut at a high cutting speed of up to 5,000 mm / min, while the cutting quality is superior to that with the low cutting speed recommended in an early study. The difficult nature in processing this type of material is attributed to their abnormal behavior when subjected to laser light due to the high light reflectivity and thermal conductivity of the coatings, as well as the difference in physical properties between the coating and the substrate. The plausible trends of the percentage of energy used in cutting in relation to the process parameters were analyzed. He showed that energy efficiency varies from 5% to about 24% under test conditions.

Siti Lydia Binti Rahim, (2007) performed the analysis and optimization of the process parameters involved in the laser processing of stainless steel (6 mm and 8 mm thick). This machine uses a laser sensor for flexible references by contactless scanning, after measuring fixed points. The command calculates the position of the item in relation to the machine itself. The translation and internal rotation by the control system ensure that the machine coordinates correspond to those of the board. The laser sensor is particularly useful for retrieving or locating references and reference points. Fanuc 16LB CNC control is one of the most advanced systems available, which guarantees the perfect reproduction of programmed contours even on the sharp edges or angles at high speed. Most finishes can be laser marked with names, part numbers, serial numbers or logos, the marking is clear, without burrs and permanent, and the process does not cause any mechanical deformation of the part and uneven or inaccessible surfaces are observed.

Jun Li și G K Anantha Suresh, Journal of Micromechanics and Micro-Engineering (2010) worked on a quality study on micromachining laser probe of electro-thermally compatible micro-devices and tried laser processing in water. A silicon sample was cut in both air and water to compare performance. The supply speed was 200 / xm s ^ 1, the frequency was 100 Hz and the discharge voltage was 20 KV. During the laser cutting in water, I put the sample in water so that there is a layer of water 3 mm above the sample. From Figure 10, we can see that the removal of the material is less than in the case of cutting in the air, but there are no residues either on the cut edge or on the surface of the sample. Silicon laser cutting in water provides a much better finish than in air, but takes longer to cut. Thus, there is a trade-off between the quality of processing and the time required for processing. This conclusion is consistent with the observations made by Krussing et al. (1999) who attempted laser cutting of NdFeB and MnZn ferrites in the water environment.

Daniel Teixidora, (2012) worked on optimizing the process parameters for laser pulse milling of micro-channels on the surface finishing of AISI H13 steel and the dimensional characteristics of micro-channels were investigated in the laser milling process of AISI H13 hardened steel tool. 3D graphics are used to illustrate trends in the effects of process parameters and a method is presented that uses multi-criteria ranking and parameter selection to find the best combinations for different quality criteria. Experimental models based on quadratic regression are developed for roughness errors and surface width and depth. Moreover, an evolutionary computational approach is applied to the decision-making problem in micro-processing parameters. Finally, an analysis of the optimal solutions that form the Pareto front in the objective functional space is provided in the variable decision space. The analysis indicates that the level ranges of the control parameters should be wider to obtain results close to the optimal ones.

Natasa Naprstkova, Stanislav Dubsky (2012) worked on Optimizing the setting parameters of the laser cutting machine. After analyzing the production costs of the usually manufactured components, the most suitable manufacturing operations were selected to look for savings and mapping of the cutting parameters of the laser cutting machine. To optimize the performance parameters of platinum machines on the following steps and were designed: determine the shape of the experimental test sample to match the machine parameters, specifying for what quality and thickness the parameters will be optimized, selecting a stock for tests; technological preparation of representative items for production; designing the methodology of the experiment; choosing the number of parts needed to optimize the parameters; performing experiments according to the methodology and evaluating them. The solution for this task was to find reserves in the use of Platinum laser cutting machines. Were conducted series of experiments in which the cutting parameters were optimized for most of the qualities of the processed materials and the thicknesses.

CONCLUSIONS

The paper focused mainly on the concept of the fourth industrial revolution, called Industry 4.0, which allows efficient, effective, individualized and customized production at reasonable costs. With the help of faster computers, smarter machines, smaller sensors, cheaper data storage and transmission could make machines and products smarter to communicate more easily.

The following conclusions can be drawn for the efficient processing of stainless steel (SS 304) through the LBM process as follows:

Assist gas pressure is the most significant factor for SR during LBM. Meanwhile, laser power and cutting speed are under significant influence. Laser power is the most significant thickness factor during LBM. Meanwhile, the assist gas pressure and the cutting speed are under significant influence. It is also shown that the performance characteristics of cutting operations, such as surface roughness, are greatly improved by using this method.

This paper can be extended to optimize other laser parameters, such as separation distance and nozzle diameter, etc.

- Experimentation can be performed on different materials with different combinations of input parameters.
- Mixed optimization can also be done.
- The different analysis methodology can also be used for optimization

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