10th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

RESULTS EVALUATION OF „PRECONTROL“ METHOD BY THE PLASTICS LASER CUTTING

Dana Shejbalova
Tomas Bata University, Faculty of Technology, Department of Production Engineering
T.G.Masaryka 275, 76272, Zlin
Czech Republic

Libuse Sykorova
Tomas Bata University, Faculty of Technology, Department of Production Engineering
T.G.Masaryka 275, 76272, Zlin
Czech Republic

Pop Mircea T.
Universita of Oradea, Fakulty of IMT
Armatei Romania nr. 5, 3700 Oradea
Romania

ABSTRACT
The paper deals with possibilities of using the laser in technologies, below it describes problems of laser cutting accuracy for the specific technological conditions. Laser, one of the greatest inventions in modern physics, is a quantum amplifier of electro magnetic wave motion based on mutual interaction of mass and radiation. The statistical methods are used for determination of process accuracy. PRECONTROL – the statistical regulation method of the cutting process was using. The experiment results was evaluated and processed into the graph.
Keywords: laser cutting, statistic methods, accuracy

1. INTRODUCTION
1.1. Carbon Dioxide Lasers
Laser, one of the greatest inventions in modern physics, is a quantum amplifier of electro magnetic wave motion based on mutual interaction of mass and radiation. For material processing from constructional and kinematical point of view suits the best CO_2 laser with fixed laser system and moveable cutting optics numerically controlled in two or three axes. For machining of polymers the sufficient output is up to 1 000W, for metals the appliance with the cutting output up to 2 500W.
Carbon dioxide lasers use the energy-state transitions between vibrational and rotational states of CO_2 molecules to emit at long infrared (IR), between 9 and 11μm wavelengths. These lasers can maintain continuous and very high levels of power, and are some of the most versatile for materials processing applications. The active medium in carbon dioxide lasers is a mixture of carbon dioxide, nitrogen and (generally) helium. The carbon dioxide produces the laser light while the nitrogen helps to increase efficiency by exciting the CO_2, causing it to emit more light in the process. The helium plays two roles, helping the CO_2 to return to the ground state and fostering heat transfer. There are three main types of carbon dioxide lasers, axial gas flow, transverse gas flow, and sealed tube. In axial gas flow carbon dioxide lasers, the gas mixture is pumped in one end of the tube and forced out of the other. Fresh CO_2 gas is continually pumped in to maintain the flow. Helium and nitrogen are added to the mixture to boost efficiency. Power output is typically 40 to 80 W per meter of tube

length (more or less independent of tube diameter). Folded optical systems may be used to reduce the total physical length of the laser. This approach is practical for output powers of up to a couple of kW. In transverse gas flow devices, the CO_2 gas flows across the tube providing high power ratings for continuous CO_2 laser operation. Power outputs of 10 kW per meter are possible with transverse excited atmospheric (TEA) designs. These carbon dioxide lasers are able to achieve a higher power output due to the increased pressure in the tube. Sealed tube devices are similar to sealed He-Ne and Ar/Kr ion lasers in that the gas is maintained within the tube cylinder and is not refilled during use. The only key differences are the size of the tube and its bore, as the device is designed to function using the much longer CO_2 wavelength. Power output of sealed CO_2 lasers ranges from a few watts to perhaps 100 W (maybe more).
Carbon dioxide lasers are available in two energy input configurations; those with an integral power supply, and those that rely on an external power source for excitation. Additionally, they are designed to output energy in either a continuous wave format, or pulsed. Some carbon dioxide lasers are Q-switchable. In this case, the device can rapidly change the Q of an optical resonator. It is used in the optical resonator of a laser to prevent lasing action until a high level of inversion (optical gain and energy storage) is achieved in the lasing medium. When the switch rapidly increases the Q of the cavity, a giant pulse is generated.

1.2. Description of method PRECONTROL

The method of PRECONTROL has simple rules:

1. The breadth of tolerance zone is divided into 4 – this tolerance zone is divided by four into the same broad parts. The limits of the middle parts of tolerance zone, that come up to two quarters of breadth of tolerance zone, determine so-called “PRECONTROL” (P-C) limits. This part of the tolerance zone is called “the green zone”. The parts of tolerance zone between upper P-C limit and upper tolerance zone, or between lower P-C limit and lower tolerance zone are called “yellow zones”. Areas over the upper or lower tolerance limit are designated as “red zones” – see figure 1.

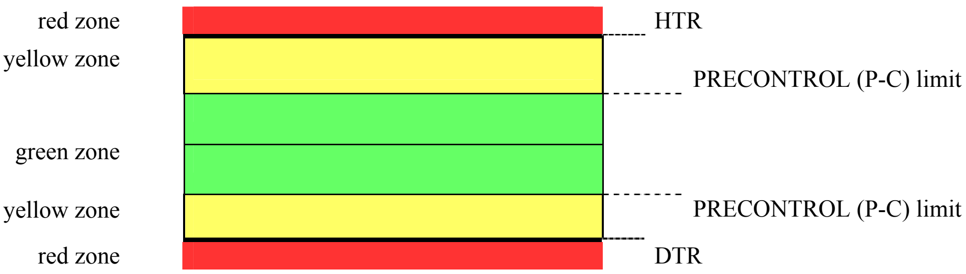

Figure 1. Graphic segmentation of tolerance zone according to method “PRECONTROL”

2. The qualification of this process is verified by the implementation of selection five data units (products), which it is (following) successive. If the value of measured parameter by of all five data units is in green zone, the process is under the control and it is possible to continue in its. However if the only value of parameter is out of the green zone, that process is not under the control, it is necessary to look for this variability source and do it away.
3. If process was under the control and it is running without interventions, we can carry out regulation in terms of periodically screened great two data units. Regulation is realized according situation, which is follows:
   a. If the value of measured parameter by both data units is inside green zone, industrial process can without interventions.
   b. If value of measured parameter of one data unit is inside the green zone and the other one inside some of the yellow zones, this process is still under the control.
   c. If both of parameters values exist inside one or inside both of the yellow zones, the process is out of the control, the production must be stopped.
   d. If only one parameter value exists inside the red zone – the process is out of the control (a waster was produced). The production must be stopped, the reason of scrap must be

identified and got out or at least it must be reduced. Again the qualification of the process must be verified also in this case – see point 2.

2. THE EXPERIMENT

Specimens set from PMMA, what are 6 mm thick and sawed by speed different were picked for the following experiment. CO_2 laser TRAUMATIC 850 was used with starting power P = 850 W. The specimen width was defined by the specified dimension 8,8 mm in accuracy class IT14. PMMA belongs among the polymers, by which material of cut is mostly evaporating. Straight and smooth cut be caused by cutting PMMA, that has got a slightly conical shape, and it can cause problems of compliance with of specified dimension by cutting more thick materials.
First specimens set was made by speed cut v = 0,4 $m.min^{-1}$ and v = 0,2 $m.min^{-1}$. Owing to the fact that cutting surface has got conical shape by laser cutting, it was necessary to realize the measuring of cut width on the enter and on the output. This values are termed upper dimension (HR) and under dimension (DR). If these defined specimens agree with the adequate accuracy, both dimensions must be inside of defined tolerance zone h14. The measuring data for speeds v = 0,4 $m.min^{-1}$ a v = 0,2 $m.min^{-1}$ are in tables 1 and 2. The measuring data are drawn in fig. 2 and 3. Limits of tolerance zone 8,8 h14 are drawn in these graphs. We have found out from the graphs, that the specimens with measuring data don`t agree with the adequate accuracy, because its dimensions don`t fall in defined of tolerance zone. The method of PRECONTROL for these speeds was not realized (although P-C limits are drawn in the graphs) because none of the measuring data are found in the tolerance zone.

Table 1. PMMA t = 6 mm v = 0,4 $m.min^{-1}$

The specimen number	1	2	3	4	5
HR [mm]	8,37	8,39	8,38	8,38	8,37
DR [mm]	8,33	8,28	8,25	8,26	8,28

Table 2. PMMA t = 6 mm v = 0,2 $m.min^{-1}$

The specimen number	1	2	3	4	5
HR [mm]	8,34	8,32	8,35	8,31	8,28
DR [mm]	8,30	8,29	8,24	8,25	8,24

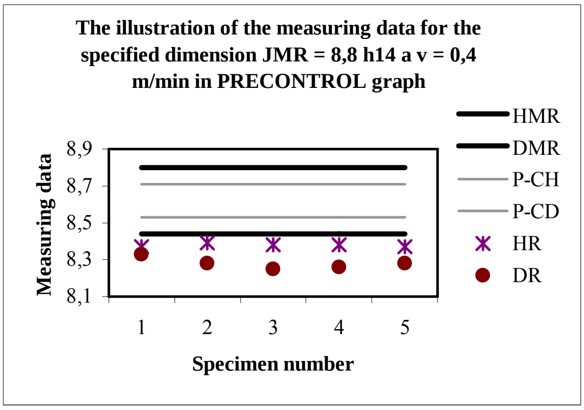

Figure 2. The graphic zoning tolerance zone by the method of PRECONTROL for the specified dimension JMR = 8,8 h14 - v = 0,4 $m.min^{-1}$

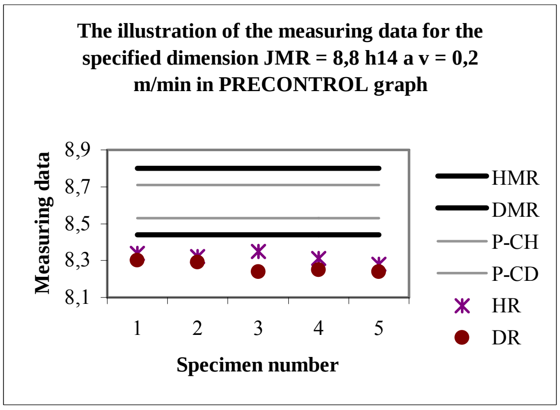

Figure 3. The graphic zoning tolerance zone by the method of PRECONTROL for the specified dimension JMR = 8,8 h14 - v = 0,2 $m.min^{-1}$

Cutting speed was changed into v = 1 $m.min^{-1}$. The measuring data are in table 3 and fig. 4. The dislocation of measuring data was found in tolerance zones and P-C limits (they characterize the variability of industrial process) by use the method of PRECONTROL. The value occurrence in the red zone shows the necessity of change in industrial process.

Cutting speed was changed into v = 2 $m.min^{-1}$ (the measuring data and data processing are in table 4 and fig. 5). It is seen from the graph that the measuring data are dislocated inside the tolerance zone and inside P-C limits too. Demand on the adequate accuracy is realized by this. The variability of industrial process doesn`t exist under the specific cut conditions (v = 2 $m.min^{-1}$).

Table 3. PMMA t = 6 mm v = 1 m.min^{-1}

The specimen number	1	2	3	4	5
HR [mm]	8,52	8,52	8,51	8,46	8,46
DR [mm]	8,44	8,43	8,40	8,39	8,42

Table 4. PMMA t = 6 mm v = 2 m.min^{-1}

The specimen number	1	2	3	4	5
HR [mm]	8,68	8,65	8,65	8,64	8,66
DR [mm]	8,57	8,54	8,58	8,56	8,55

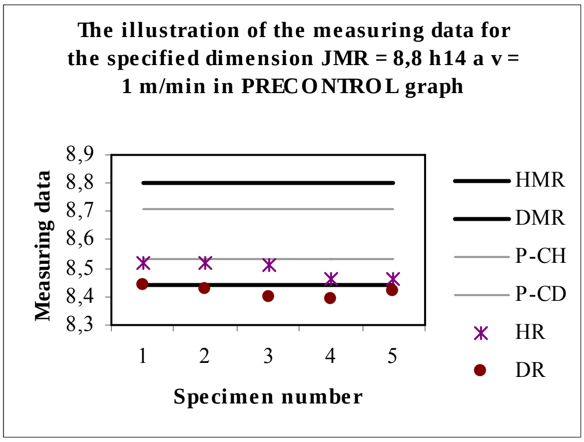

Figure 4. The graphic zoning tolerance zone by the method of PRECONTROL for the specified dimension JMR = 8,8 h14 - v = 1m.min^{-1}

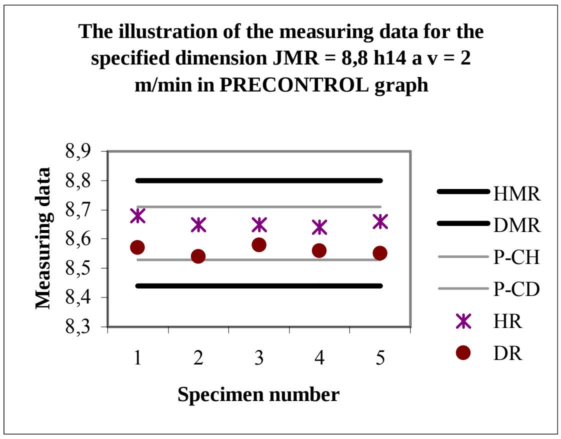

Figure 5. The graphic zoning tolerance zone by the method of PRECONTROL for the specified dimension JMR = 8,8 h14 - v = 2m.min^{-1}

3. CONCLUSION

Laser beam is the tool of the future. It can cut without affecting the surrounding material. Its energy is clean, reliable and docile it's ready to be tamed and handled to give an unequalled quality to the process. Quality of cut depends from working parameters of laser cutting process (laser power, feet rate, material thickness) as we can see from the results of the experiments.

It is obvious that when the interaction laser – material is longer during lower speed, more material evaporates and specimen cannot be produced in adequate accuracy.

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5. ACKNOWLEDGEMENT

This work was supported by the Ministry of Education and Youth of the Czech Republic under grant MSM 7088352102. This support is very gratefully acknowledged.