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Polygonal scroll cut test for database of laser cutting conditions

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This paper deals with laser cutting database and the authors suggest the fitting method to get the suitable process condition on user's cutting machine when result is different from the database.

1. INTRODUCTION

The Authors take part in 'Digital Meister Project,' a national projects of digitalization of manufacturing skills, and are developing open database for laser cutting conditions. Several researchers have developed laser processing database for the reference of process design [1, 2]. Due to different machine conditions, cutting results under conventional database did not fit to the actual cutting results sometimes. Another reason for this is the records of the laser cutting process,

Fig. 1. Schematic drawing of PSC test piece

which tends to be performed on limited conditions[3-5]. Hence, the application of the conventional database does not tend to work well. In this paper, we propose the polygonal scroll cut (PSC) for comparing the characteristics between machines and the fitting method for getting the suitable process conditions, using our database. Schema of PSC test was shown in **Fig. 1**.
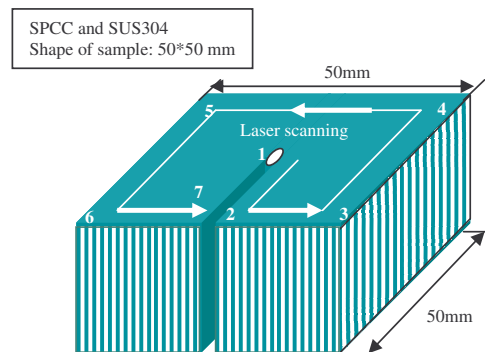
2. OUTLINE OF THE DATABASE AND THE POLYGONAL SCROLL CUT (PSC) TEST

2.1 Database of Laser Cutting Conditions

- **Query and output of a database**

Outline of the developed system is illustrated in Fig.2. In laser cutting, many parameters should be considered for good cutting result. Especially, following parameters are quite

important to decide the cutting conditions; material, thickness of material, laser power, cutting speed, roughness of cut face and kerf width. The database system requires a part of above
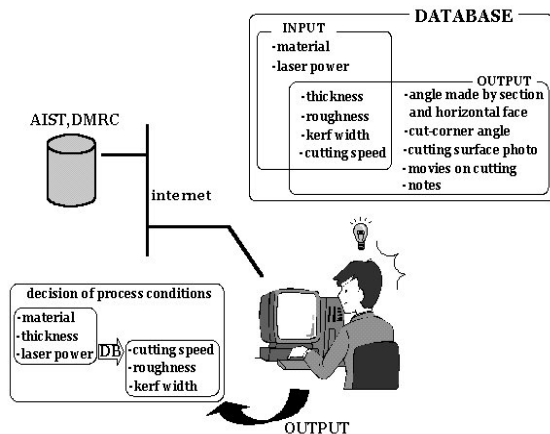

conditions as the input, and answers the other necessary conditions with result, such as cutting condition data (cutting speed, material thickness), cutting result (roughness, kerf width, cutting surface photo, cut corner angle, movies on cutting and angle made by section and horizontal face) and notes to help deciding the cutting conditions. The system contains cutting conditions and cutting results data compiled from the experiments by LD pumped YAG laser with SPCC and SUS plates.

Fig. 2 outline of database

2.2 Polygonal Scroll Cut (PSC) Test

2.2.1 Experimental conditions

The cutting conditions used in this study are shown in Table 1. Cut shape is shown in Fig.3. This specimen shows us the information in each direction. Therefore, the user can easily know not only the major cutting characteristics but also machine characteristics to be considered when the user inspects the data on the database. Then the user decides cutting conditions by comparing the result with the database.

2.2.2 Relationship between the result of PSC test and the characteristics of a laser-cutting machine

In the case that the specimen is not cut well on the PSC test, the database user can find the defects on the specimen, which may be dross formation, surface roughness, wide kerf width, angle made by section and horizontal face and edge dropping. The defects are caused by miss setting of cutting condition. The cause analysis chart of laser cutting is shown in Fig. 4.

According to the chart, the user can guess the cause of defects. For example, the dross formation and wide kerf width was appeared in a test piece, the user finds too much molten

Table 1 Cutting conditions

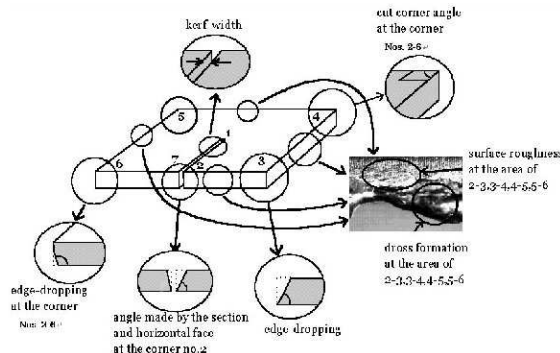| Laser	YAG laser (LD pumped)
Material	Carbon steel (SPCC), SUS304; 0.5, 1.0, 1.2, 2.0, 2.3, 3.0, 3.2, 4.0 mm^t
Laser power	500, 1000, 1500, 2000, 2500, 3000 W (CW)
Cutting speed	7 steps between self burning and gauging
Shielding gas	Gas pressure; 0.06 MPa (SPCC), 0.5MPa (SUS304) Gas nozzle diameter; 1.2 mm

Fig. 3 Schema of cutting shape and reference points in PSC test

metal appears because of heat concentration to know that slow cutting-speed or big laser-power may be causes of the defects.
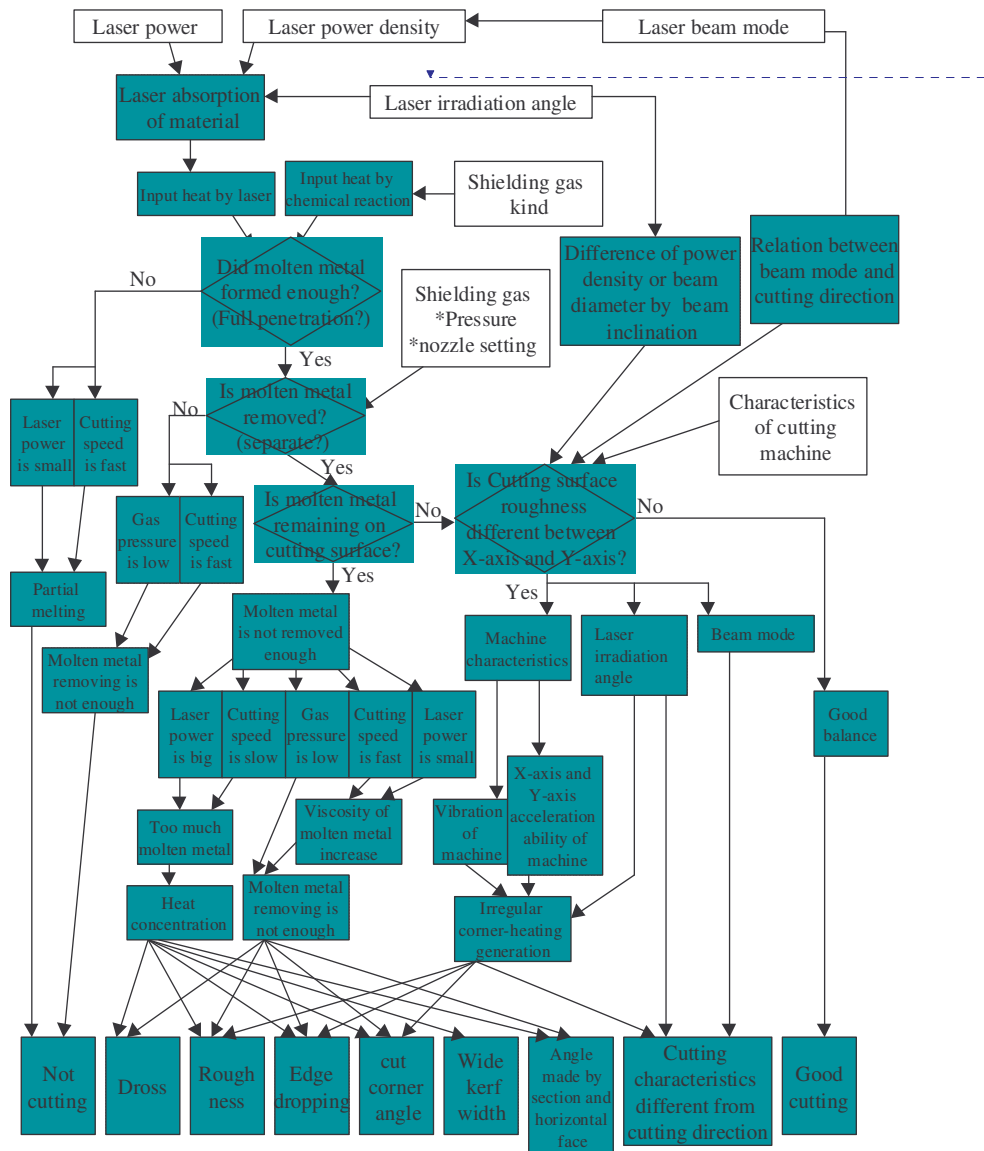
Fig. 4. Relationship between result of PSC test and thecharacteristics of laser cutting machine and cutting conditions

3. USE OF THE DATABASE WITH REGARDING THE RESULT OF PSC TEST

The cutting result of PSC test by the user may be different from the database because of the individual laser machine characteristics even on the same cutting conditions. However, the user can guess good cutting condition by examining similar cutting data from the database.
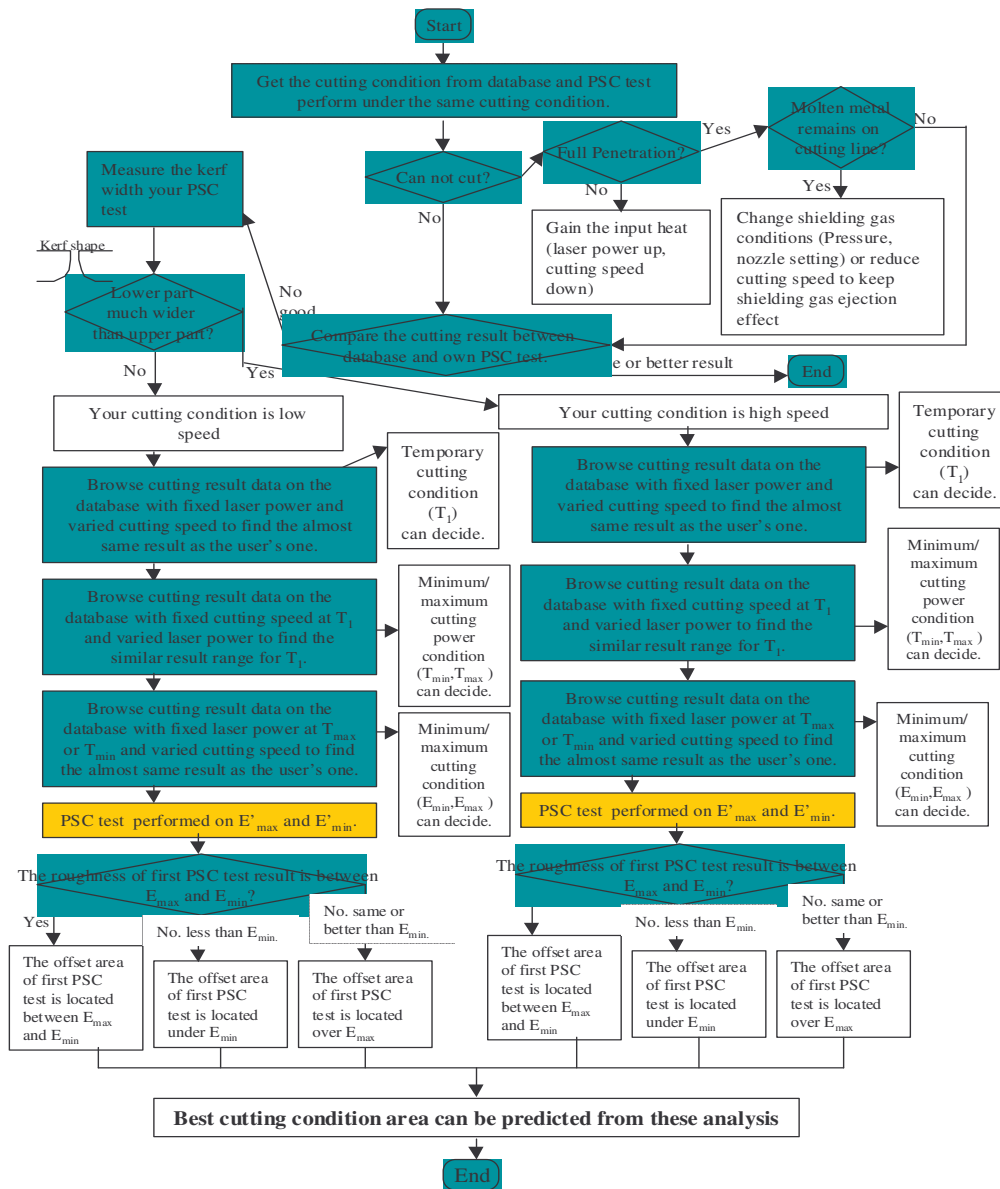
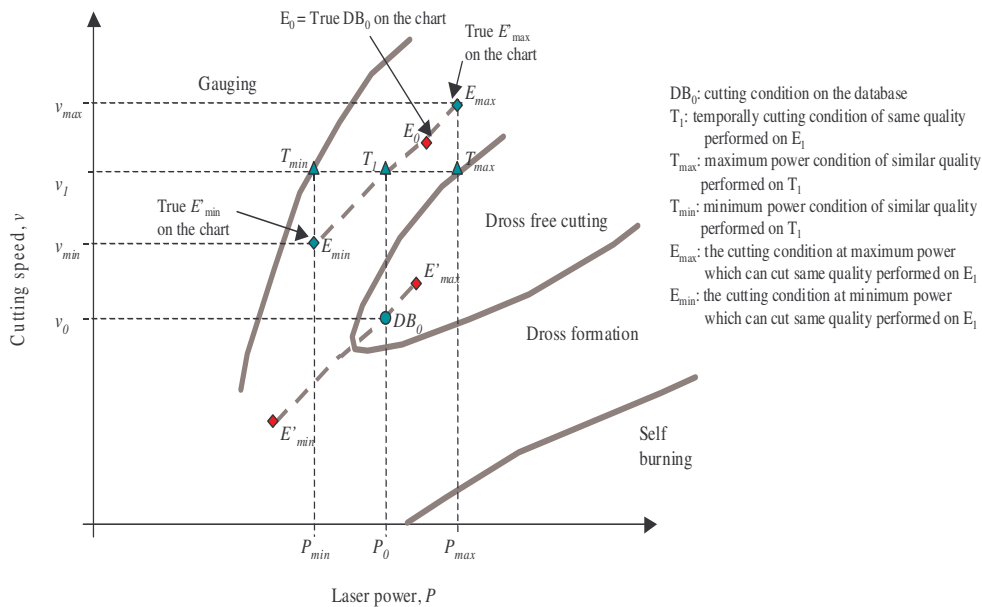Fig. 5. Flow chart of the database to fit the user's result

Fig. 6. Schematic drawing of fitting between the database and user's result

Flow chart of fitting between the database and user's result is shown in Fig. 5. And schematic drawing of fitting between the database and user's result is shown in Fig. 6.

At first, the user must check whether the test piece is separated completely or not. If it fails, the user must change shield gas pressure or speed and cutting speed or laser power condition with referring the chart. When cutting result of PSC test was different from the database at the reference point shown in the Fig.3, the user must offset the difference by tuning the location in the database with user's result. For example, the user checks the pattern of kerf to know whether the best cutting speed is located at the faster or slower condition. When the kerf has much wider width on the lower side face than the upper side, the best speed may locate at the slower condition. When kerf width is enough narrow, the best speed is almost located at user's condition. When kerf is too wide and it has almost same width on the lower side and upper side face, the best speed may locate at the faster condition.

Second, the user must decide the most important reference point to be tuned.

Third, the user browses cutting result instances on the database with fixed cutting power to find the cutting speed having almost same result as the user's one (T_1). Then the user searches minimum and maximum laser power to make similar cutting result at this cutting speed from the database (T_{min}, T_{max}). Next, the user browses the database to find the cutting speed having almost same result as the user's one at this minimum and maximum laser power (E_{min}, E_{max}).

Fourth, the user performs PSC test twice at the offset cutting condition of E'_{min} and E'_{max}. When the cutting surface roughness of first PSC test is located between second PSC cutting test pieces performed at E'_{min} and E'_{max}, the user can guess that the offset area of first PSC test is located between the cutting condition of E_{min} and E_{max} from the database. When the cutting surface roughness of first PSC test is less than the second test on E_{min}, the user can

guess that the offset area of the first PSC test is under the cutting condition of E_{min} from the database. When the cutting surface roughness of first PSC test is same or better than the second test on E_{max}, the user can guess that the offset area of the first PSC test is over the condition of E_{max} from the database. Repeating the above trial, the user decides the offset area more exactly.

3. CONCLUSION

When we use the value of conventional database, there is a trouble of getting the different processing result, which caused by machine characteristics or condition difference. In this paper, the authors develop a database for laser cutting and propose the PSC test to solve the problem. In adopting our newly developed method, the user can find desirable cutting condition, comparing the different between user's machine result and data on the database. .

Acknowledgement

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