RESEARCH OF INFLUENCE OF THE FORM OF DETAILS ON ACCURACY OF ASSEMBLAGE

DETAĻU FORMAS IETEKMES IZPĒTE UZ SALIKŠANAS PRECIZITĀTI

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Abstract: ***In given article it is shown, that on course of assembly process, except for other parameters, the geometry of working surfaces of details influences too. To define the optimum form of edges compared three various variants. As a result of the analysis of forces of the friction arising between contacting details, have come to conclusion, that the optimum form is the edges with radius form.***
Also in article is shown, that from standard parameters of a roughness only two influence on accuracy of performance of assembly process, namely: arithmetical mean deviation of the profile (Ra) and mean spacing of the profile irregularities (Sm).

Introduction

Course of assembly process influences: a material of assembled details, character and technology of their manufacturing. But, except for the listed parameters on process of assembly the geometry of working surfaces of details also influences.

As criterion by definition of the optimum form joined surfaces - surfaces of friction we shall choose the force of friction arising between contacting surfaces.

Details (type a shaft - the cartridge) under the geometrical form of working surfaces, on their arrangement, and also on the friction arising between contacting surfaces, are similar to spherical support of sliding. Therefore at definition of the optimum geometrical form of working surfaces the formulas used at calculations of spherical support of sliding [1] are suitable.

Optimum form of details definition

The optimum form of details edges between which there is a dry friction, we establish, defining the moment of friction resistance - in an optimum case the minimal moment of friction should be provided.

$$M_{shaft\ resist.} = \frac{3}{16}\pi f P \rho = 0{,}407 f \cdot \frac{P^{\frac{3}{2}}}{\sqrt{\sigma_k}}, \quad (1)$$

where P – axial loading;
f – factor of friction;
ρ – radius of a platform of contact of a shaft with the cartridge;

$$\rho = 0{,}881 \cdot \sqrt[3]{P \frac{\left(\frac{1}{E_{shaft}} + \frac{1}{E_{cart}}\right)}{\frac{1}{r_{cart}} + \frac{1}{r_{shaft}}}},$$

where E_{shaft} and E_{cart} – modules of materials elasticity of a shaft and the cartridge;
r_{cart} and r_{shaf} – edges radiuses of a shaft and the cartridge;
$\sigma_{k\ max}$ – the maximal contact pressure on a platform of contact of a shaft with the

$$\sigma_{k\max} = 0{,}617 \cdot \sqrt[3]{P \frac{\left(\frac{1}{r_{cart}} + \frac{1}{r_{shaft}}\right)^2}{\left(\frac{1}{E_{cart}} + \frac{1}{E_{shaft}}\right)^2}} \quad (2)$$

Let's define the optimum form of edges for three variants: edges with radius form, “ideally” sharp edges and edges in the form of facets.

The first case: edges with radius form (Fig. 1). We shall calculate the moment of resistance of friction for the following settlement sizes: a material of assembled details steel ШХ 15; $P = 0{,}5$ кgf; $r_{shaft} = r_{cart} = 0{,}1$ cm; $f = 0{,}22$ [2]; $E_{shaft} = E_{cart} = 2{,}1 \cdot 10^6$ кg/cm^2.

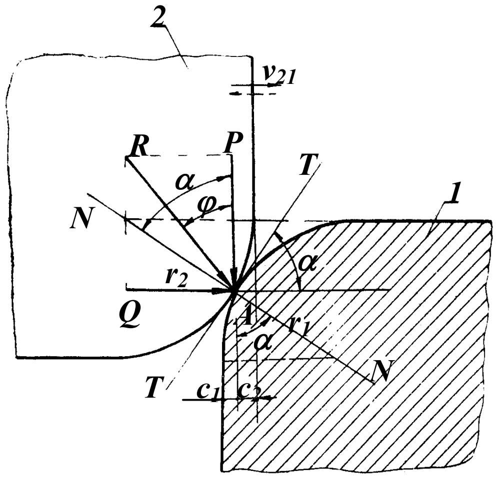

Fig.1. The scheme of details contact at which edges have the radius form.

After substitution in formulas (1) and (2) given sizes have defined, that the maximal contact pressure on a platform of contact of a shaft with the cartridge $\sigma_{\kappa\ max} = 37{,}275 \cdot 10^3$ кg/cm^2, and the moment of resistance of friction $M_{shaft\ resist} = 1{,}6396 \cdot 10^{-4}$ кg·cm.

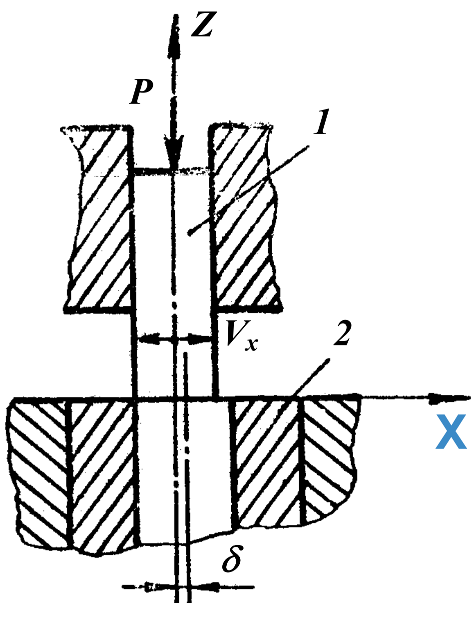

Fig.2. The scheme of assembly of details without facets: *1* – shaft; *2* – cartridge.

The second case: "ideally" sharp edges (Fig. 2). It agrees [3, 4] edges radius we shall accept; $r_{shaft} = r_{cart} = 0{,}04$ cm.

The maximal contact pressure $\sigma_{\kappa\ max} = 68{,}662 \cdot 10^3$ кg/cm^2, and the moment of resistance of friction $M_{shaft\ resist} = 1{,}208 \cdot 10^{-4}$ кg·cm.

The third case: edges in the form of facets (Fig.3.). In this case it is necessary to consider two kinds of contact: contact on a spherical surface (Fig.3, a) and on a plane (Fig.3, b). Therefore the moment of resistance develops of two components

$$M_{shaft\ resist} = M_{sph} + M_{pl} = 3/16\ \pi\ f\ \rho + P\ f\ l\,, \quad (3)$$

where l – length of the gone way.

The size of a facet we shall accept *0,1* cm, then $l = 0{,}07$ cm

After substitution in the formula (3) initial sizes have defined, that

$$M_{shaftresist} = M_{sph} + M_{pl} = 1{,}208 \cdot 10^{-4} + 0{,}7755 \cdot 10^{4} = 78{,}758 \cdot 10^{-4}\ \text{кg} \cdot \text{cm}.$$

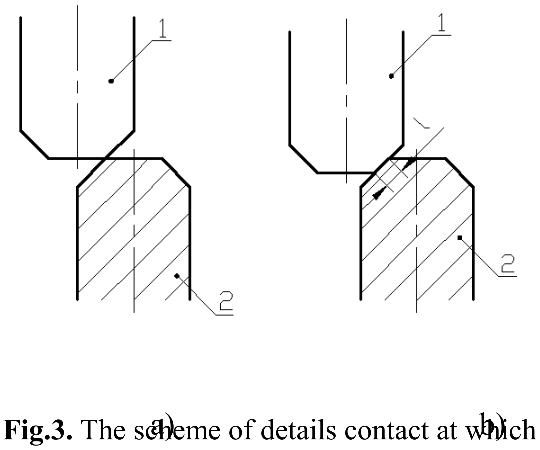

Fig.3. The scheme of details contact at which edges have the facets.

Analyzing all three cases, it is possible to draw a conclusion, that the minimal forces of friction arise during the contact of "ideally" sharp edges. However, for conditions of automatic assembly the best conditions arise, if contact of details occurs on edges with radius form: during the first moment the platen nestles an edge with radius on an edge of an aperture of the cartridge, and then (during the second half-cycle) the platen slides off in an aperture, i.e. there is an assembly of details.

Therefore defining the optimum form of joined surfaces, we compare edges with radius form and edges as facets. The platform of contact and, accordingly, force of friction is less at radius form of edges than - hence this variant is chosen as optimum.

Automatic connection of details

During optimization of technological process of assembly on rotary automatic devices, except for other problems, it is necessary to solve the problem of metrology assurance. It is known, that the decision of these questions gives the greatest technical and economic effect and demands thus the least expenses only when is carried out at the initial stages of creation of new kinds of production, development and mastering of technological processes, and also at the organization of manufacture.

At automatic connection of details on rotary automatic devices application of working power heads almost always is required as it is not necessary to count that assembled details to join with each other only owing to gravity. Necessity of compulsory connection of details is caused by impossibility absolutely precisely to orientate details rather each other; requirement to increase of productivity of the automatic assembly equipment; and also presence of roughness on interfaced and directing surfaces and front-end facets (edges).

Roughness of interfaced surfaces

From above told follows, that the roughness of interfaced surfaces, among other major factors, influences on the value of assembly afford.

Let’s consider process of connection of details after they have contacted with each other (Figure 1). Contact interaction of details in units of friction is concerned with geometrical and physicomechanical parameters of quality of interfaced surfaces. Roughness (microroughnesses), a direction of roughnesses, accuracy of the form of details are concerned with the first group of parameters – with geometrical parameters; among physicomechanical parameters (that is the second group of parameters) are microhardness of a surface, degree and the depth of cold-hardening, etc.[5, 6]

In the general case of contact the microroughness undergo both elastic, and plastic deformations. In an initial stage the micropeakes are deformed elastically, bet in the process of achievement of some critical size (critical rapprochement) the plastic current of a peak is begin. The kind of contact depends on elastic properties of a material and microhardness of a superficial layer.

In assembly process change of a microrelief is not supposed at contact of details and besides the forces of friction, arising between contacted surfaces, should be minimal – hence at interaction of roughnesses of one surface with another their elastic deformation should be provided.

Let’s define what microgeometrical parameters and physicomechanical characteristics it is necessary to consider at a choice of a material and a kind of processing of collected details.

Elastic deformation of micropeaks

Let’s consider an elastic kind of contact for the case most widespread in practice when one detail is much more smoothes than another one and its roughness can be neglected. Then dependences for definition of the relative area of contact η_{el} and specific pressure q_{el} can be presented in a following kind [7]:

$$\eta_{el} = k_\eta \left[1 - \Phi(y)\right]; \tag{4}$$

$$q_{el} = k_q^{el} \frac{Ra}{\Theta \cdot Sm_1} \cdot F_1(y), \tag{5}$$

where k_η and k_q^{el} – the factors depending on anisotrophy of roughness C;

$\Phi(\gamma)$ – Laplace function in the form of $\Phi(\gamma) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\gamma} e^{-t^2/2}\, dt$

$F_1(\gamma)$ – the function depending on a level of deformation γ ;

γ – level of deformation, which is normalize on size σ;

$\Theta = \frac{1 - \mu^2}{\pi E}$ – elastic constant of a material (μ - Poisson's ratio, E - coefficient of elasticity);

Ra – arithmetical mean deviation of the profile

Sm_1 – mean spacing of the profile irregularities.

Studying the influence of the initial sizes entering into the formulas (4) and (5), it is possible to note, that its contain attitude of Sm_1 / Ra. It means, that at contacting of details heights and steps of roughnesses don't play the important role, and their attitude does it. Dependences of the attitude of parameters Sm_1 / Ra from a kind of processing are tabulated.

Conclusion

In assembly process the forces of friction arising between contacting surfaces, should be minimal - hence at interaction of roughnesses of one surface with another their elastic deformation should be provided.

Therefore defining the optimum form of joined surfaces, we compare edges with radius form and edges as facets. The platform of contact and, accordingly, force of friction is less at radius form of edges than - hence this variant is chosen as optimum in process of assembly

Besides at calculation it is necessary to consider anisotropism of a roughness C and elastic constants of a material - E and μ. These parameters are easy for operating during manufacturing details.

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Detaļu formas ietekmes uz salikšanas precizitāti izpēte
Dotā rakstā tiek uzradīts, ka uz salikšanas procesa kvalitāti ietekme dažādi parametri, tajā skaitā arī savienojamo detaļu virsmu formas ģeometrija. Lai noteiktu šķautnes optimālo formu, tika apskatīti trīs dažādi varianti. Izpētot berzes spēkus, kas parādās starp kontaktējošām virsmām, tika konstatēts, ka šķautnes optimāla forma ir forma ar salaidumu.
Rakstā arī ir parādīts, ka no raupjuma standartu parametriem tikai divi parametri ietekme uz salikšanas procesa kvalitāti: parametrs Ra un Sm.

Н.Мозга, И.Гриневич, Я.Кандис, И.Бренсонс. Исследование влияния формы деталей на точность сборки
В данной статье показано, что на качество сборочного процесса влтяют разные параметры, в том числе и геометрия формы рабочих поверхностей собираемых деталей. Для того, чтобы определить оптимальную форму кромок, было рассмотрено три различных варианта. В результате анализа сил трения, возникающих между контактирующими поверхностями, пришли к выводу, что оптимальная форма кромок с радиусным закруглением.
Кроме того, в статье показано, что из стандартных параметров шероховатости только два параметра влияют на точность выполнения сборочного процесса. А именно: среднее арифметическое отклонение профиля (Ra) и шаг между вершинами профиля (Sm).