DYNAMIC MODELLING OF AIRCRAFT COMPOSITE METALLIC THIN-WALLED CONSTRUCTION SHAPING ELECTROMAGNETIC PROCESS

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The presented paper "Dynamic modelling of aircraft composite metallic thin-walled construction shaping electromagnetic process" reviews the axisymmetric blank assembly process with magnetic impact metal processing method. Shell junction formation process is divided into three basic stages: free shifting stage, consequent shifting stage and unloading stage. According to a numeric resolution of shifting equalities, a axisymmetrical metal composite formation process is modelled for each stage. On basis of the model developed, real time tubular jointment creation kinematics was studied from 0 time up to time of deformation process termination, i.e. creation of hermetic construction, that allows to determine time and speed characteristics of wall movement while pressing the aluminium blank. To learn magnetic impact assembly process, contemporary 3rd graphics systems are used.

Keywords: *dynamic modelling, electromagnetic process, aircraft CONSTRUCTION, free shifting stage, consequent shifting stage, unloading stage, 3rd graphics systems*

1. Introduction

The use of 3d modelling application suites allows to create complex models of geometry objects, as well as carrying out real time dynamic modelling technological process of aircraft construction, consisting of many parts. As versatile components Unigraphics, SolidWorks, Autodesk Inventor, 3DS and other software systems were used. Application of those software/hardware suites allows to automate complex system design process, while imitation modelling allows to track all the object parameters changes: their forms, dimensions, position, material characteristics etc.

2. Basics

Autodesk Inventor, 3DS and SolidWorks 3d design software systems were used to research impulse magnetic field assembly process kinematics. Use of these application suites allowed to create a wide class of axisymmetric shells with curvilinear generatrix, but moreover to model a real time deformation process. Different object categories, such as "Geometry", "Shapes", "Space Wraps" etc. were used to model 3d objects of complex geometry form, which includes axisymmetric shells with curvilinear generatrix, joint constructions, tools (inductors) for magnetic impulse deformation and equipment. Complex geometry models, consisting of multiple parts are created using this and other categories of 3DS and SolidWorks objects, as well as wide variety of precision modelling facilities. 3d models of tubular elements and axisymmetrical metallic composite joints with different generatrix form are listed below (Fig.1).

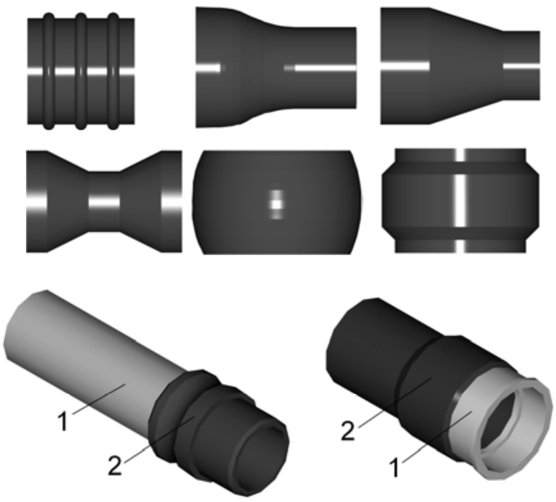

Fig. 1. Parts with tubular elements and axisymmetric joints with different generatrix form
1. – glass-fiber pipeline; 2 – aluminium tip

To evaluate magnetic impact assembly dynamic and kinematic characteristics the process of two aluminium tube connection was modelled, the process involves pressing external tube over internal with use of composite materials. According to the research, the most acceptable blank form is thin-walled cylindrical shell. At the same time, the primary condition for wall thickness is that field must not infiltrate through the blank wall and field infiltration depth depends on discharge rate and material’s specific electrical resistance factor. It is 0,7mm for copper and 1-2mm for aluminium alloy. Distance between blank and inductor is 3-4mm and radius of the blank is 15-20mm (minimal size). Thus with 1,5mm blank wall thickness and 40-50mm diameter we can consider that thin-wall and blank pressure equality conditions are complied. Constructions of selective lamellar inductors and variable working door inductors were used during modelling. Their constructions allows to change working diameter in range of few millimetres. This change is made to meet the need of geometry gap minimization and possibility to apply one device to deform different dimension-type shells.

Possibilities gained by use of these software suites allowed modelling 3d objects with granting the real shell deformation, imitating different power impact. Modelling was handled with use of keyframe-based animation principles for main stages of assembly process: free shifting stage, simultaneous shifting stage, unloading stage (Fig.2).

I. Freeform deformation stage (free pressing). On this stage external axisymmetric blank is formed [1].

$$\frac{\partial^2 B_1(t)}{\partial t^2}-\frac{a_1\pi}{2\sqrt{3}\rho_1\ln\frac{R_2}{R_1}}\ln\frac{1+\left(\frac{4b_1}{\pi\sqrt{3}}B_1(t)\right)\Big/R_2^2}{1+\left(\frac{4b_1}{\pi\sqrt{3}}B_1(t)\right)\Big/R_1^2}-\frac{\rho_0\cdot\Delta\cdot e^{-\beta}\cdot\sin^2(\omega)}{\rho_1\left[\frac{B_1(t)}{R_1}+\Delta\right]\ln\frac{R_2}{R_1}}=0$$

ρ_0 – conventional pressure;
Δ – the gap between inductor and blank;
ω – digit current circular frequency;
β – damping constant;
a_1 and b_1 – external tube material characteristics factors;
ρ_1 – external tube material solidity.

II. Joining and simultaneous active movement stage. Two parts are joined by means of external tube involvement in internal tubular blank, installed in mounting on that stage; i.e. this stage consists of pressing one tube over another [1].

$$\frac{d^2B_1(t)}{dt^2}\left[\rho_1\ln\frac{R_2}{R_1}+\rho_2\ln\frac{R_3}{R_2}+\rho_3\frac{R_4^2}{AR_3^2}\right]-\frac{a_1\pi}{2\sqrt{3}}\ln\frac{1+\frac{4b_1}{\pi\sqrt{3}}\frac{B_1(t)}{R_2^2}}{1+\frac{4b_1}{\pi\sqrt{3}}\frac{B_1(t)}{R_1^2}}-\frac{p_0e^{-\beta}\sin^2(\varpi)}{\frac{B_1(t)}{R_1}+\Delta}$$

$$-\frac{a_2\pi}{2\sqrt{3}}\ln\frac{1+\frac{4b_2}{\pi\sqrt{3}}\frac{B_1(t)-\Delta_1R_2}{R_3^2}}{1+\frac{4b_2}{\pi\sqrt{3}}\frac{B_1(t)-\Delta_1R_2}{R_2^2}}+\frac{v^2c^2\rho_3}{AR_3^2}B_1(t)-\frac{v^2c\rho_3R_2\Delta_1}{AR_3^2}=0$$

a_2 и b_2 – internal tube material characteristics factors;
$\rho_1\ \rho_2\ \rho_3$ – internal and external tube and mounting material density.

III. Reverse movement. On that stage, unloading of gained junction is made by means of potential energy, gained by blanks.

$$\frac{\partial^2 U_{разг}}{\partial \bar{t}_1^2}+L_{св}^2\cdot U_{разг}=G_{св}$$

$$L^2=\frac{\overline{E}_{1,2}}{\rho_{1,2}\cdot R_2^2(1+\alpha)}$$

$$\bar{t}_1 = \bar{t} - \bar{t}_0$$

$$G = \frac{\overline{E}_{1,2} \cdot \varepsilon_{1\max} - a_{1,2} \cdot arctg(b_{1,2} \cdot \varepsilon_{1\max})}{\rho_{1,2} \cdot R_2 \cdot (1+\alpha)}$$

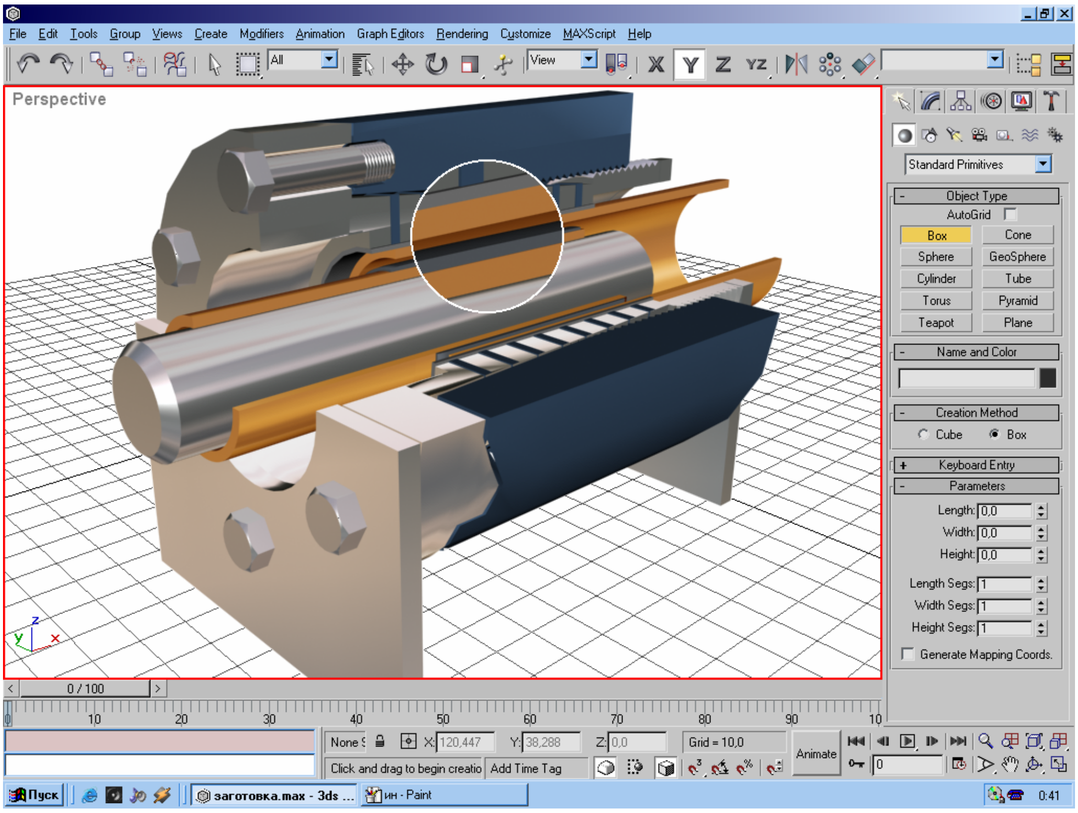

Fig. 2. "Pressing" external tube over internal with use of variable working door inductor in 3D stage

Modelling with use of animation principles is an automated process of image sequence, each of which shows some change in the assembly state. These changes affected mutual objects and subobjects position, their form, described by different modifications, deformations, object material properties, etc., i.e. modelling was handled considering physical characteristics of object surface materials, such as elasticity, static friction factor and sliding friction, as well as physical influence on objects, as pressure, imitated by volume deformation emitters, object collisions, which results depended on the speed of objects and physical properties of their materials [2]. Animation process automation consisted in assignment of parameters to be animated in key frames, which divided into interstitial and, according to them, time shifting diagram was created as an animation track. The project describes blank wall movement kinematics, beginning from 0 and finishing at time when deformation stops, i.e. when final joinment is made [3].

Conclusions

In practice, different methods are used to track and register blank ng and deformation in magnetic impact deformation process. However existing methods analysis showed that their use requires the use of complex equipment, further processing the results of shifting as well as vast amount of blanks, plant and tools exploitation. Using received time diagram of blank shifting we can find out their position in any fixed moment of time, thus, when permanent absolute deformation is determined by simple measurement of its diameter after pressing and having time-shift constraint chart it is possible to determine it's speed and acceleration by graphic differentiation. The performance of such system comes down to tracking all the process of joinment kinematics and to give recommendations about choosing the optimal axisymmetric joinment and constructions assembly mode made with magnetic impulse processing [4].

In that way, the use of systems (CAD/CAM/CAE) and technologies allows to create multilevel 3d models and model dynamic processes on all productions stages and complex construction exploitation.

References

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