guidelines for assessing satisfaction and improving the quality of services provided. In our opinion, special attention should be paid to sections of the standard. ISO 9000 is related to customer requirements because passengers are direct consumers of the service. Therefore, in the system of long-distance transportation, mechanisms for assessing customer satisfaction should be developed and applied.

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Analysis of designs of modern stretch-forming dies for lineforming aircraft skin

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Abstract

This article presents an analysis of the designs of modern stretch-forming dies both used in Russian enterprises and the experimental developments of scientists from China. The main purpose of the work is to determine the most promising and cost-effective designs of stretch-forming die for shaping the skin of the aircraft.

Keywords: stretch-forming process, aircraft, aircraft skins, the theoretical contour

The manufacture of stretch-forming parts has found a great use in aircraft construction due to the higher productivity, the rational use of the material, and a sufficiently high reproduction accuracy of the required dimensions and shape of parts.

Meeting the accuracy requirements of external contours of the aircraft with a significant increase in the size of the lineforming sheet airframe parts requires solving the problem of the choice of materials and the design of the bulk equipment – stretch-forming dies.

For decades, concrete and wood were used for the manufacture of equipment. However, most of these materials did not provide the necessary efficiency of tooling [1].

Stretch forming refers to the shaping processes of sheet metal forming associated with an increase of the surface area of sheet part due to the application of tensile loads to the sheet in two directions from the side of the clamping devices of the stretch-forming machine. The limiting factors are uneven stretching due to the influence of friction forces and shear deformations due to the complex shape of the shell of double curvature. If uneven stretching is the cause of unacceptable localization of the deformation of the sheet part, then the complex shape of the double curvature shell leads to shear deformations, leading to the formation of folds and an uncontrollable stretch formation.

At this stage of development of science and technology such constructions of stretch-forming dies are distinguished as:

- multi-sectional design of a stretch-forming die;
- topologically optimized design of the stretch-forming die, manufactured using additive technologies [2];

— design of universal stretch-forming die of variable geometry [3].

Let us consider these constructions in more detail.

1. The design of a multi-sectional stretch-forming die

This design is a frame or slab which a stretch-forming die is installed on, made of recycled aluminum casting (Fig. 1). To reduce the weight of the section the stretch-forming die has a hollow design.

Fig. 1. Multi-sectional stretch-forming die: 1 – the first section; 2 – the second section; 3 – frame or plate

The multi-sectional stretch-forming die is made from the waste of the machining production of aircraft the so-called secondary aluminum casting [4].

Advantages:

- High rigidity of the material, the modulus of elasticity $E = 72000$ MPa.
- The high resource provided with rigidity of material.
- Low cost of the material amounting to 0,093 \$ / kg [4].

Disadvantages:

- High dynamic coefficient of friction while stretch-forming. This value is due to the fact that aluminum-alloys of different chemical composition, as a rule, are the material of formable casings. On average, the friction coefficient of two different aluminum alloys is $\mu = 0.34$ [5].
- It is required to make a separate stretch-forming die for each metal shell of the aircraft.
- A large mass of the structure, an average of 2 tons [4].

Despite all its disadvantages this design is often used in aircraft manufacturing. The problem of high friction and ways to solve it were discussed in article [1]. Other disadvantages are solved by applying two other designs.

2. Topologically optimized stretch-forming die design.

This design is a topologically optimized design which can be made only with the help of additive three-dimensional printing technology (Fig. 2).

Fig. 2. Topologically optimized stretch-forming die design. Bottom view [2].

Topological optimization lies in the fact that in the most loaded places the structure has thick supports of complex geometry. At the same time, in not loaded zones the supports have a low thickness. Also, it is worth noting that the design is solid. In order to make this design, you must use three-dimensional printing.

It is necessary to consider the advantages and disadvantages of this design when using aluminum powder as a material, for example AlSi10Mg.

Advantages:

- High rigidity of the material, the modulus of elasticity $E = 72000$ MPa.
- The high resource provided with rigidity of material.
- Low mass of the structure, namely, less by $\sim 50\%$ than when using a multi-sectional structure.

Disadvantages:

- High dynamic coefficient of friction while stretch-forming.
- The high cost of the material which is $1,54\$ / \text{kg}$.
- It is required to make a separate stretch-forming die for each metal shell of the aircraft.

This design solves the problem of the high weight of the stretch-forming die. For this design and multi-sectional ones the problem of a large mass is not so acute. This is due to the fact that in any case such constructions must be transported to a stretch-forming machine using a bridge crane. This design is advisable to use only in enterprises with low-capacity crane beams, if you have equipment for three-dimensional printing of metal.

3. The design of the universal stretch-forming die of variable geometry

This design is a platform with a huge number of retractable rods, which are equipped with swinging ball heads that accept the geometry of the theoretical contour of the part. To avoid defects on the surface of the molded skin, polyurethane plates are also installed on the swinging ball heads [3].

Fig. 3. Fragment of the design of the universal stretch-forming die of variable geometry [3]

Advantages:

- According to the calculations made by the authors of the article [3], the construction has sufficient rigidity.
- The high resource provided with sufficient rigidity of material.
- Versatility means that it is no longer necessary to make a separate stretch-forming die for each aircraft skin.

Disadvantages:

- High dynamic coefficient of friction while stretch-forming equal to 0.57 [3].

The only disadvantage of this design is the high coefficient of dynamic friction. In the given article authors present a model and field tests. This friction coefficient value did not affect the surface quality of the finished skin. This is due to the extremely heterogeneous material use. While using a stretch-forming die from an aluminum alloy sticking of particles of a deformable metal occurs [4].

In conclusion, it is important to add that analyzing the advantages and disadvantages of the design of stretch-forming dies, it should be noted that the most advantageous design of the stretch-forming die is the design of a universal stretch-forming die of variable geometry. The use of this design will significantly reduce the labor costs for the manufacture of stretch-forming dies. This design is required to be transported to the stretch-forming machine once. As a consequence, the time and material costs of transporting the stretch-forming die are reduced.

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Air refueling without participation of pilots

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Abstract

In article problems of refueling of aircrafts, ways of their solution and also ways of refueling are considered.

Key word: refueling of aircrafts, automatic management system process of refueling of aircrafts.

Аннотация

В статье рассматриваются проблемы дозаправки воздушных судов, пути их решения, а также способы дозаправки.

Ключевые слова: дозаправка воздушных судов, автоматическая система управления процессом дозаправки воздушных судов.

The first aircraft flew for a short time, as they quickly ran out of fuel. So that the aircraft could fly for a long time without launching for refueling, in 1917 the Russian test pilot came up with a risky system of refueling the aircraft with fuel in the air. However, there is information that before there was a way to transfer cans of fuel from one aircraft to another with a long rope, but it was an inconvenient and dangerous way.

Then the Russian test pilot simplified a task, having created a special hose on which fuel from one aircraft on another by means of attracting force flew. That is, the aircraft with gasoline flew above other aircraft which was required to be filled, at the same time aircrafts flew slowly. Before it the hose needed to be caught and to manually insert its end into the fuel tank. Then the pumps simplifying refueling were not. Only by 1940 the hose was equipped with the pump, and refueling began to take place quicker. Thanks to refueling the aircraft can be airborne infinite time, of course, if the engine is operational and the pilot has a relief [1].