Bull. Mar. Sci & Tech 9:1, 2000
Research Institute of Marine Science and Technology
Korea Maritime University

International Journal Of Ocean Engineering and Technology
3:2, 2000

Research on the Object-Oriented Welding Information System for Shipbuilding

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(Received 14 July 2000, accepted 20 September 2000)

ABSTRACT: *Welding is the major manufacturing process in shipbuilding industry and has a great influence on the productivity and quality of ship construction. Shipbuilding process needs a lot of information and welding information is the important part of it. Welding information is required throughout entire shipbuilding process, from design stage to the final erection stage. This paper aimed to develop a welding information system to provide the suitable information necessary for each stage of shipbuilding in an easy and rapid way. For this work, the properties of the welding information used at each stage of shipbuilding and the information flow were analyzed systematically in the viewpoint of the object-oriented paradigm. Welding information distributed in various sources such as classification society rules, practices and standards of a shipyard was integrated into the object-oriented information model. To get the high effectiveness and extensibility of the information system, database system was combined with the information model. Estimation of the quantity of welding material consumption, joint design standard, guidance for welding technique and welding procedure specification are the main output of the information system. Event-driven programming technique and graphical user interface were used to give the richer interactive user environment and the flexibility of the application.*

KEY WORDS: Object oriented model, Welding, Shipbuilding, WPS, Information system, Database

1. Introduction

Shipbuilding is a highly integrated technology and belongs to fabrication industry. A ship consists of several hundred thousand of members. They are made by many kinds of material processing method and fabricated each other by welding. Shipbuilding process goes with a great information flow. A lot of information is required at each stage of shipbuilding process and they are closely related to each other. Therefore, an integrated information system is a very important tool to improve the productivity and quality in shipbuilding. Welding information is a major part of fabrication information. It is used over almost all stages from design to erection.

This research aims to develop an object-oriented welding information system for shipbuilding. For this work, the types and the characteristics of the welding information for shipbuilding were analyzed from the viewpoint of object-oriented method. The flow of welding information and its relationship to other information were also investigated. To describe and process this welding information, a suitable object-oriented data model combined with relational database was proposed from these works. The proposed data model consists of two base objects, the member object and the joint object, and the innumerable derived objects from them[1]. The data which each object contains are saved in the database.

The various combinations and operations of these objects according to the users requirements or classification rules give the useful welding information such as welding material consumption, welding procedure data etc. by calculations or data searching.

The welding information which is distributed in the different stages of design and production is integrated into this object-oriented data model. This model can be easily connected to the other information of the design and other fabrication stages. It can be used as a part of CIMS (Computer Integrated Manufacturing System) for shipbuilding.

1.1 Characteristics of Welding Information in Shipbuilding Process

Most of welding information in shipbuilding is given in the design stage although it is used in the fabricating stages after the ship design stage. The ship design cycle can be subdivided into four steps: concept design, basic design, detail design and production design. Each design step is directly related to stages of the shipbuilding process. The drawings and documents at each step are made by the correspondent design group such as hull form design group, structural design group, outfitting design group, etc.[2].

Providing welding information is a part of the work of the structural design group. Welding information is prepared in line with ship structural design process, and inserted in the structural drawings step by step.

In general, a shipyard has several standards or guideline booklets for design and construction to get a lot of welding information more accurately and more comfortably. These publications are referred throughout the entire shipbuilding process.

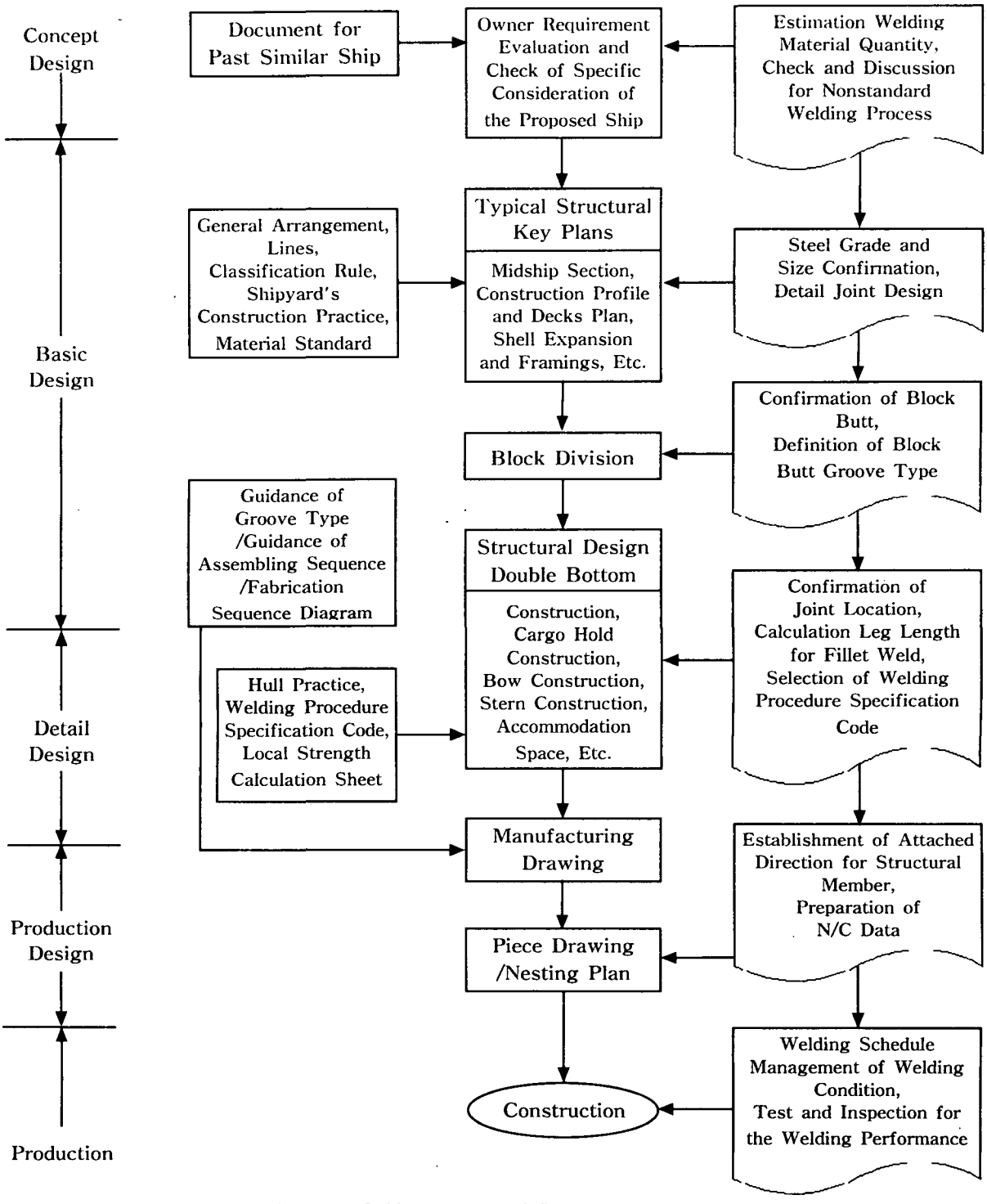

Fig. 1 Design step of ship structure and flow of welding information.

1.2 Flow of Welding Information in the Shipbuilding Process

The complete ship structural design process and the corresponding welding information is shown in Fig. 1. Each design step has a different task and requires a different welding information. Concept design deals with the topology and overall geometry of the structure. Overall structural layout and principal dimensions are determined by general requirements such as beam and draft limitations, cargo capacity and others rather than by structural considerations. At this step, the quantity of welding material consumption is estimated and the information for special welding joints of the nonstandard structural members is also

considered. Structural engineers communicated with hull construction production engineers concerning requirements for nonstandard structural joints.

The main works at the basic design step are the scantlings of all main structural members, drawing up the key plans and some naval architectural calculations. Size and scantlings of hull structural member is determined on the basis of rules and regulations of classification societies. The welding information decided at this step includes selection of appropriate steel grade, location of erection butts and seams and detailed joint shape for the major structural joints.

Detail design is concerned with standard building block, which should be heavily dependent on the shipyard practice and facilities. The information generated at the basic design step is refined at the detail design step, and the amount of detail information is greatly expanded. The leg length of fillet joints, joining location of each component and welding procedure specification code number or symbols are given at this step.

Production design is to complete the detail design and to prepare shop drawings used for the actual construction of the ship. All the joints which are not yet defined in the previous steps are supplemented. The instructions for parts fabrication and assembly are inserted in the shop drawings. At this step concrete welding procedure data which include welding sequence, welding conditions and inspection method should be provided[3].

1.3 Documents for the Welding Information for Shipbuilding

Welding information for shipbuilding is distributed in the various documents. The classification rule is the most important reference for the ship design. It does not, however, cover all design aspects, therefore, other materials besides the classification rule and various categories of information are necessary for the structural design.

The goal of design and engineering is reduction of the production cost and it can be realized through standardization of design and construction practice which comes from the accumulated experiences and data. The standards are developed to accomplish the high design performance and quality. They can be used as a tool to convey the design information to the shop in concise manner. Selection of appropriate material, detail design of the joint and matching of quality assurance requirement are the main part of them. It is possible to design more reliable hull structure in a simple and efficient way by use of the standards.

Technical criteria and design guidelines concerning the welding information are formulated in the classification rule, the shipyard's hull construction practice and the standard welding procedure specification booklets.

i) Rules for regulations of Classification Societies

The classification society rules prescribe some requirements to ensure the hull strength, that is, steel grade and scantlings of structural member, rough guidelines of structural details, suitable welding materials, kind of fillet weld and fillet weld size. These rules are referred as a part of standards for design and construction throughout the entire shipbuilding process. Technical considerations and useful information for welding in the classification rules are usually incorporated in shipyard's practice to simplify design procedure and to eliminate time- consuming works

ii) Shipyards hull construction practice

This document is made in order to overcome an undesirable situation in shipbuilding procedure, such as repetition of the same work, errors in fabrication. It contains the valuable information and guidelines for the overall ship design and construction process, such as various symbols, abbreviations, joint details. Using this practice design process can be simplified and the design productivity can be greatly improved. For instance, it is very simple to choose the right size and shape of joint details for sound structural quality. Most of shipyard's hull practices include the welding practices which are described commonly in the form of welding symbol on structural drawings.

iii) Standard Welding Procedure Specification booklets

Standard welding procedure specification is a document that includes the correspondent certification code number, and the detailed welding information, that is, groove shape, welding process, welding material, welding sequence, welding conditions and heat treatment. It serves also as one of the quality standards for hull structures. All of the welding techniques and data included in this document must be verified through the performance qualification. Welding procedure specification and performance qualification should be certified also by the classification society.

2. Modeling of Welding Information for Shipbuilding

2.1 Target and Scope of Modeling

For modeling of welding information the above-mentioned properties of welding information for shipbuilding must be considered and its target and scope should be decided to be able to realize the practical welding information system.

The target and scope of modeling in this research are as follows:

(a) The information model of welding should be consistent with the flow of ship design information.

(b) The applicable scope of the pilot information system is confined to two unit blocks for a specific class, a specific ship type and size.

(c) Database is built to store the standardized welding information.

(d) It is focused to generate and to retrieve the welding

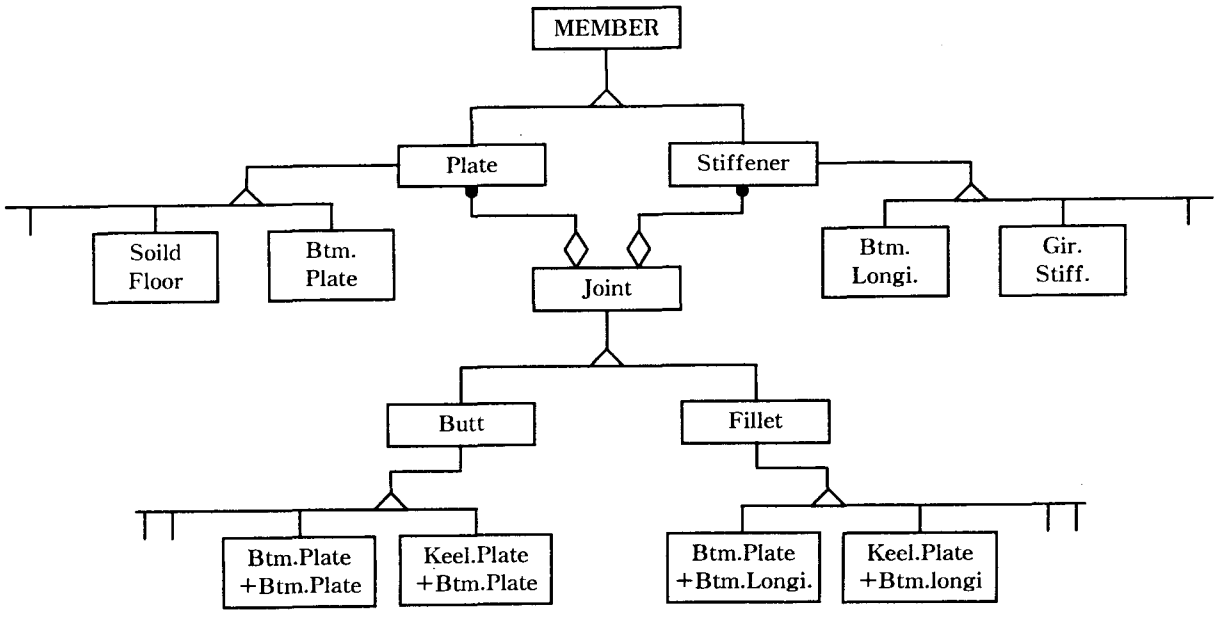

Fig. 2 Hiearchy of objects and their aggregation relationship

information itself rather than the information which belongs to the ship design or construction

(e) The welding information served by this system is joint shape and dimension, welding process, welding sequence and techniques, code no and data of welding procedure specification.

2.2 Object-Oriented Information Model for Welding Information

The welding information model for shipbuilding consists of two basic objects and numerous derived objects from them.

The two basic objects are member and joint object. The member object is a basic unit composing a hull, while the joint object is a basic unit fabricating two or more pieces. The member object is divided into two object, plate and stiffener as its derived objects according to its geometric shape[4]. Hundred thousand of hull pieces are derived from one of them. They have the common attributes inherited from plate or stiffener object and their own information additionally given by their location in the ship, class requirements and so on. The joint object means a weld joint. According to AWS(American Welding Society), weld joints are classified into 5 types, butt, T, lap, corner and edge joint[5]. Roughly speaking in a viewpoint of shipbuilding, however, the weld joints can be composed of two types, butt and fillet. Each type of joint objects contains at least two member objects and a lot of information related to welding such as joint shape, weld process, weld size and length etc. Each object possesses a lot of operation functions which determine the attributes of the object from various sources. They transmit a useful information to other related objects also. Fig. 2 shows the inheritance hierarchy of the objects and their aggregation relationship which are represented using OMT(Object Modeling Technique) methodology suggested by Rumbaugh[6].

An object is created from a class which is a template for the object. The definitions of class for member and joint object and the derived ones from them are shown in Fig. 3.

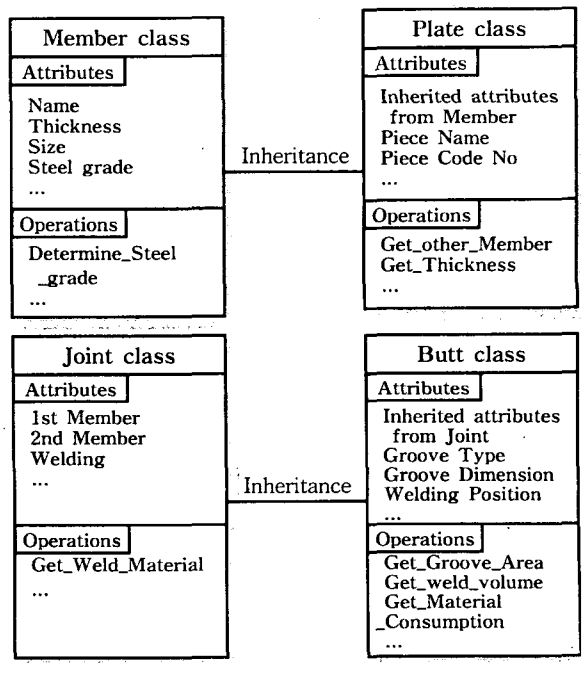

Fig. 3 Definitions of classes for member and joint object

2.3 System Description for Modeling

The final result of this system is the welding information which

contains concrete welding process, kind and size of welding material, welding procedure specification, the quantity of welding material consumption and other welding data. They are distributed in the several databases. They are searched from the databases and gathered into objects. They are presented as the final results through the modification and calculation processes according to the requirements of user. The components of the system is illustrated in Fig. 4.

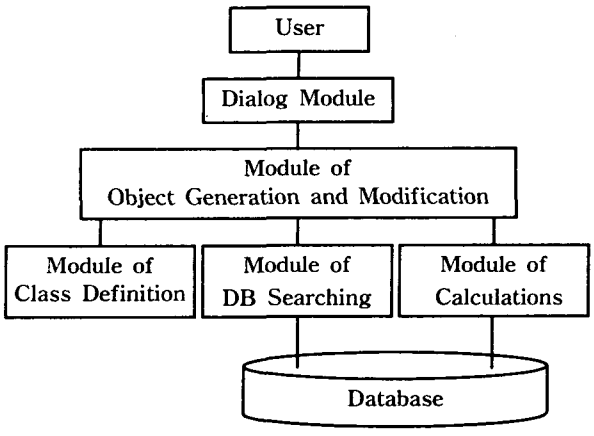

Fig. 4 System component

i) Selection of an unit block of ship structure

As the first step, an unit block of ship structure is selected to get the welding information for the selected block. At this step, load state, available welding processes and correspondent rule requirements are determined from the rule requirement database.

ii) Creation of joint and member objects

Joint objects are created by selecting the specific joints in the selected structure. At creating a joint object the member objects owned by the joint object are also created. The attributes of member objects such as member type, material type, thickness and size are determined from the values stored in the standard member database. These values can be changed according to the current ship type, size and owners requirements. The standard values of the joint object attributes such as joint geometry, welding process and position, welding material and weld length are obtained from the standard joint database. They can be also edited by the same reason as for the change of member attribute values. This creation process is repeated until all the joints in the selected block of ship structure are created.

iii) Creation of welding information

The final step is creation of welding information for the selected joints. This information comes from the various sources. Weld size and welding method of fillet and butt joint is given in the requirement of rule and regulation and hull construction standards. Some queries can be sometimes introduced to determine a definite solution of available choices. Welding procedure data such as welding condition, pre- and postheat treatment, back cleaning and so on are stored in WPS and PQR database. The estimation of the quantity of welding material consumption is calculated using the appropriate equation and the correspondent coefficients stored in the special database for this purpose.

3. Application Test of the System

The developed system was tested to verify the rightness and the usefulness of the output result. This system can be used double bottom and side hopper tank block in the midship section because the database of this system has only data of those blocks up to the present.

3.1 Development Tool and System Environment

The welding information system was developed using the following tools and system environment.

- Hardware: IBM PC compatible/Pentium
- OS: Windows NT
- Languages: Visual C++ and Visual FoxPro Language inclusive SQL
- Database: Visual FoxPro

3.2 Test of the System Step by Step

i) Selection of an unit block

Fig. 5 shows selecting an unit block of 5 unit blocks in the midship section of hull. When an unit block is selected, the correspondent rule requirements are searched from the database and the next detail drawing of the selected unit block is prepared.

ii) Creation of member objects

Member objects are created when a joint object is created. In this system all the member objects are created before the creation of joint objects for higher efficiency. The creating process of member object is shown in Fig. 6. The number on the drawing corresponds to a hull piece, that is, a member object. Clicking on a number creates a member object and enrolls it in the grid in the right side of the figure which contains the already created members. Steel grade or thickness of the created member objects may be changed as shown in Fig. 6. The non-standard members such as special brackets, collar plates and other auxiliary pieces, which are not presented in the drawing, can be also created.

iii) Creation of joint objects

The creation of a joint object by clicking on the number on the drawing is illustrated in Fig. 7. The type of member objects of a joint and the type of the joint are already known by its location in the block. The detail information is therefore entered only by determining a combination of the available members for the selected joint as shown in Fig. 7.

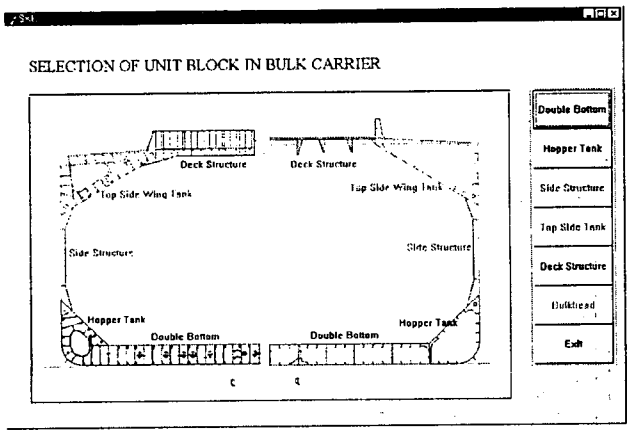

Fig. 5 Selection of an unit block of ship structure

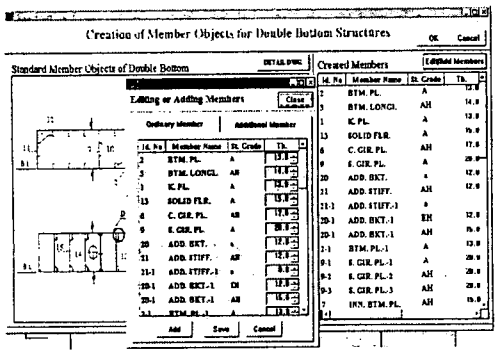

Fig. 6 Creation of member objects

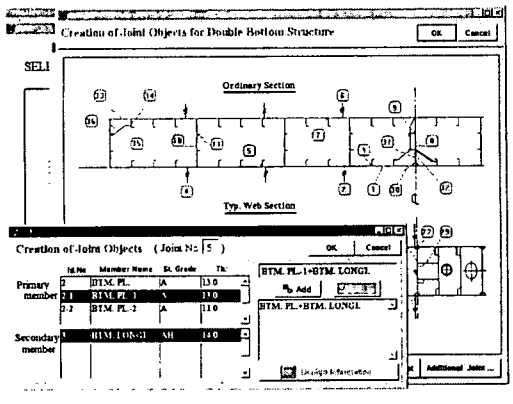

Fig. 7 Creation of joint objects

iv) Obtainment of welding information

The next step is to obtain the suitable welding information by searching the database and to assign it to the attribute values of the joint object. To get the detailed welding information, several dialog steps of query and answer are given. Groove shape, fillet weld type and fillet size, welding process, welding position, other welding techniques and compartment requirements are determined through the dialog processes interactively, as illustrated in Fig. 8. On the basis of these data, the concrete welding procedure data are searched from the database and presented as the final result, as shown in Fig. 9.

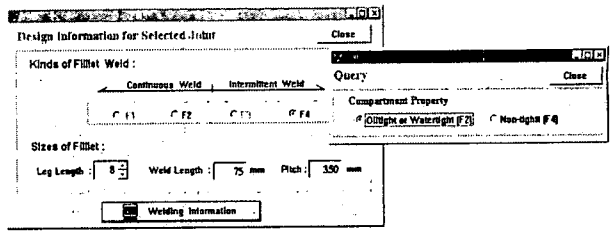

Fig. 8 Dialog for searching the welding procedure data

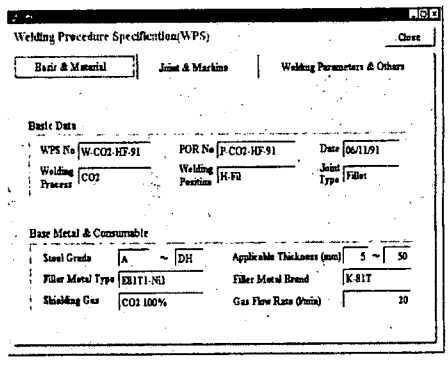

Fig. 9 The welding procedure data as the final result

4. Conclusion

Welding information is required over all stages of shipbuilding process and should be given at the design stage. Therefore, it is a very important task to develop the effective information system which is able to provide the appropriate welding information and to be easily used by a designer. This paper proposed an object-oriented information model combined with database system for welding which can give various welding information necessary for each step of shipbuilding. This information model consists of two basic objects and numerous derived objects from them, which contains a lot of properties and operations to store and to process the welding information. The welding information distributed in the various sources could be integrated by using this information model. The use of object-oriented technology and the integration lead to effective generation and easy handling of information, consistency of welding information with the information in various stages of for design and construction. Additionally, the database system connected to this welding information system made the storage of the vast welding data for shipbuilding and the easy and prompt search from them possible. In the future, the parametric modeling technique will be introduced into this system and CAD

system for shipbuilding will be connected to this system.

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