Optimization of the technological process of selective assembly of precision pairs of fuel equipment

N. Mozga[1], A. Aleksejevs[1]
[1]*Riga Technical University, Institute of Mechanical Engineering, Latvia*

natalija.mozga@rtu.lv

Abstract

Selective assembly is a cost-effective approach for reducing the overall variation and thus improving the quality of an assembled product. In this process, components of a mating pair are measured and grouped into several classes as they are manufactured. The final product is assembled by selecting the components of each pair from appropriate classes to meet the required specifications as closely as possible. This approach is often less costly than tolerance design using tighter specifications on individual components. It leads to high-quality assembly using relatively inexpensive components.

In this article the component parts of technological maintenance of assembly of the precision pairs (bearings, ball screw pairs, plungers pairs), which have an influence on the assembly quality of pairs and possibility of realization of assembly process are described. To achieve this goal, authors suggest solving two tasks: research the influence of form deviations and the influence of camber of axis of the parts on the technological process of assembly of plunger precision pairs.

1 Introduction

The quality and performance of an assembled product depends critically on the dimensional variation of its component parts. In fact, part dimensional variation is one of the major sources of quality problems in the machine-building industry. In most applications, the overall tolerance of the assembly is determined by the sum of the individual component tolerances. Thus, the components need to be manufactured at a much higher level of precision in order to meet the overall assembly tolerance. This can be very costly and sometimes even infeasible.

Selective assembly is a cost-effective alternative in these situations. It can be used to achieve high-precision assembly from relatively low-precision components. Selective assembly focuses on the fit between mating parts rather than the absolute dimension of each component. In this approach, the mating components are measured, sorted by dimension and binned into groups prior to the assembly process. The final product is assembled by selecting the components from appropriate bins to achieve optimal assembly dimensions (e.g. clearance).

Metrological tools allow realizing the automatic measuring of geometrical parameters of details with precision 0,1 - 0,2 µm in the mass production's conditions.

It is of decisive importance the problem of determination of the details parameters which have to be measured. This is due to the fact that in the real process of assembly the possibility of connection of details and product's quality does not have to be guaranteed even in the case when measured parameters are in the tolerance group zone [2]. This indeterminacy is the result of 1) form deviations of connected details from the ideal; 2) measuring errors, and 3) instability of assembly process, which is determined by the errors of positioning, by influence of vibrations, pollutions and by others reasons.

After carrying out of finishing operations, the high-precision details of plunger pair go at the position of the form deviations control. As a conclusion, the high precision of details' production is replaced by the high precision of measuring of geometrical parameters [3].

Technical requirements for the precision details of fuel injection equipments envisage the completely definitive of form deviations in the transversal section, which ensure the occurrence of the minimum gap.

2 Form deviations of the precision pairs

During the experiment, the assembly of 100 bushings with holes $Ø8^{+0,015}$ and 100 plungers $Ø8^{+0,0045}_{-0,0045}$ (fit *8H7/js6*) with clearance *0,0045...0,009* mm was examined, by using the attestation means with $\Delta_{rel}=0,2...0,4$ and relative camber of axis $\delta_{rel}=0,2...0,6$. The group tolerance will take $T_{gr}=0,002$ mm and that is equal to the half of tolerance gap.

During the details sorting because there are form and measuring deviations details from others, groups will be mixing, i.e. part of the details from group "i" will be placed in the groups "i-1"and "i+1", but part of the details from groups "i-1" and "i+1" will be placed in the group "i" and that can lead to the defect at the assembly.

Therefore, the important problem at the assembly of precision pairs is to ensure the geometrical precision of details and choosing the measuring means which guarantee the specified precision.

Reduction of the limited error of measuring, Δ_{lim}, leads to the rise in price of means of sorting. For the determination of rational precision of sorting it is necessary to estimate the influence of form and measuring errors on the part of defect at the assembly of precision pairs.

For the determination of form deviations in the cross section (roundness) and its influence on the defect at the assembly, the measurements were performed in the one and two perpendicular sections of the details: in the transversal – in the middle and across of the detail, in the transversal – in the middle and across the edges of the detail.

During the analysis of data of the measurements, the possibility of decreasing the group tolerance T_{gr} by n times for permanent values of form and measuring deviations was examined, and therefore the part of defective connections Pd was determined. The results of the experimental data analysis have been processed statistically and the results are shown in Figure 1.

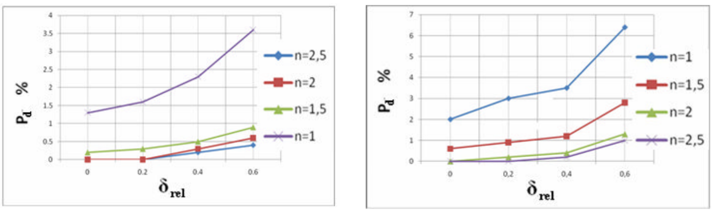

Figure 1: Dependence of the assembly probability Pd from the relative form deviation δ_{rel} in the cross section and in the transversal section

The data analysis shows that 1) with increasing of camber of details axis the number of defective connections increases; 2) form deviation in the transversal section has more influence on the size of defective connections than the deviation of the details in the cross-section; 3) measuring the details in several sections allows a decrease of defective connections of the 60-80%; 4) decreasing the group tolerance by 2 - 2.5 times can reduce the proportion of defective connections by 70 - 80%.

3 Clearance in precision pairs

During the experiment we measured 100 examples of the connected details – shafts and bushings for determine the real dimension (in one section). Also the camber of axis in the transversal section was measured.

The results of the experimental data analysis have been processed statistically and the results are shown on the Figure 2.

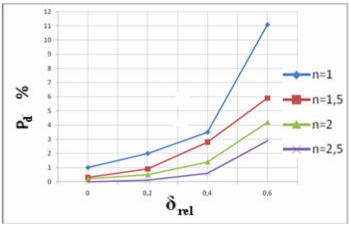

Figure 2: Dependence of the assembly probability Pd from the relative value of camber of details axis δrel. at change of group tolerance in n times

Conclusion

The data analysis shows that camber of axis of details has more influence on the size of defective connections of the precision assembly than the form deviation of the details in the transversal and cross-sections.

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