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Research Article

The Aviation Adaptability of the New Structure Framework Material

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Abstract: In this study, 0Cr15Ni5Cu2Ti, stainless steel sheet material with high strength is introduced to replace light metal of magnesium as aviation structural material. The research on heat process technology is emphasized and overall welding of 0Cr15Ni5Cu2Ti sheet is employed, adopting such methods as argon arc protection, anti-deformation technology of hot bending forming, special heat treatment technology, five-axis numerical control machining. It is the first time for the new material applied to the external measuring set with pylon-balance of aircraft in our country, overcoming the weaknesses of the aluminum framework in strength and meeting the needs of new airborne equipment.

Keywords: Aviation framework material, anti-deformation technology, aviation adaptability, overall welding

INTRODUCTION

With the development of science and technology in our country, stainless steel material of high strength has been adopted in aviation body framework. Compared with domestic aluminum alloy and common structural steel, this framework material is equipped with incomparable performance, which is recognized by domestic peers. The corresponding domestic material is 0C15Ni5Cu2Ti. The relevant divisions in our country have done a lot of work on the earlier stage of manufacturing the structure framework material, which laid solid foundations for producing raw materials (Liu *et al*., 2008).

Corrosion-resistant steel 0C15Ni5Cu2Ti with high strength is a kind of precipitation-hardening martensitic stainless steel. It is the first time for it exploited as the body structure material in the main structural equipment of aviation suspension launcher in our country. The framework is relative long, about 4m. Besides, because of the high demanding on its overall strength and strict control on its weight, such techniques are adopted as sheet metal forming, heat treatment, gang welding, machining forming. During the actual producing process, compared with other materials such as 1Cr17Ni2MoV, choosing this kind of material as aviation framework material gives rise to high strength, low elongation, local intense deformation with a tendency to crack, hard control on sheet metal deformation, deformation and unstable size after heat treatment. However, forming mechanism of these problems haven't been decided, restricting the popularization of the material in our country and affecting the progress of new engineering products and the cost of manufacturing enterprises. In order to find the internal relations among these problems and solve them, systematical research should be done on the variation mechanism of the internal tissue and performance during the processing of the material (mainly for sheet metal welding) under various circumstances (such as high and low temperatures, high overload, vibration and shock). In this way, realistic deformation laws and the first-hand effective data are to be found so as to improve its overall stability and strength, to overcome such defects as crack and distortion and to lay a theoretical foundation for promotion and application of this product. Through the implementation of this project, deformation laws during the process of the new material forming are sought to solve the key problems in current project and to provide a theoretical basis for finding causes after problem occurring, providing reliable technique support for the application of new aviation suspension launcher in new types of aircraft. Meanwhile, there is greater promotion value when this technology is applied to products in service. Under the precondition of weight controlling, strength, accuracy and load capacity are improved, which makes contribution to enhancing the level of aviation equipment in our country and narrowing the technology gap with advanced countries (Ye, 2001).

PERFORMANCE OF AVIATION FRAMEWORK MATERIAL 0Cr15Ni5Cu2Ti

The material chosen is precipitation-hardening martensitic stainless steel. The basic ingredients are: Cr 13.5-14.7%, Ni 4.8-5.8%, Cu 1.75-2.5%, Ti 0.03-0.15%, C no more than 0.08%, respectivly. In addition to martensite, the tissue still contains a small amount of austenite. Compared with other materials, its

Table 1: Sheet metal bending production process

Process headings	Production Contents and Process Parameters	Equipment and fixtures
Unloading	Cut in parts according to patterns	Steel plate shearer
Pre-heat	180°C for 20 min	Far infrared box resistance furnace
Spray	To spray the surface evenly with glass-protective lubricant JR-6 (0.05-0.08mm);To dry it for 12 h or more	
Hot-bending forming	Bend forming to spray the surface with animal oil	Special bending mold
Hot-bending straightening	1. To put the parts into heating furnace and to keep thermal insulation for 20 min after the furnace temperature reaches 960°C±10°C; 2. To take the parts out and cool them to 380°C, then carry on heat-bend straightening. To keep the parts in molds and take them out when cooled to room temperature.	Special mold
Cleaning	To remove surface dirt and clean with alcohol	

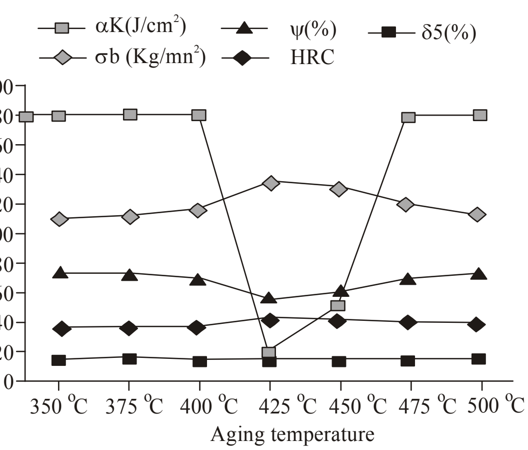

Fig. 1: Experimental result of aging and performance

Table 2: Test results of welding seams strength values

Sample No/. Performance	1	2	3
ϭb (Mpa)	1050	1040	1050
Ak (J)	24	24	26

performance is characterized with:

- High strength, which can be above 1200-1600MPa after age hardening
- Low plasticity, standard plasticity δ of 8-15% according to technical specification
- Good welding ability with high welding strength and small welding deformation, without the necessity of heat treatment after welding;
- Strong resistance to gas corrosion
- Strong resistance to impact, stress concentration and relatively low crack sensitivity

The above performance determines that the weak points of the material are high forming resistance, small deformation, severe resilience and hard sheet metal forming, while the advantages are strong strength, good welding, small deforming in welding, stress concentration and low sensitivity. Therefore, the material possesses potential advantages and broad application prospects in aviation industry.

Sheet metal shaping with hot bending: After repeated tests of plate bending, process technique suitable for actual situations has been worked out (Cheng, 2007) and the specific process route is as follows: raw material (solid solution state) → bending →aging → machining. The essential points are:

- Bend radius R≥3δ
- During its bending in solid solution state, if common bending mold is used in bending machine, bending cracks tend to appear. In order to solve this problem, we designed a special bending mold. It makes deformation area of the material become larger when employed on hydrostatic machine, which reduces the cracks produced due to excessive local deformation.
- When solid solution is air-cooled to 250-300ºC from 950 ºC, hot bending is carried on, which leads to good bending quality. Even in bending machine cracks are not easy to appear (Zhou *et al*., 2005).

Stability aging treatment: In order to compile heat treatment instructions and to provide a best specification guaranteed drawing for heat treatment, we test the performance of the material in different aging states. Test materials and state are bar materials, solid solution treatment (975ºC) +aging. The results are shown in Table 1, while the relation curve between aging temperature and performance can be seen in Fig. 1, which is also compared with that of relevant Russian materials. The performance data and regularity of data are basically the same, only ak somewhat low between 425-450ºC, respectively. The reasons are analyzed to be that:

- The test batch sample is processed roughly
- Their processing is not same. Russian materials are treated as 900-1000ºC, respectively hardening+650ºC tempering+950ºC hardening+ (-70ºC) cooling treatment+aging 1h. The sample is ₵200mm bar stock. The sample state: solid solution: 975ºC/50 min, air cooling; is aging: 2 h.

Table 3: Argon arc welding manufacturing process

Serial No.	Process headings	Production and process parameters	Equipment and fixtures
1	Assembling and temporary welding	To assemble and to weld temporarily	Temporary welding fixture
2	Cleaning	To polish and clean	
3	Assembling and temporary welding	Welding wire ɸ3.0, trade name S659, gas flow 6.0-7.0L/min, electric current 110-130A, butt gap≦0.1, allowed to not add welding wire	Assembling welding fixture equipment AEF-500
4	Electron beam welding	To weld with clamp, and to control deformation	Welding fixture
5	Repairing welding	Welding rod ɸ3.0, trade name S659, gas flow 6.0-7.0L/min, electric current 110-130A	Equipment AEF-500
6	Straightening	To straighten	
7	Defect detection	X ray examination, welding seam level II	X-ray machine
8	Rough milling	To mill core hole (as required)	Numerical control machine
9	Final straightening	To debur and to straighten as required	

Welding performance and welding process: The material contains low carbon content. The transformation temperature of martensite is close to room temperature and material of welding seams and of heat affected areas near them is low-carbon marten site with good flexibility. Both welding stress and deformation generated in welding process are very small. Accordingly, there is no tendency of welded joints to form heat cracks and cold cracks. Therefore, the material possesses good welding process. It is very easy to weld the stainless steel by using tungsten electrode argon arc welding and defect-free welding seams can be obtained without using a special welding process. Due to the long shape of the designed product framework, the sheet needs to be welded as a whole. Considering the above analysis, experiment is done by adopting common manual tungsten electrode argon arc welding method. In this respect, the performance of the material is much better than other aviation materials such as aluminum alloy.

Manual argon arc welding is exploited to weld. The solder is (resembling Russian) S-659 (HOOCr12Ni9Mo2Si) with temporary standard of GY06-00-2000. It possesses good welding performance and performance indicators of welding seam after welding are shown in Table 2.

The sample is $\delta = 3$ plate with the state of solid (solution) +450°C for 1h aging. It can meet the requirements of product drawings. With welding deformation into consideration, electron beam welding is also used for partial parts. Through the examination of the test piece, the strength value of welding seams can be $\sigma b \geq 1000$ MPa. The sample thickness is 3 mm and the sample plate is to be welded after it is in a state of solid solution +450ºC. And the Argon arc welding manufacturing process is shown as Table 3.

Due to the long shape of product framework, a segmented welding approach is adopted. Heat treatment leads to great deformation after welding structural steel materials originally made in China, which cannot guarantee the product requirements. 0Cr15Ni5Cu2Ti material is welded after it experiences segmented heat treatment and it is not necessary to go through heat treatment after welding. In this way, it not only guarantees the requirements of deformation degree, but also meets the requirements of drawings on performance. The application objectives are: to satisfy the requirements of product shape and size and performance technologically, to pass product qualification test finally and to meet the requirements of product on environment and mechanical property.

NUMERICAL CONTROL MACHING AND COMPREHENSIVE EXPERIMENT

Process route of solid solution→ machining → aging is widely used in machining, but using such material wears tools badly and the efficiency is low. Although at present it is still capable of overcoming this problem, more suitable tools are still needed. Meanwhile, both economy and efficiency improvement need to be considered. Parts manufactured by using Ocr15Ni5Cu2Ti material are tested in terms of environment and mechanical property along with the product. By now, such test projects have been carried on as damp heat test, high temperature storage test, static test and vibration test and there is no problem of the material in these tests.

CONCLUSION

In this study, importance is attached to research on hot bending process and overall welding stainless steel sheet material with high strength 0Cr15Ni5Cu2Ti is employed, which is applied to CLTP external measuring set with pylon-balance of a certain type of aircraft for the first time in our country. The framework of CLTP external measuring set with pylon-balance is hot-bending formed and cut by laser. And with the guarantee of special fixtures, methods like electron beam welding and argon arc welding are adopted to ensure the accuracy of the framework. Other methods like special heat treatment technology and five-axis numerical control machining are also used, overcoming the weaknesses of aluminum framework in strength. The external measuring set with pylon-balance manufactured has been verified and applied in a certain type of aircraft.

The requirements of product shape and size and performance are ensured technologically and the product finally passes qualification test like test flight and the material meets the requirements of product on environment and mechanical property. Through the implementation of this project, deformation laws during the process of the new material forming are sought to solve the key problems in current project and to provide a theoretical basis for finding causes after problem occurring, providing reliable technique support for the application of new aviation suspension launchers in new models of aircraft. Meanwhile, there is greater promotion value when this technology is applied to products in service. Under the precondition of weight controlling, strength, accuracy and load capacity are improved, which provides experience for the selection of structural materials of aviation equipment in our country.

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