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Dynamic Drawing Treatment of the Three-bridge High-pressure Waterjet Cutting Machine

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Abstract. The multi-bridge high-pressure waterjet cutting machine greatly improved cutting efficiency, and also made one-off processing of large workpiece possible. In order to further improve the efficiency of this system, this paper have put forward a drawing treatment—using ObjectARX development kit to do secondary development of AutoCAD drawing. Through customized menu commands of AutoCAD to call ObjectARX application, thus achieve automatic drawing segmentation, namely assigned equivalent workload as possible for each cutting head to increase the simultaneous work time of cutting heads and improve efficiency. At last, experiments were taken to verify the feasible of this method.

Introduction

The high-pressure waterjet, as a new technology, has been developing rapidly since it was found. As cleaning, cutting, crushing and carving tools, waterjet has a unique superiority because it's fast, accurate, environmentally harmless, no thermal distortion and omnipotent cutting. Thus, high-pressure waterjet occupies an important position in the cutting field. At the same time, such new cutting technology faces various kinds of challenges too. In recent years, high-pressure waterjet cutting was no longer limited to processing small-scale workpiece and the growing demand for large workpiece processing is becoming increasingly urgent, such as large parts of the aviation industry, aircraft wings and the impeller of wind turbine. If we continue to use the single-bridge (single cutting head) high-pressure waterjet cutting machine, both efficiency and cost will be affected. Waterjet cutting industry at home and abroad have started to develop a new type of cutting machine and cutting technology to meet the needs of large workpiece processing. In overseas, the Germany OMAX Corporation has developed a double-bridge, double-CNC high-pressure waterjet cutting machine, but this machine do not have expansibility. In China, Nanjing dardi water cutter Co., Ltd and Shenyang All-Powerful Science and Technology Corporation are aim in developing a multi-bridge high-pressure waterjet cutting machine. For large workpiece, we can reduce cutting time through increasing the number and the simultaneous work time of bridges. Under the determined number of bridge, we can increase the simultaneous work time of bridges by assign equivalent workload as possible for each cutting head (namely segment the technique drawing). If we segment the drawing manually will cause many problems, such as inaccurate, inefficient and not suitable for industrial production.

Based on the above-mention reasons, this paper take three-bridge high-pressure waterjet cutting machine as the platform and puts forward a set of drawing treatment rules to solve the shortcoming of the manual segmentation.

Three-bridge Waterjet Cutting Machine and Drawing Treatment Rules

The three-bridge high-pressure waterjet cutting machine, as shown in Fig.1, using suspended-type slide rail cutting head, each bridge carrying one cutting head, all cutting heads located in the same X-Y plane cutting table, share the same coordinate system. As shown in Fig. 2, because of the relation between any zone of three-bridge waterjet cutting machine and others zones only single edge and double edges overlapped, thus three-bridge have infinite expansibility.

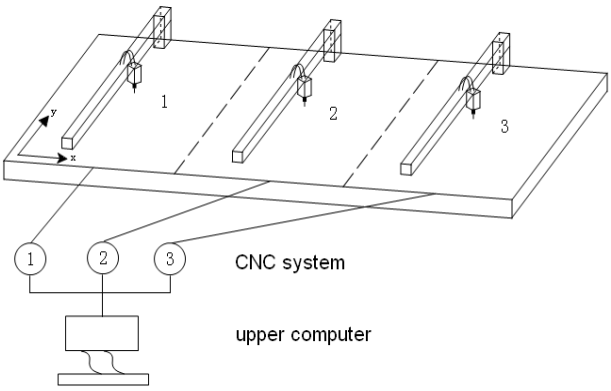

Fig. 1 Three-bridge high-pressure waterjet cutting system

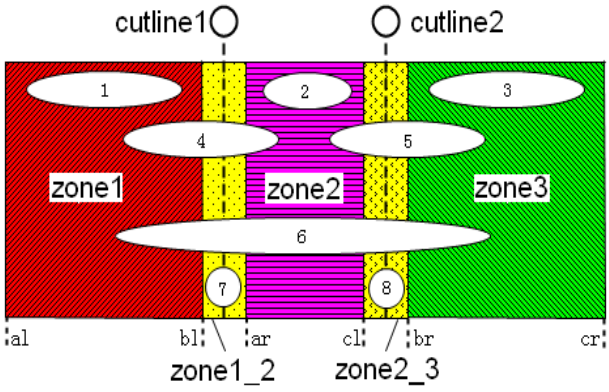

Fig. 2 Technique drawing treatment rules and parts distribution schematic diagram

Working Principle of Waterjet Cutting Machine. First, segment the technique drawing of workpiece by ObjectARX application program. Using CAD/CAM software, translate the processed drawing to NC code. Add coordination code. Then, pass the NC code to CNC system by WinDNC. At last, start CNC system to machine workpiece.

Drawing Treatment Rules. Drawing treatment rules shown as follows: According to the Fig. 2, cutting table was divided into five parts: zone1, zone2, zone3, zone1_2 (zone1 and zone2 overlap) and zone2_3 (zone2 and zone3 overlap). zone1, zone2 and zone3 represent the work range of cutting head 1, cutting head 2 and cutting head 3 respectively. zone1_2 refers to the mutual range of cutting head 1 and cutting head 2, the same as zone2_3. xl and xr (x = a,b,c) are right and left boundary of zoney (y=1,2,3). cutline1 and cutline2 are directrix to segment drawing. According to the distribution of graphic element (see ellipses in Fig. 4), it can be divided into eight kinds. We have prescribed that: workload of cutting head 1 was graphic element 1, graphic elements 4 and graphic elements 6 in the left part of cutline1, graphic element 7; workload of cutting head 2 was graphic element 2, graphic elements 4 in the right part of cutline1, graphic element 5 in the left part of cutline 2_3, graphic element 6 between the cutline1 and cutline2; workload of cutting head 3 was graphic element 3, graphic elements 5 and graphic elements 6 at the right part of cutline2, graphic element 8. The way to assign workload for cutting head was the drawing treatment rules.

Reflection of Dynamic Treatment. According to drawing treatment rules (see 2.2) which defined as static drawing treatment, cutting heads can only achieved equivalent work range rather than equivalent workload. An example of static drawing treatment was shown in Fig. 3. Workload of third cutting head is too small, compared with the cutting head 1 and cutting head 2. Therefore, based on the static drawing treatment, this paper proposed a dynamic drawing treatment which selected the distribution range of drawing as segmentation framework. Then, segment the same drawing (Fig. 3), cutting heads can achieved equivalent workload as possible, as shown in Fig. 4.

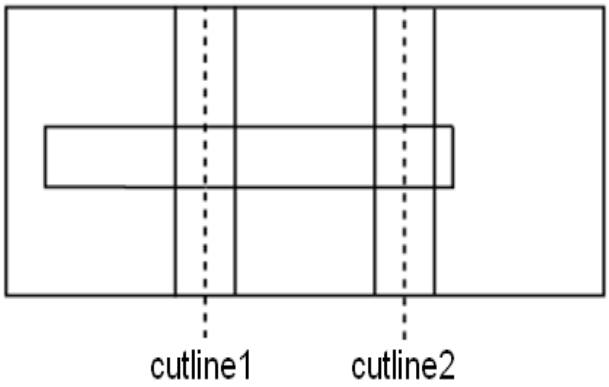

Fig. 3 Static drawing treatment

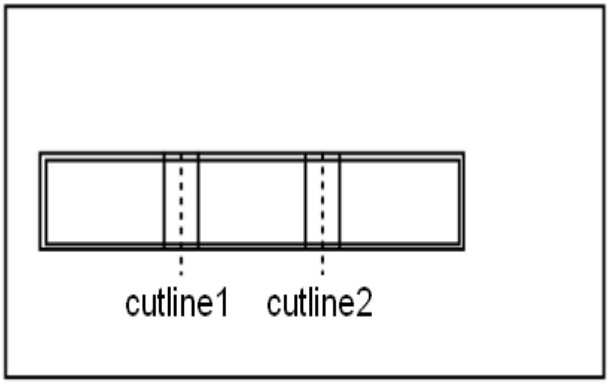

Fig. 4 Dynamic drawing treatment

Realization of Dynamic Drawing Treatment

Considering the reality of waterjet cutting machine, the rules of dynamic drawing treatment was extended. For example, if we need to cut a small circle and one cutting head can complete, then drawing not need segmentation. We assume the length of cutting table was 3000 and width was 2000. Situation 1: $X_d \in (1200,2100]$ (X_d is the length of technique drawing), technique drawing can be divided into two parts. Situation 2: $X_d \in (2100,3000]$, technique drawing can be divided into three parts. When $X_d \leq 1200$, not segment.

The introductions of drawing treatment flow——take the drawing extraction of cutting head 2 for instance, was shown in Fig. 5. Customized command "pt" used to process special graphics, such as blocks, region and wipeout. Execute "init()" can obtain the value of xl and xr (x = a,b,c), cutline1 and cutline2. Function "trimb()" is the core part of graphic extraction, it calls the internal commands of AutoCAD to trim graphic element 4, 5 and 6.

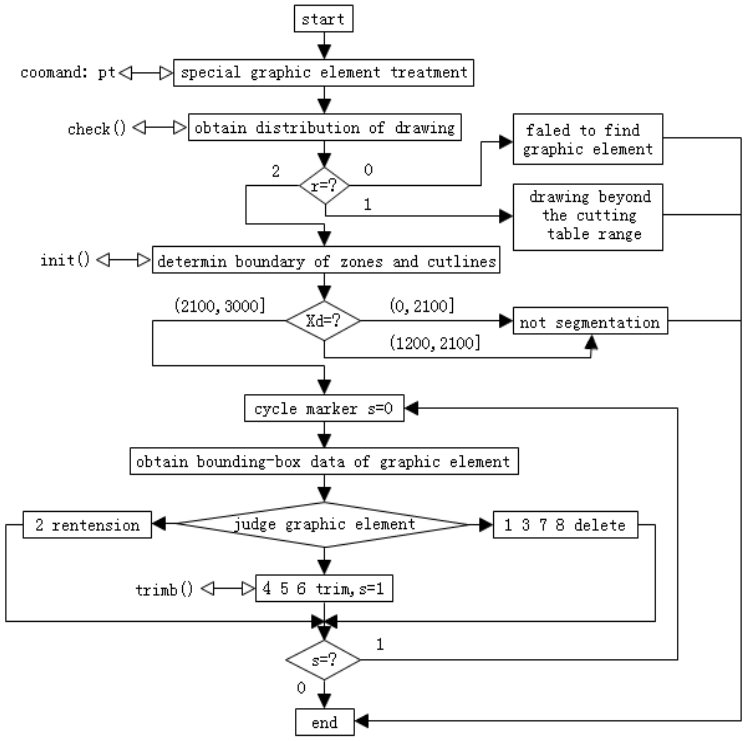

Fig. 5 Graphic extraction flow of cutting head 2

Example Verification

According to the size of technique drawing of workpiece, two experiments have been taken to verification dynamic drawing treatment. Fig. 6 to Fig. 14 were intercepted from AutoCAD in the process.

Situation 1: The original technique drawing (Fig. 6) divided into Fig. 7 and Fig. 8. Fig. 9 was shown the restored technique drawing. By comparison, the segmentation point coordinates of closed graphics were same, indicating that segmentation was accurate and effective. Meanwhile, command bar output "bl = 1072.534, ar = 11372.534" to provide data for future work.

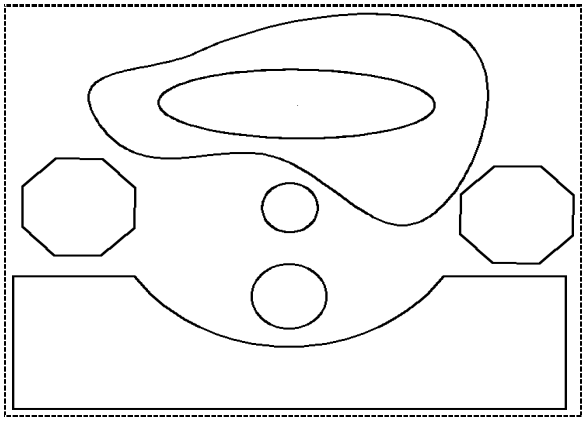

Fig. 6 Original technique drawing

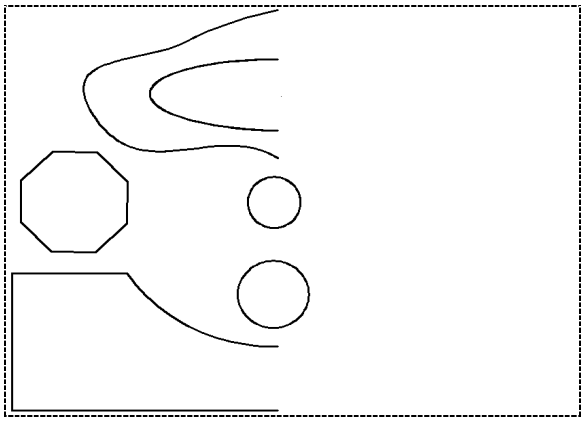

Fig. 7 Workload of cutting head 1

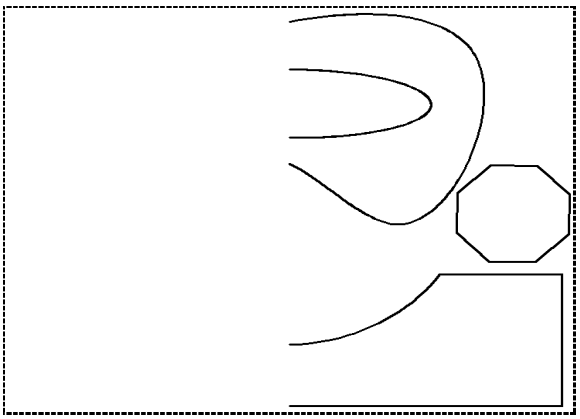

Fig. 8 Workload of cutting head 2

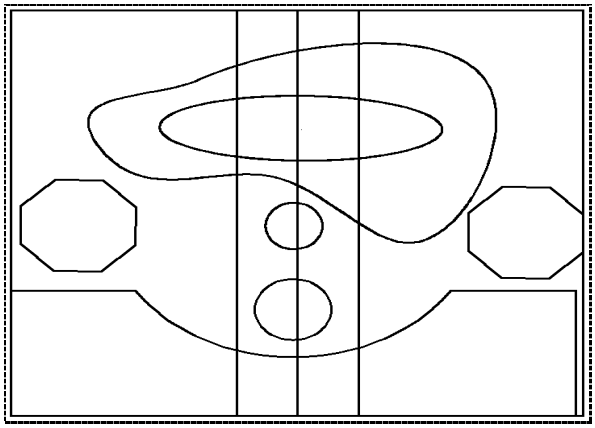

Fig. 9 Restored technique drawing

Situation 2: The original technique drawing (Fig. 10) divided into Fig. 11, Fig. 12 and Fig. 13. Fig. 14 was shown the restored technique drawing. In Fig. 13, command bar output "a3=985.652, c3=1997.673, b3_l=1285.652, b3_r=1697.673".

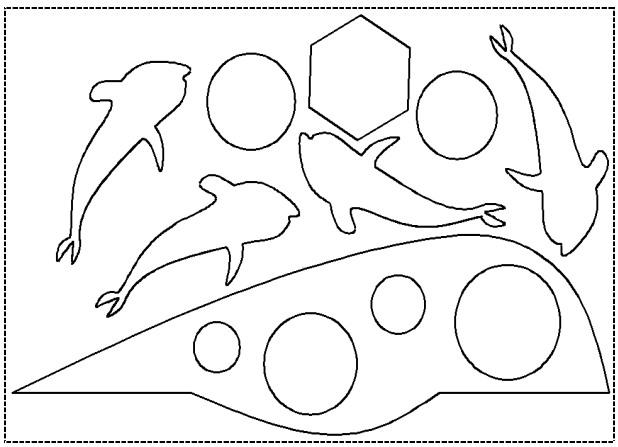

Fig. 10 Original technique drawing

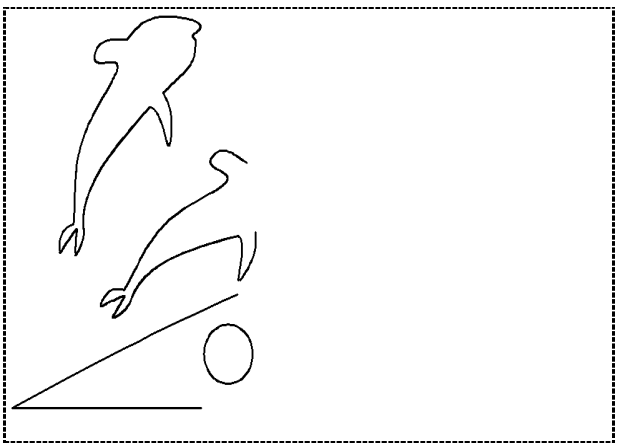

Fig. 11 Workload of cutting head 1

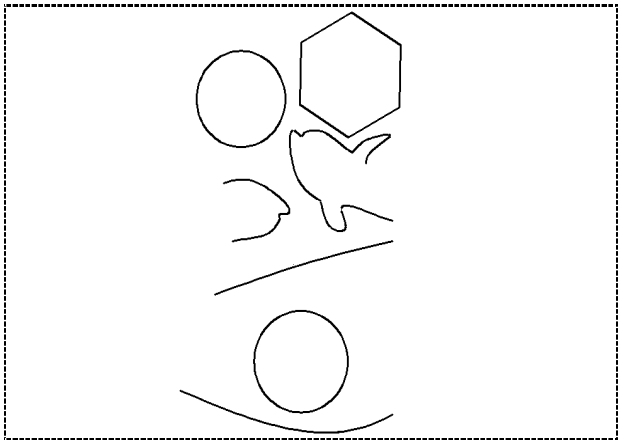

Fig. 12 Workload of cutting head 2

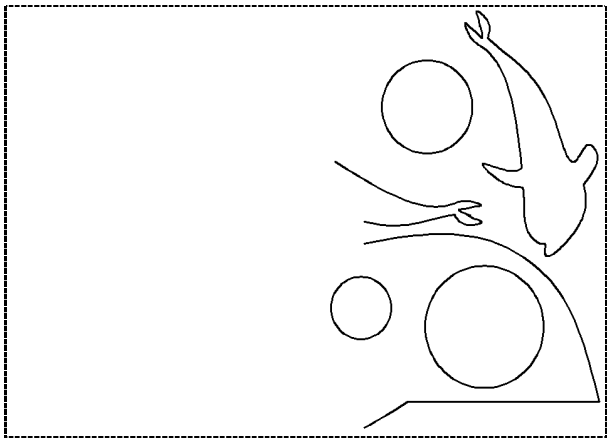

Fig. 13 Workload of cutting head 3

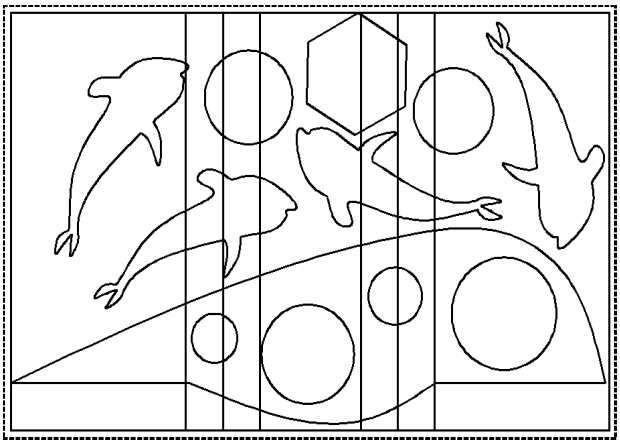

Fig. 14 Restored technique drawing

Conclusion

In this paper, two schemes of graphical treatment of three-bridge high-pressure waterjet machine (static drawing treatment and dynamic drawing treatment) have been comparative analyzed. Taken drawing extraction of cutting head 2 for instance, according to the dynamic drawing treatment rules, the flow of dynamic drawing treatment were explained in detail. Finally, the customized menu command of AutoCAD which written by ObjectARX were used to complete drawing segmentation and that has been verified by experiments. Results shown that dynamic drawing treatment was feasible, it completely resolved the shortage of manual graphical treatment and provided data support for future coordination control of cutting heads at the same time.

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