SURFACE MOUNTING OF ELECTRONIC ASSEMBLIES WITH THE USE OF MANIPULATORS

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Abstract. *The use of manipulators for surface mounting at pilot and small-lot production can provide the acceptable positioning accuracy and increase the productivity in several times in comparison with vacuum pencil.*

The modern electronics tendencies to circuit density increasing and overall size decreasing are raising the equipment requirements, meant for assembly and repair of electronic units. The decrease of electronic components dimensions required the mechanization and automation of mounting production. The most cost-effective solution at the first stage is the use of SMT manipulators. It's the first step of surface mount technology mastering. With the minimal investments, the equipment allows to improve the quality of output products and to decrease the need of highly qualified mounters [1].

Semi-automatic mount systems differ from automatic systems by the lack of mounting head actuator - the movement is performed by operator. The process automation is concluded in the each components coordinates memorization of control instrument and in the manipulators movement blocking in specified positions. This mounting concept is convenient for small-scale production and for laboratory conditions. The productivity of components mounting achieves 500-600 units per hour [2].

The manipulator consists of vacuum pencil, Y-axis drive for vacuum pencil, batcher, control panel, armrest and monitor (Fig. 1). The manipulator realizes the SMD mounting in following sequence: applying of glue or soldering paste on circuit board surface with the help of batcher and attachment of SMD with vacuum pencil. The standart equipment of manipulator is: control unit, head actuator optical sensor, camera, monitor, compressor, pedal and commutator.

The manipulator can be supplied with belt, cassette or carousel feeders. The belt feeders provides the component feed, packed in blister-belt, with the help of spinning bobbin. The cassette two-deck feeders are designed for storing SMD in belt snips. The maximal concentration of different SMD types can be achieved by the two-deck configuration. Carousel feeders are designed for storing SMD in scatters. The carousel is mounted on ball bearing and spins in both directions with the help of handle.

Fig. 1. Surface mount manipulator EM-4725 (Belarus)

Because of small SMD dimensions the SMT equipment accuracy requirements are very high. Particularly, the best mount manipulators allows to provide the mount accuracy around 10-15 μm. The basic tolerance for centering and body shift is 25 μm [3].

The required positioning accuracy can be calculated from geometrical dimensions of binding pads, component outputs and their possible deviations. The scheme (Fig. 2) considers the soldering paste positioning relatively bonding pad. The bonding pad of soldering paste is shifted to the left and the output – to the right. When they're placed in the center of bonding pad, the error will be equal to 0, i.e. $\Delta_x=h=0$.

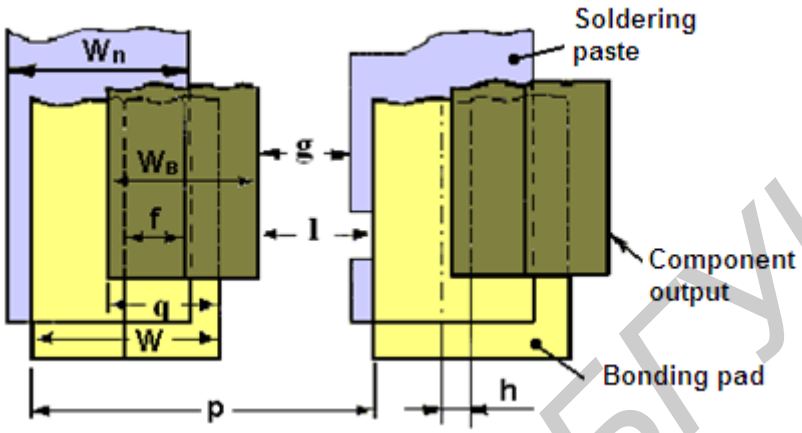

Fig. 2. The scheme for positioning accuracy calculation:

P – lead pitch; W – bonding pad width; $W_в$– output width; l– minimum positive allowance for insulation resistance; q – the overlap width of bonding pad by output; Δ_x – positioning inaccuracy; W_n – soldering paste area width; g – distance between output and paste area; h – paste positioning inaccuracy

SMD positioning accuracy during the mounting process depends on the following factors:

1. Accuracy parameters of manipulators, which has next tolerances: SMD mounting tolerance in required position, body centering tolerance, PCB positioning tolerance;
2. The PCB manufacturing tolerance, which includes photomask manufacturing; mechanic treating tolerances; the modifying of PCB mechanical properties at the cost of PCB dimensions and external influences;
3. The tolerance of SMD output shifting relatively the PCB body

There're 3 criteria for positioning accuracy rating:

1. The minimal distance between paste and bonding pad for insulation strength:

$$\Delta x_1 = P - {}^1/_2\left((W_в + \delta_k) - (W + \delta_c)\right) - l, \quad (1)$$

where δ_k–SMD dimension allowance; δ_c – plate manufacturing accuracy.

2. Minimal width of overlap area:

$$\Delta x_2 = {}^1/_2\left((W_в + \delta_k) + (W + \delta_c)\right) - g, \quad (2)$$

3. The minimal distance for soldering paste positioning:

$$\Delta x_3 = P - {}^1/_2\left((W_в + \delta_k) - (W + \delta_c)\right) - l - h \quad (3)$$

where $h \leq 0{,}05$ mm.

During the control of element inaccuracy mounting the offset values by X,Y axes (Δx, Δy) with the help of instrumental microscope (table 1) [4].

Table 1. SMD positioning control results

	Manipulator			Vacuum pencil		
Element	Δx, μm	Δy, μm	Δφ, deg	Δx, μm	Δy, μm	Δφ, deg
C1	300	200	0°30'	400	300	1°35'
C2	250	200	0°53'	300	250	1°58'
C3	100	400	1°35'	200	300	1°10'
R1	150	100	0°35'	150	300	0°50'
R2	200	100	1°15'	500	400	1°15'
R3	150	200	0°46'	300	200	0°40
VT1	100	100	0°27'	200	250	0°3'37'
VT 2	150	150	0°45'	250	300	0°65'
VT 3	150	100	0°36'	280	350	0°86'
DD1-2	100	100	0°15'	200	200	0°45'

The analysis shows, that SMD mounting with vacuum pencil has significant inaccuracy (200-500 μm). Manipulator EM-4725 (Belarus) allows to decrease the accuracy up to 2 times because of more accurate X and Y axes motion. The optimal amount of soldering paste is necessary for inaccuracy decreasing, because with the paste excess causes the positioning inaccuracy increment. The bigger amount of outputs leads the improve of positioning accuracy, what involves the quality improvement of circuit module assembly (Fig.3).

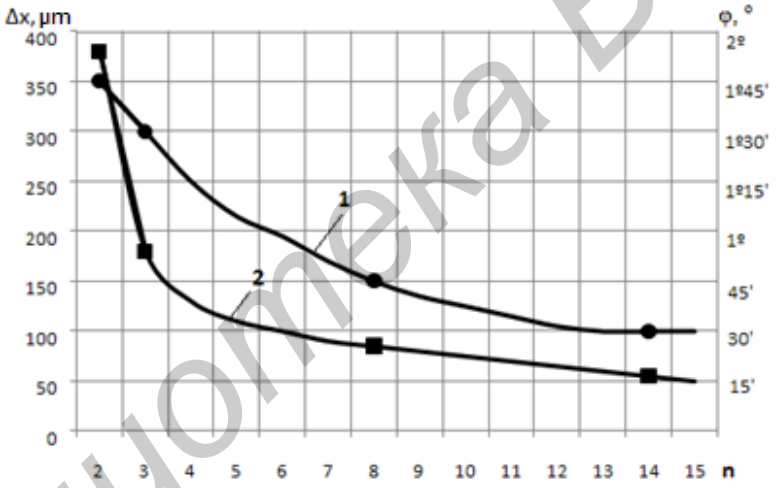

Fig. 3. The dependence of mount accuracy (1) and deviation angle (2) on the output amount

The manipulators use for surface mount of electronic assemblies is preferable because of low minimal output step value, quantity-price ratio and the possibility to be equipped by additional options.

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