Design and Key Structure Analysis of the Building Tile Making Machine

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Abstract

Based on the existing tile making equipment has a poor degree of mechanical integration and there are some problems with the stability of key structures,taking a new type of building tile making machine as the object of study,the main problems in the design of its structural parameters are determined,the mathematical model is used to analyze the physical characteristics of key structures,on this basis,the stability analysis of each key structure is carried out according to the principle of reliability interference,the analysis proves that the structure of this new type of building tile making machine is reasonable,and simulation experiments were conducted to determine its reliability, the research methods and results can provide theoretical guidance for lean design of key parts of building tile equipment.

Keywords

The building tile making machine;Tile making;Physical characteristics;Simulation analysis.

1. Introduction

The traditional tile process mainly depends on artificial, complicated links, long production cycle, this backward process can not meet the rapid, high-quality industrial and market requirements, followed by the rapid development of tile industry technology and equipment, but the degree of integration is currently in the primary stage of tile equipment is not high, and the key structure in the work the process is easy to interfere with each other for tile effect of efficiency and quality, and even the failure[1-4]. The research on tile making equipment in China mostly focuses on structure and function design, ignoring the influence of key structure on its production reliability, and the existence of short service life. [9-10]. At present, the research and analysis of the tile equipment and its key structure are relatively rare. Therefore, it is of great significance to study and analyze the equipment of the tile making.

In view of the above problems, designed a new type of building tile machine structure, with the main function of mud conveying, tile molding, tile delivery of three parts, the main part is conveying mud mud with grasping and conveying belt longitudinal dip into the mud; the key is tile molding molding; key tile conveying is tile crawling and discharging mechanism, structure of figure 1.

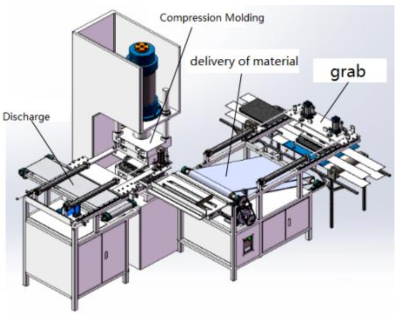


Fig.1 Structural Diagram of the Building Tile Making Machine

From the implementation of the mechanical integration into mud to link, significantly reduces the labor intensity and production cycle, analyzed the main parameters of the structure function design, the stress and the key influencing factors of the key structure using mathematical model is analyzed, based on the simulation analysis of its key structure using finite element analysis software, and explores the design of stability and rationality, reliability of the production was verified by experiments. Study on tile equipment is the high technology to transform traditional industry model, on behalf of the manufacturing technology of [9] gangwa advanced industry.

2. The Main Problems to be Determined in the Design of the Structural Parameters of the Building Tile integrated Machine

2.1 Determination of Main Problems of Slime Slab Grasping Unit

The adsorption force sucker is a key to the success or failure of grasping movements, effective absorption area A suction force is equal to the vacuum sucker sucker for p times, to provide sufficient adsorption force the design adopts multi suction side by side adsorption way of mud, according to the actual shape of the design layout as shown in Figure 2.

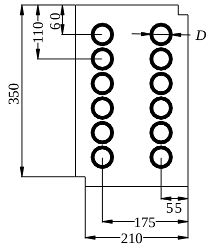


Fig. 2 Sketch Map of Arrangement of Suction Cups

The vacuum p in the suction cup can be determined by the following formula:

$$p \geq \left(\frac{8mgh}{t^2} + 4mg \cdot a \right) \Big/ \pi \cdot nD^2$$

The lifting height of the design is h=50mm, the lifting time is t=0.3s, the suction disc diameter is D=40mm, the quality of the billet is m=3kg, the number of sucker is n=12, the safety rate a=5 is taken into the upper form: then, the magnitude of the adsorption force is determined.

2.2 Determination of Main Problems in the Conveying Unit of Mud Billet

The transportation of billet is carried out by longitudinal feeding of the billet inclined angle, the inclination angle is 16 degrees ~18 degrees, the lifting height is 290mm, the belt speed is 0~2.7m/s, and the length of the billet is 370mm. Considering the overload and other reasons, the belt width 480mm is designed, the 55mm width is reserved on both sides, the diameter of the belt roller is 60mm, and the length is 500mm.

In order to accurately enter the platform after throwing the belt, it is necessary to analyze the throwing speed V of the billet. The influencing factors include throwing speed and horizontal angle a, gravity acceleration g and movement time t, and establish the motion model shown in Figure 3.

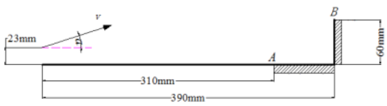


Fig.3 The Model of the Mud Slab

When the dip angle is a and the drop point is A point, V needs to be satisfied:

$$\begin{cases} -v \cdot t \cdot \sin a + \frac{1}{2} g t^2 = 0.023 \\ v \cdot t \cdot \cos a = 0.31 \end{cases}$$

When the dip angle is a and the drop point is B point, V needs to be satisfied:

$$\begin{cases} v \cdot t \cdot \sin a - \frac{1}{2} g t^2 = 0.037 \\ v \cdot t \cdot \cos a = 0.39 \end{cases}$$

2.3 Determination of Main Problems of Tile Forming Unit

The speed increasing cylinder is the driving element of compression molding. The main design size is set up: the diameter of the piston rod increasing chamber is d0=45mm, the inner diameter of the cylinder is D=160mm, the diameter of the piston rod is d=150mm, and the oil cylinder stroke is S=400mm. The key to the forming of the tile is that the lifting force of the cylinder should meet the load requirement, and the calculation formula of the lifting force when the cylinder rises is as follows:

$$F_t = P \cdot \pi \cdot (D^2 - d^2)/4$$

The range of the working pressure of P is 15~20MPa, the range was Ft lifting force is 36.5~48kN, a known load of the ascension is about 1.5kN, much more than the lifting load, meet the load requirements.

2.4 Determination of Main Problems of tile Conveying Unit

The key to tile transportation is the body grasping mechanism. The layout and parameter setting of suction cups are the same as those of the billet grasping mechanism. The difference is that the tile billet is grabbed by adjustable double row suction cups to grab the tile blank, and the double row suction cups grabbed by the billet are fixed.

3. Analysis of the Physical Characteristics of Key Structures

3.1 Analysis of Absorptive Capacity of Sucker

In the process of sucking the slime, the reset spring is always in the compressed state, and the slime grasping mechanism is reset under the push and pull of the compression spring. The reduction process is a reciprocating linear motion, and the acceleration is larger. The mud billet may fall off from the friction force of the sucker because of the speed change. The reset model is shown in Figure 4.

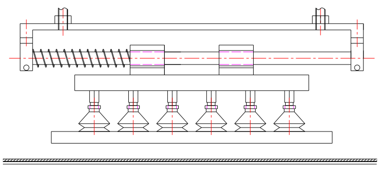


Fig.4 Resetting Model of the Gripping Mechanism

Speed change is the key factor [10] of slime reliability. Therefore, it is necessary to study the frictional force requirement of reciprocating linear motion to calculate the maximum acceleration Amax of clay movement. The calculation formula is as follows:

$$a_{max} = \frac{\mu \cdot n\pi D_1^2 p}{4m_1}$$

In the formula, M is the quality of the mud billet; it is the static friction coefficient of the sucker, 0.61 of the mu; the n is the number of the sucker; the D1 is the diameter of the sucker, and the P is the vacuum degree in the suction cup.

3.2 The Force Analysis of the Scratch Arm

The grabbing arm is the key structural part of the billet conveying and tile conveying unit. For the cantilever structure, its lateral spacing is L, which is affected by the whole grasping mechanism's self weight and the conveying cylinder pressure of the billet. The force analysis diagram is shown in Figure 5. The basic mechanical model is established, and the rotation function in the vertical direction is expressed as X. The maximum displacement function in the vertical direction of the grabbing arm arm beam is U (x). Then the expression of the shear lag warping displacement function U (x) of the grabbing arm arm beam is:

$$u(x) = \frac{R}{\rho}L(y,z)U(x) = \frac{R}{\rho}(M_{s0} - z\varphi_s(y))U(x) \quad \varphi_s(y) = 1 - \frac{(b-y)^2}{b^2}, \ 0 \le y \le b.$$

In the formula, x, y, Z coordinates for the grasping arm beam tile transverse and longitudinal and vertical direction; L (y, z) as the shape function of warping function; Ms0 bending moment, decided by the formula $\int_A \sigma_{sx} dA = 0$, and its value is:Ms0= (4h1tb)/(3A); to grasp the tile arm width; R arm bending radius is the radius of curvature; P, R-b≤ρ≤R

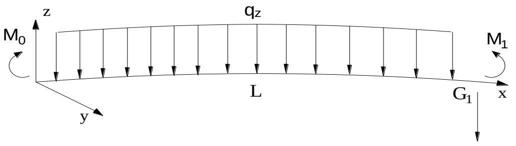


Fig.5 Stress Analysis Diagram of the Tile-Grabbing Arm

Considering the effect of twist angle deformation and shear lag effect on [11-12], the size of positive stress produced by the brachial arm beam structure is as follows:

$$\sigma_{sx} = E\frac{\partial u(x)}{\partial x} = E\frac{R}{\rho}(M_{s0} - Z\varphi_S(y))U^{'}(x)$$

The size of shear stress is:

$$\tau_{sx} = G\frac{\partial u(x)}{\partial y} = -G\frac{R}{\rho}\frac{d\varphi_s(y)}{dy}zU(x)$$

$\varphi_s(y) = 1 - \frac{(b-y)^2}{b^2}, 0 \le y \le b$; A is the area of the cross section of the brachial arm, and the young's modulus is E, and the G is the shear modulus.

The bending moment of the total vertical direction is:

$$M_y = -EI_y(\varphi^{'} - \frac{\theta}{R}) - EI_{sy}U^{'}$$

The corresponding positive stress size is as follows:

$$\sigma_{za} = \frac{R}{\rho}[-Ez(\varphi^{'} - \frac{\theta}{R}) + E(M_{s0} - z\varphi(y)U^{'}]$$

$$I_y = \int[(R/\rho)z]^2 dA, \ I_{sy} = \int_A (R/\rho)z(M_{s0} - z\varphi_s(y))dA.$$

3.3 Natural Frequency Analysis of Mould Press

Molded frame is the key structure of tile molding, pump motor and the frame body is fixedly connected with the rigid molding, easy to cause the motor vibration molded frame frame structure to avoid resonance, resonance caused by the deformation of the frame body natural frequency analysis[. Molded frame body by vibration influence is the largest part of the top three side position, for the calculation of the resonance frequency of the frame body, the frame body can be molded as a simplified frequency frequency calculation sheet model shown in Figure 6, to establish the neutral surface sheet as shown in the coordinate system, C, D, H said is in the process of vibration plate deformation in X, y, z direction.

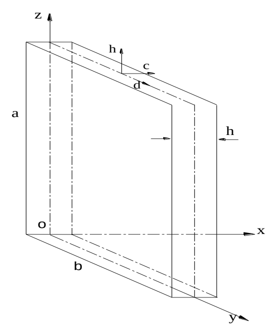


Fig. 6 Model Diagram of the Sheet

In the process of vibration, the displacement occurs in the direction of X. Based on the dynamic balance, the differential equation of free vibration on the X direction of thin plate is established.

$$D(\frac{\partial^4 w}{\partial x^4}+2\frac{\partial^4 w}{\partial x^2\partial y^2}+\frac{\partial^4 w}{\partial y^4})+\rho h(\frac{\partial^2 w}{\partial t^2})=0$$

The form of general solution is set by separating the variable:

$$w(x,y,t)=W(x,y)T(t)$$

$$W(x,y)=\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}A_{mn}\sin\frac{m\pi x}{a}\sin\frac{n\pi x}{b}$$

For a thin plate with fixed constraints on the edge, the maximum potential energy produced by the deformation is as follows:

$$U_{\max}=\frac{D}{2}\iint(\nabla^2 w)^2 dxdy$$

The maximum kinetic energy is:

$$K_{\max}=\frac{w^2}{2}\iint\overline{m}W^2 dxdy$$

The whole vibration process establishes the following equilibrium equations according to the law of conservation of energy: $U_{\max}=K_{\max}$, Thus the value of the natural frequency W of the plate in the vibration process is solved.

4. Simulation Analysis of Key Structure Reliability

4.1 Simulation Analysis of Reset Acceleration

For the verification process will not change speed of mud reduction resulted in the decline of the reliability of sorption problem, using AMESim on the mud reset mechanism simulation analysis, according to the actual condition of variable settings, set the mass 8.5Kg, viscous friction coefficient of 2N/ (m/s), 0.2N 0.17N, static friction, sliding friction coefficient of elastic spring reset, 650N/m, initial compression the amount of 40mm, 10-5s, 10s simulation, simulation time.

The simulation results are shown in Figure 7. From the graph, we can see that the maximum velocity of mud motion is 0.34m/s2, the maximum acceleration is 1.04m/s2, and the speed and acceleration are decreasing alternation, which satisfies the simple harmonic motion rule of spring under sliding friction. The results show that the maximum acceleration of the mud billet is less than the maximum allowable acceleration of the reposition of the mud billet. Therefore, the adsorption reliability of the mud billet meets the required requirements.

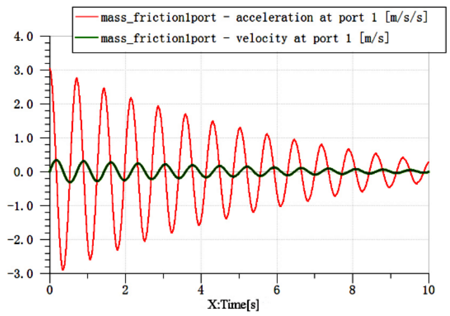
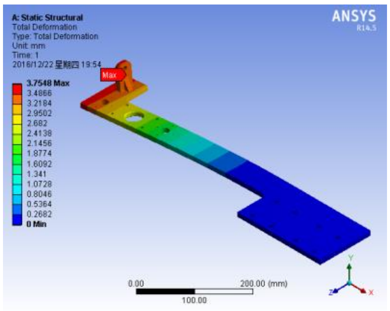


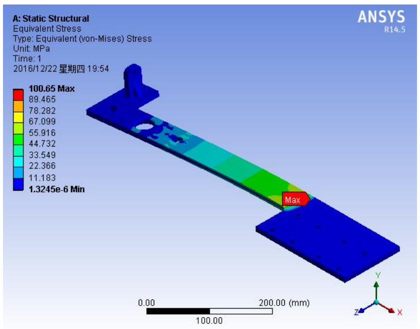
Fig.7 The Acceleration Curve of the Reset Velocity

4.2 Structural Mechanics Simulation Analysis of Scratch Arm

Catch the tile arm as the cantilever beam structure, the weight in the grab mechanism and tile billet conveying cylinder pressure will produce under the influence of local stress and strain, so it is necessary to grasp the tile arm structure static analysis to ensure its reliability, in order to avoid catching tile arm grab and other institutions contact interference, should also guarantee the catch w arm end deformation is less than 8mm. The analysis results are shown in figure 8.



(a)Total Deformation Cloud Diagram of the Tile-Grabbing Arm



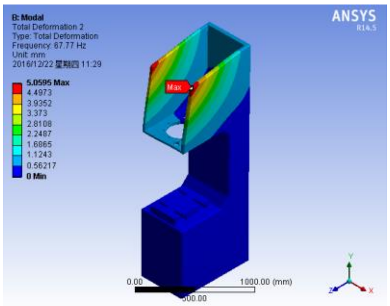
(b)Equivalent Stress Cloud Diagram of the the Tile-Grabbing Arm

Fig. 8 Static Analysis Results of the the Tile-Grabbing Arm

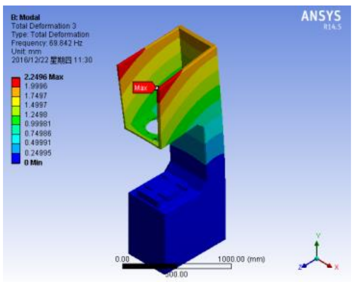
From the equivalent stress distribution results, the maximum stress appears in the fixed constraint and cantilever junction value is 100.65MPa, far less than the material yield strength Q235, meet the design requirements of strength; from the total deformation nephogram results, the maximum deformation position in the distal end of the cantilever, the maximum deformation is 3.7548mm, less than the allowable deformation 8mm, so grab a structure that does not produce interference. Through the analysis results, it is known that the design reliability of the grab arm meets the work requirements.

4.3 Model Simulation Analysis of Mould Pressure Frame

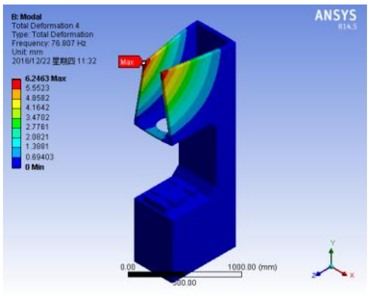
The results of the four - order modal vibration analysis of the moulded frame are shown in Figure 9.



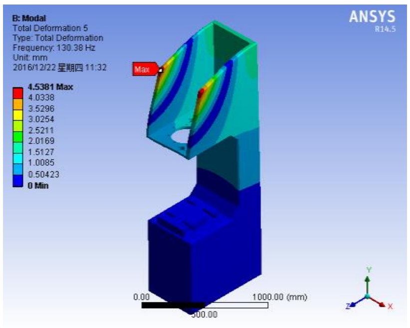
(a)One Order Vibration Pattern Nephogram



(b) Two Order Vibration Pattern Nephogram



(c) Three Order Vibration Pattern Nephogram



(d) Tour Order Vibration Pattern Nephogram

Fig.9 Modal Analysis Results of the the Mould Frame

The analysis results from the analysis of images: (1) the maximum deformation of the frame in three modes, the maximum total deformation is less than allowable deformation 10mm institutions; (2) the frame body deformation is mainly modal cylinder mounted bracket portion in the upper part of the frame body, the deformation of the molding mode the accuracy of impact; (3) a frame frequency is 67.77Hz, the excitation frequency of pump motor is 15~25Hz, so the motor vibration will not cause strong resonance molded frame. In a comprehensive analysis, the design reliability of the mould press meets the requirements, and the influence on the precision of molding is in the expected range.

4.4 Fatigue Analysis of Cylinder Cylinder

Cylinder cylinders are subjected to cyclic fluctuating load of oil pressure during operation, and work continuously for 24 hours. In order to ensure effective and stable molding work, it is necessary to analyze the fatigue characteristics of cylinder's cyclic load.

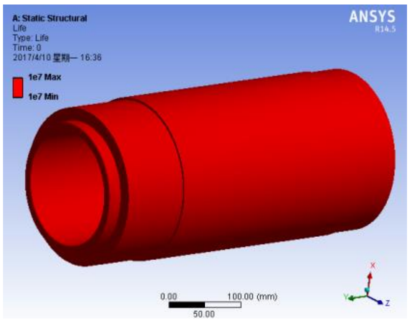


Figure.10 Life (Lifetime) Nephogram

Fig. 10 is the fatigue life chart. The life equivalent cloud chart obtained from the fatigue analysis indicates the working cycle times of the fatigue failure to the cylinder under the action of cylinder pressure. The fatigue life of the cylinder is minimum 107 times, which exceeds the design life value and meets the design requirements.

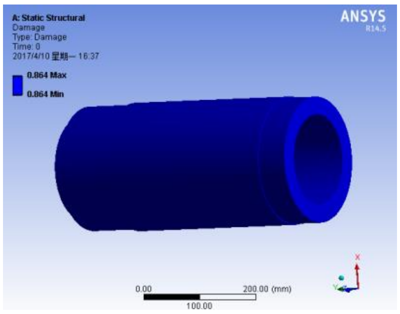


Fig.11 Damage Nephogram

Figure 11 is the structure cloud of fatigue damage. Fatigue damage cloud contour line refers to the ratio between design life and service life. From the graph, we can see that the maximum ratio of fatigue damage is 0.864, that is, where fatigue strength is the weakest, and its design life is still less than that of usable life, which indicates that there will be no fatigue failure of cylinder or crack during design life range.

5. Experimental Analysis

To catch tile experiments by the arm, shown in Figure 12, up to 400 times the confidence interval in number (two black curve) became smaller and the fluctuation is slow, this means that the number of simulations can fully reflect the characteristics of the subjects, the experimental data to summarize the actual building reliability of tile development pilot period grab after work. The maximum values of deformation appear before the 100 times of simulation, and then tend to be gentle. The maximum deformation is not 4mm, and the final stability is 1.5mm, which is smaller than the allowable form variable 8mm. This indicates that there will be no interference when the stress and variable shape are too large in the long term working condition of the grabbing arm, which will affect the normal operation of the whole machine, and it has high reliability.

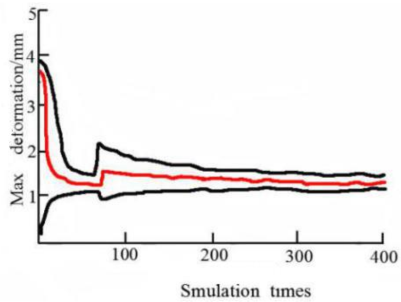


Fig. 12 Simulation Experimental Data Graph of the Tile-Grabbing Arm

Figure 13 is the oil cylinder fatigue sensitivity characteristic curve. According to the data in the chart, when the load change range is less than 135%, the service life meets the design requirement of 8.64 *106 times. This shows that the oil cylinder will not have too large deformation, meet the requirements of long-term work and have high reliability.

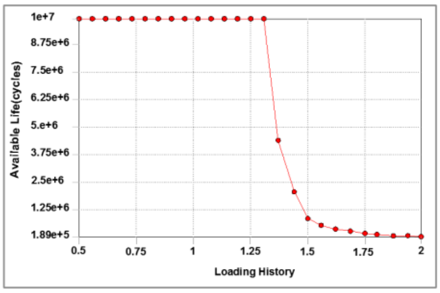


Fig.13 Fatigue Sensitivity Curve

In the tile production line workshop, the four workstations are placed in the building tile machine, and the blank pieces are processed and transported. Building clay all-in-one under the actual working condition of continuous work week, set up the confidence level of 0.95 for reliability test, data statistics show that: the strength reliability of 0.94, the stiffness reliability is 0.96, it shows that the clay machine has high reliability.

6. Conclusion

The design of a new type of building tile machine has greatly improved the mechanical integration level of the tile equipment, reduced the manual operation strength, and realized the breakthrough and improvement of the machine making equipment. The main parameters in the design are analyzed, and the structure design is completed. Analysis and study of its key structure stability, in combination with mud reset dynamics analysis, grasp the mechanics model of the arm and moulded body vibration frequency characteristic, the simulation of mud slab reduction and movement characteristics, verify chuck can reliably, sucking mud slab; The structural mechanics analysis of the grasping arm was completed, and the deformation amount of the grasping arm was verified. The modal analysis of the prestress is carried out to verify that there is no strong resonance with the motor. Then the fatigue strength analysis of cylinder cylinder under pulsation load is carried out to verify that the life of cylinder cylinder can meet the design requirements, and the fatigue failure will not occur. Through simulation experiment, the analysis of experimental data shows all the key structure and the whole machine has high reliability, the new construction system all-in-one structure stability can be guaranteed and the structure optimization design needs further research and analysis.

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