# 船形高频腔壳体成型工艺研究 *

邢银龙[1,2],吴杰峰[1,3],裴仕伦[4],刘志宏[1],李波[1,3],刘振飞[3,5],马建国[1,5]

(1.中国科学院等离子体物理研究所,安徽　合肥　230031;2.中国科学技术大学,安徽　合肥　230036;
3.合肥聚能电物理高技术开发有限公司,安徽　合肥　230036;4.中国原子能科学研究院,北京　102413;
5.淮南新能源中心,安徽　淮南　232000)

**摘　　要**:大功率质子束加速器广泛应用在基础物理、核工业、家庭安全等领域,其中大功率波导型射频腔极为重要。船形射频腔具有最高的空载 $Q$ 值和分流阻抗,是 GeV 质子束加速器的良好选择。船形铜射频腔体的制造,主要难点在于腔体复杂轮廓壳体的成型,为此,本文对其进行了详细的成型工艺研究。通过 PAM-STAMP 2G 仿真分析软件对高频腔壳体进行了模压成型数值模拟,分别分析了椭圆弧成型过程中壳体的减薄量、残余应力以及成形回弹,为实际模压成型提供了理论依据。根据模拟结果设计的高频腔椭圆壳体成型模具能够成功实现椭圆弧的实际模压成型。

**关　键　词**:船形射频腔;复杂轮廓壳体;模压成形;数值模拟;PAM-STAMP 2G

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## Study on the Forming Technology of Boat-shaped High Frequency Cavity Shell

XING Yin-long[1,2], WU Jie-feng[1,3], PEI Shi-lun[4], LIU Zhi-hong[1], LI Bo[1,3], LIU Zhen-fei[3,5], MA Jian-guo[1,5]

(*1.Institute of Plasma Physics Chinese Academy of Sciences, Hefei 230031, China*;*2.University of Science and Technology of China, Hefei 230026, China; 3.Hefei Juneng Electric Physics High Technology Development Co., Ltd., Hefei 230036, China; 4.China Institute of Atomic Energy, Beijing 102413, China; 5. Huainan New Energy Research Center, Huainan 232000, China*)

**Abstract**: The high-power proton beam accelerator is widely used in basic physics, nuclear industry, home safety and other fields, and the high-power waveguide RF cavity is an extremely important component. The ship-shaped RF cavity has the highest no-load $Q$ value and shunt impedance, which is a good choice for GeV proton beam accelerator. For the manufacture of ship-shaped copper RF cavity, the main difficulty lies in the forming of the complex contour shell of the cavity, thus the detailed forming process research is developed in this work. Through the PAM-STAMP 2G simulation software, the die forming numerical simulation for the complex contour shell of the high frequency cavity is carried out, and the thinning amount, residual stress and forming rebound of the shell during the elliptical arc forming process are simulated respectively, which provides a theoretical basis for the actual die forming. The high frequency cavity elliptical shell forming mold designed based on the simulation results has successfully implemented the actual molding of the elliptical arc.

**Key words**: boat-shaped RF cavity; complex contour shell; die forming; numerical simulation; PAM-STAMP 2G

近年来,全球癌症患者的发病率逐年上升,与常规放射治疗相比,质子治疗具有准确度高、副作用小的特点[1-3]。为了扩大质子在基础物理、核工业、家庭安全、医疗等领域的应用,研究人员致力于研制能量为 ~GeV、功率为 ~MW 的质子束加速器,提出了一种圆形质子加速器复合体[4]。由于束流负载大,研制高 $Q$、高 $R$ 的数控大功率波导型射频腔以提高能量效率极为重要。通过对矩形、欧米茄、跑道和船形四种矩形波导射频腔的系统研究,发现船形腔具有最高的空载 $Q$ 值和分流阻抗,是

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**作者简介**:邢银龙(1988-),男,安徽省合肥市人,博士。　　**通讯作者**:吴杰峰,博导。

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