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摘 要

真空挤出机是建筑砖瓦等墙体材料制品塑性挤出成形的关键机械设备，真空挤出机挤出泥段的质量直接影响成型坯体的质量。目前真空挤出机挤出过程的理论研究还不成熟，并且发展缓慢，导致真空挤出机的设计、制造中还存在很多问题。在真空挤出机下级的挤出段时常出现绞刀轴断裂，而经机头和机口挤出的泥段则存在裂纹等产品缺陷，这些问题都严重制约着真空挤出机的使用和推广，进而影响着砖瓦行业的发展。因此有必要对影响泥料挤出质量的绞刀轴、机头和机口等挤出元件进行专门的研究分析，为真空挤出机的设计和改进提供理论依据和优化方案。

本文以 JKY95-65/60 型真空挤出机为研究对象，利用流变学、测量技术、有限元方法、计算流体动力学和优化设计等理论和方法，对挤出段的压力场进行了研究，并根据研究结果对挤出段内的绞刀轴进行了有限元分析，最后对与挤出段相连的机头和机口内的流场进行了流体分析。主要完成的研究内容包括：

(1) 对泥料的流变模型进行了研究，并运用 APDL 建立了真空挤出机挤出段中泥料的几何模型。然后通过对挤出段流场几何模型进行边界条件加载，在 ANSYS 软件的 Flotran 模块中对挤出过程中泥料的压力场进行了模拟，得到了真空挤出机挤出部分的压力分布，揭示了砖瓦泥料在挤出过程中的运动机理，也为下一步绞刀轴的有限元分析提供了参考。

(2) 根据挤出段流场分析所得压力结果，对影响挤出过程中砖瓦坯体质量的绞刀轴进行有限元分析，得出绞刀轴的应力和变形情况。找出了绞刀轴发生破坏的原因并对其进行形状和尺寸优化，并对优化结果进行了对比验证，得出了满足工况要求的最优几何模型。

(3) 在 Pro/E 软件中对真空挤出机机头和机口进行建模后导入 Workbench 下的 CFX 模块对流场进行了流体分析得到了速度分布。根据机口出口截面的速度分布找出了泥坯存在缺陷的主要原因，并据此对模型进行优化设计。通过优化设计得出了机头出口尺寸与机口出口截面速度差之间的关系，然后采用目标驱动优化设计得出了最小出口截面速度差下的最优机头出口尺寸，并对优化前后的速度场进行了对比验证。最后分析了机头和机口流场的表面压力分布，为机头和机口设计中的厚度尺寸等提供了一定的指导。

关键词：真空挤出机，绞刀轴，流场，优化

Finite Element Analysis and Optimization of Extrusion Component in Vacuum-extruder

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ABSTRUCT

The vacuum-extruder is the key mechanical equipment in building brick and tile wall materials products such as plastic extrusion. The quality of mud segment in the vacuum-extruder influences the quality of the shaping base directly. At present extrusion process theory research of the vacuum-extruder still immature, and development is slow, which lead to many problems in the design and manufacturing of the vacuum-extruder. Many product defects frequently appeared in extrusion region of the below grade of vacuum-extruder, such as breakage on screw, crack defect on shaping base in head and die for vacuum-extruder. These problems are severely restricts the use and promotion of the vaccum-extruder, then affects the development of brick and tile industry. So it is necessary to make a specialized research and analysis for the extrusion machine components that influence the extrusion quality of the mud materials, such as screw, head and die for vacuum-extruder. And this can provide a theory basis and optimization scheme for vacuum-extruder design and improvement.

Based on the model JKY95-65/60 vacuum-extruder, this dissertation researched the pressure field of the extrusion region synthetically applying of material rheology, measure technology, finite element method, calculate fluid dynamic and optimization and so forth theories and methods, and then made an analysis of the screw according to the results of the study, and made an fluid analysis of the head and die of vacuum-extruder which connected the extrusion region at last. The main study contents include:

(1) The mud rheological model was studied, and the geometric model of the mud in extrusion region of the vacuum-extruder was modeled with APDL. Based on these, the boundary conditions were loaded on the finite element model of the fluid field in the extrusion region, the pressure distribution was simulated in the Flotran module. The study revealed the movement mechanism of the mud during the process of extrusion, obtained the distribution of the pressure of mud, which provides a reference for the finite element analysis of screw in the next step.

(2) By means of loading the pressure distribution and corresponding restrains on the finite

model of the screw in the Workbench, the deformation, *von-Mises* equivalent stress and shear stress of the screw was obtained, that reveals the reason of the defects on the screw. Through shape improve, one optimal screw model was got, which meets the safety requirements in the operation.

(3) The head and die of the vacuum-extruder is modeled in the Pro/E and imported the CFX module of the Workbench to simulate the velocity distribution. The velocity distribution of the export section of the die of the vacuum-extruder reveals the main cause of defects on the shaping base, and then optimize the design of the model according this. Through size optimization, the relationship between the size of the head of the vacuum-extruder and the velocity of the export section on the die of the vacuum-extruder obtained, and then reached an optimal size on condition that minimize the velocity difference on the export section using the goal drive optimization design. The surface pressure distribution of the flow field obtained at last, and this can provide some guidance for the design of thickness of the model.

Keywords: vacuum-extruder, screw, flow field, optimization

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