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CYCLE TIME REDUCTION IN CNC 2D LASER CUTTING MACHINE

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Abstract: *This report presents a cycle time reduction in CNC 2D laser cutting machine. Laser cutting is a technology that uses a laser to slice materials. While typically used for industrial manufacturing applications, it is also starting to be used CAD (top) and stainless steel laser-cut part (bottom) by schools, small businesses, and hobbyists. Laser cutting works by directing the output of a high-power laser most commonly through optics. The laser optics and CNC (computer numerical control) are used to direct the material or the laser beam generated. A commercial laser for cutting materials involved a motion control system to follow a CNC or G-code of the pattern to be cut onto the material. The focused laser beam is directed at the material, which then either melts, burns, vaporizes away, or is blown away by a jet of gas, leaving an edge with a high quality surface finish. Industrial laser cutters are used to cut flat-sheet material as well as structural and piping materials. The closed-loop feed drive dynamics does not have much influence on the cycle time, since the tracking delay is insignificant in position control servos. The proposed algorithm is validated in experiments and an experimental result has shown that the cycle time prediction error remains within 5% for various 2-axis, 3-axis and 5-axis tool paths.*

Key Words: *Feed rate, Depth of cut, Cutting speed, Spindle speed.*

1. INTRODUCTION:

In this challenge world, industries around the world constantly strive for lower cost solutions with reduced lead time and better surface quality in order to maintain their competitiveness. Automated and flexible manufacturing systems are employed for that purpose along with computerized numerical control (CNC) machines that are capable of achieving high accuracy and very low processing time. in the CNC machining, determining optimal cutting conditions or parameters under the given machining situation is difficult in practice. Conventional way for selecting these conditions such as cutting speed, feed rate, and depth of cut has been based upon data from machining handbooks and/or on the experience and knowledge on the part of programmer. As a result, the metal removal rate is low because of the use of such pre-defined machining parameters turning is the first most common method for cutting and especially for the finishing machined parts. In a turning operation, it is important task to select cutting parameters for achieving high cutting performance. Cutting parameters reflect the surface roughness (r_a,r_z),roundness(ø),material removal rate (mrr) and the dimensional deviations of the product. surface finish obtained in manufacturing processes mainly depends on the combination of two aspects: the ideal surface finish that can be produced from the manufacturing process and the actual surface finish which is generated taking into account irregularities and deficiencies that may appear in the process and changing manufacturing methods.

1.1 OBJECTIVE OF THE PROJECT:

- TO INCREASE THE FEED RATE
- TO INCRESE THE PRODUCTION RATE
- TO MINIMIZE THE CYCLE TIME
- HIGHER MATERIAL REMOVAL RATE

2. LASER TECHNOLOGY:

Lasers are light sources. The concept is very versatile; they can emit visible, infrared or ultraviolet spectra; they can generate long as well as very short pulses (pulsed lasers), or very powerful steady beams (continuous-wave, or CW, lasers), which are focused using simple elements such as lenses or concave mirrors in small micrometer-size spots, or to propagate nearly parallel beams extending for several kilometres (collimated beams). They differ from a fire, the sun or an ordinary light-bulb in terms of the intrinsic light generating mechanism which radiates as a continuous repetition of spontaneous and disordered processes, producing generally uniform illumination around them. The generation of the light from lasers is by amplification of a well-ordered and single-frequency seed, which produces a very directed emission, which is single-coloured and coherent across the beam. The amplification occurs within a resonator, usually consisting of a pair of aligned mirrors, with parallel surfaces, in which the seed grows through multiple passages through the gain medium. The output beam slips off the resonator via one of the mirrors which is semi-transparent. Figure 1 depicts the principal components of a laser:

- Active laser medium;
- Laser pumping energy;
- High reflector;
- Output coupler;
- Laser beam

3. METHOD:

3.1. **Cutting parameters considered:** In turning process, there have lot of parameters that will influence the process such as tool geometry, cutting speed, depth of cut, etc. The consideration needed to make to determine the effect of cutting parameters on the work piece. Lalwani et al. (2007) has made an experimental investigation on the effect of cutting parameters such as cutting speed, feed rate and depth of cut on the feed force, thrust force, cutting force and Surface Roughness in finish hard turning of MDN250 (50 HRC) steel using coated ceramic tool. They found that the cutting speed has no significant effect on cutting forces and surface Roughness. But before the researcher has stated that the cutting speed has greater influence on Roughness followed by the feed and the depth of cut has no significant influence on the Roughness according by Davim(2001). He also mentioned that the interaction cutting velocity/feed is the most important of the other analyzed parameters. Besides that, Nalbantetal. (2006) also found that the insert radius and feed rate are the main parameters among of three controllable factors (insert radius, feed rate and depth of cut) that influence the turning process. Noordin et al. (2003) has applied the RSM in investigation into the effect of feed rate, side cutting edge angle (SCEA) and cutting speed on the Surface Roughness and tangential force. He revealed that feed is the most significant factor influencing the response followed by the SCEA. Moreover, a test were conducted to find the effect of tool parameters such as insert shape, cutting edge preparation, type and nose radius by Arunachalam et al. (2004).

3.2.Cutting speed: The speed of the work piece surface relative to the edge of the cutting tool during a cut, measured in surface metre per minute (SMM).

3.3. Spindle speed: The rotational speed of the spindle and the work piece in revolutions per minute (RPM). The spindle speed is equal to the cutting speed divided by the circumference of the work piece where the cut is being made. In order to maintain a constant cutting speed, the spindle speed must vary based on the diameter of the cut. If the spindle speed is held constant for varying diameter of the workpiece, then the cutting speed will vary.

3.4. Feed rate: The speed of the cutting tool's movement relative to the work piece as the tool makes a cut. The feed rate is measured in mm per revolution.

3.5. Depth of cut: The depth of the tool along the radius of the work piece as it makes a cut, as in a turning or boring operation. A large depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is often machined in several steps as the tool moves over at the depth of cut.

4. DESIGN OF EXPERIMENT (DOE):

The objective in the type of experiment studied here is the comparison of the effect of treatments on response. This will typically be assessed by estimates and confidence limits for the magnitude of treatment differences. Requirements on such estimates are essentially as follows. First systematic errors, or biases, are to be avoided. Next the effect of random errors should so far as feasible be minimized. Further it should be possible to make reason-able assessment of the magnitude of random errors, typically via confidence limits for the comparisons of interest. The scale of the investigation should be such as to achieve a useful but not unnecessarily high level of precision. Finally advantage should be taken of any special structure in the treatments, for example when these are specified by combinations of factors. The relative importance of these aspects is different in different fields of study.

4.1. ANALYSIS: In identifying the optimal conditions from the Taguchi's method analysis of variance (ANOVA) plays a major role in determining the percentage contribution of the machining parameters on the response factors. The various characteristic types of signal to noise ratio is as mentioned below.

Characteristic type	Target	Examples
Nominal Is The Best	Centered On The Given Value	Television, Voltage, Turntable Rpm
Smaller The Best	Small As Possible(Zero)	Tool Wear, Surface Roughness
Larger The Best	As Large As Possible(Infinity)	Fuel Economy, Weld Strength
Signed Target	Zero	Residual Current
Classified Attributes	-	Good-Bad, Low-Medium-High

Table 1 various characteristic types of signal to noise ratio

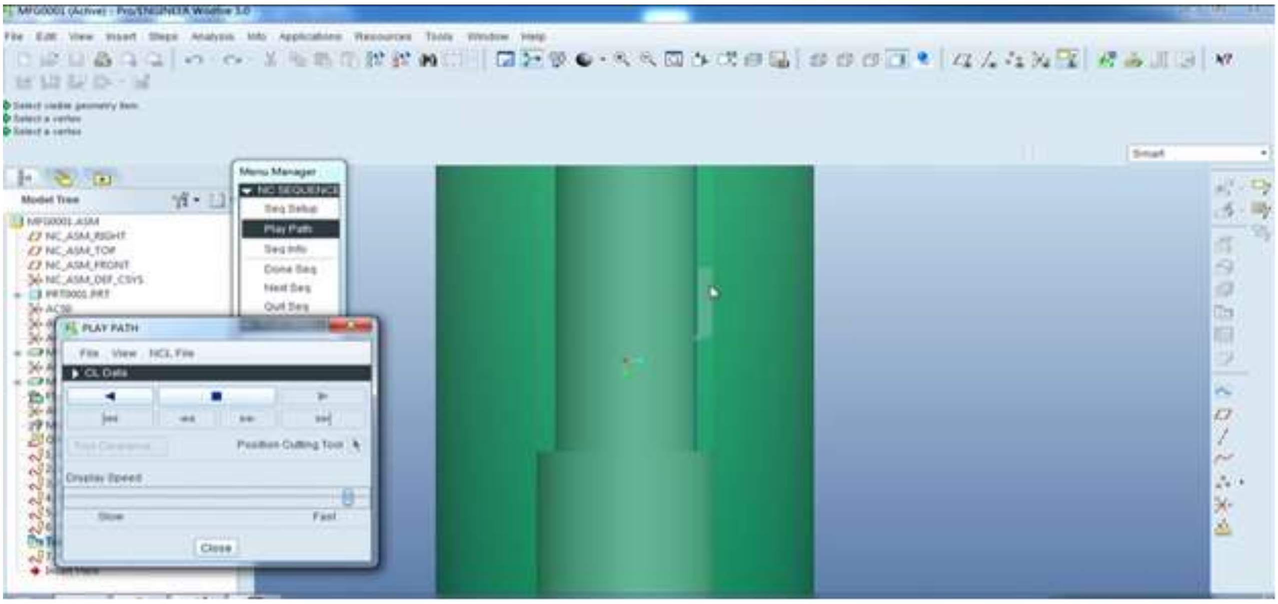

Figure 1 Pro-E Simulation of Our Project

Materials Thickness (mm)	Cutting Speed (m/min)		
	Mild Steel (O_2)	Stainless Steel (N_2)	Aluminium (O_2)
2	5.85	7.25	8.60
5	4.00	3.00	3.10
10	2.35	1.30	0.82
15	1.58	0.70	-
20	1.10	0.42	-

Table 2. Material thickness Vs Cutting Speed

5. RESULT :

Job number	Cutting Speed(m/min)	Feed rate(mm/rev)	Depth of cut(mm)	MRR Value (cm3/min)	S/N ratio
1	119.223	0.050	0.10	0.2123	-13.4610
2	158.964	0.050	0.15	0.3865	-8.2570
3	198.705	0.050	0.20	0.5821	-4.7000

Figure 2. Finished Jobs

6. CONCLUSION:

- Taguchi method also shown that the performance characteristics of the turning operations, such as the material removal rate, Roundness and the Surface Roughness are greatly enhanced by using this method. The effect of three machining parameters i.e. Cutting speed, feed rate and depth of cut and their interactions are evaluated using ANOVA and with the help of MINITAB 16 statistical software. The purpose of the ANOVA in this study is to identify the important turning parameters in prediction of Surface roughness, Roundness, MRR. The optimal cutting parameters can be identified for response factors from response table which shows for Surface Roughness R_a(µm),feed rate is the most influencing parameter followed by cutting speed and then depth of cut. Feed rate contributes about 63.610% on R_a,while cutting speed has 17.845% and depth of cut has the contribution of 15.244% on surface Roughness(Ra).
- Also, the optimal cutting parameters to obtain a minimal value of Roughness Ra=0.3379 µm predicted is as mentioned below,
  - ✓ Cutting speed= 119.223 m/min.
  - ✓ Feed rate=0.05 mm/rev.
  - ✓ Depth of cut=0.15 mm

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