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HOW TO CARRY OUT A FINAL TEST ON A MACHINE TOOL

You have certainly had the experience of purchasing a machine tool to be installed in your company's production department: when the machine is finally delivered, a delicate phase begins aimed at making sure that the purchased equipment is consistent with the agreements entered into.

No one wants to install a new machine tool in the production department that has geometric problems, that is unable to produce conforming pieces, that is able to produce them only at the limit of the set tolerances and that, after being used for a short time, ends up producing scrap.

Today, I will tell you how to seriously and effectively handle a geometric check of a machine tool so as to avoid any unpleasant surprises.

A SERIOUS AND EFFECTIVE METHOD FOR CONDUCTING A GEOMETRIC CHECK ON A MACHINE TOOL

"No one wants to install a new machine tool in the production department that has geometric problems, that is unable to produce conforming pieces, that is able to produce them only at the limit of the set tolerances and that, after being used for a short time, ends up producing scrap."

The purpose of this chapter is to provide an overview of the final testing to be carried out on a machine tool and, specifically, of the geometric check, by describing how an efficient final testing service should be set up at a company that manufactures machine tools. Here is a model of how a final testing service should be organised at a company that produces machine tools.

Four functional areas can be identified:

- INCOMING ACCEPTANCE TEST
- INTER-OPERATIONAL TEST
- TEST DURING ASSEMBLY
- FINAL TEST AND INSPECTION

INCOMING ACCEPTANCE TEST

This includes activities aimed at guaranteeing the company conformity of the products supplied by the marketplace to the technical specifications contained in the order.

The incoming acceptance test is a test that checks external supplies, meaning that it looks outside the company and only verifies whether the finished product meets the requirements specified in the order, without worrying about the work process.

It is important to underline that all test actions have to start from a reference document: if this is not clear, the test cannot be carried out as it would not have any sense.

In the case of the incoming acceptance test, the reference document is the purchase order of the material. Materials usually purchased on the market by a company that produces machine tools belong to the following categories:

- semi-finished goods;
- mechanical parts made to customer specifications;
- parts available on the market not made to specifications(catalogue parts);
- technical installations (electrical, hydraulic, electronic, mechanical).

The reference documents as far as the incoming acceptance test is concerned are usually:

- supply order;
- supply technical specifications;
- drawing;
- technical standards.

If the material is declared to be conformant after the test, the company is authorised to accept the material and consider it available for the subsequent operations.

In case of non-conformity, the material is analysed by a committee that should be made up of all company functions concerned by the decisions taken.

The criteria used to evaluate non-conformities should almost always be of a technical nature, even though sometimes they may be affected by scheduling needs of the subsequent processing phases, or influenced by the type of supplier involved and by its relationships with the company.

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A non-conformity may entail one of the following opinions:

- acceptance as an exception;
- permanent scrap;
- acceptance with repair.

In order to complete this structure, it would also be appropriate to have a metrology room and a laboratory where to check the chemical-physical mechanical and integral characteristics of the materials.

INTER-OPERATIONAL TEST

A company's testing does not end with the incoming acceptance test as part of the purchased material may be subjected to internal processing. In this case, the material is taken from the warehouse and processed by the various machines during the production phase.

The check phase that takes place while the piece is being processed is known as inter-operational test.

It can be considered as a product verification, but more often as a process check (see the SPC techniques). Unlike the incoming acceptance test, the inter-operational test included in the world of company production specifically follows the processing, consequently, from a certain standpoint, it has to take into account the difficulties of the production.

Inter-operational tests must be planned during the phases deemed to be more delicate from the point of view of quality, in other words those phases in which there is a high risk of generating non-conformities.

The last operation of the inter-operational test is the final product check. All checks planned by the processing cycle have to result in an opinion of conformity or non-conformity, exactly as it happens during the incoming acceptance test.

When the inter-operational test identifies a conformity, the conforming piece is allowed to continue on to the next processing phase; if, on the other hand, a non-conformity is detected, the piece is stopped.

The non-conformity must be immediately examined by the pertinent department so that one of the following decisions can be taken: acceptance as an exception, permanent scrap and acceptance with repair.

TEST DURING ASSEMBLY

The test during assembly includes checks that are carried out during the course of the assembly operations of the units and/or of the general assembly of the machine.

The assembly phase brings together all pieces produced and those that have been purchased from external companies.

The assembly department is usually split into two sub-departments: one where the units are assembled, and one where the final machine assembly is carried out.

The individual units are assembled in the units assembly department; each unit that makes up the machine is assembled separately.

Once the assembly is finished, the individual units are taken to the final assembly sub-department, where they are joined together and where the final machine assembly is carried out.

The test during assembly is a particularly delicate check, since it is highly dependent upon the tester's individual skills.

This test has references which are very difficult to identify correctly. Indications of a general nature are provided but, aside from this, the individual experience of the employee assigned the task of conducting the check is extremely important.

The assembly operations are identified by the assembly cycle similar to the

"The test during assembly is a particularly delicate check; the individual experience of the employee assigned the task of conducting the check is extremely important."

processing cycle that identifies the processing sequences.

During the assembly cycle, the assembler is shown the sequence of operations to be followed. The assembly tester is an assembler who has acquired significant experience, allowing him to act as a guide during the assembly operations.

The testing operations during the assembly must be planned by an assembly cycle at those points of the cycle deemed especially delicate from the quality standpoint.

These operations must be defined by means of suitable operational instructions and testing protocol that each company draws up based on its own experience.

The operational instructions accurately describe the methods that must be used in order to carry out the testing operations.

The testing protocol is a document that indicates the expected results and in which the obtained results are recorded.

These documents are crucial to the execution of the testing operations during assembly, and they represent reference documents.

The testing operations during assembly usually concern:

"The operational instructions accurately describe the methods that must be used in order to carry out the testing operations. The testing protocol is a document that indicates the expected results and in which the obtained results are recorded."

- THE FUNCTIONALITY OF THE UNITS
- ALIGNMENTS
- COUPLINGS BETWEEN STRUCTURES

An example of UNIT FUNCTIONALITY is the functional check of an operating head or of a cross carriage.

An example of ALIGNMENTS is checking the proper alignment of the supports of a translation screw of a linear axis and its nut. An example of COUPLINGS BETWEEN STRUCTURES is the mounting of a slide and the base of the machine itself. Let's suppose, for example, that we have a slide which mounts on a base and we want to check the coupling between these items.

Obviously, the coupling is the one between the slide guides and the base. This means that you need to check the compatibility of the surfaces that define the coupling of the base with the slide.

It is necessary to ensure that the coupling between the surfaces of the slide and of the base is properly carried out, so as to avoid, for example, the slide only resting on a part and not mounted to the other guide. In this particular case, the entire load would end up on one guide only, leaving the other one with no load, thus losing its basic function which is to support the weight of the slide.

In order to check these couplings,

there are procedures aimed at verifying the contact between the coupled rigid surface. One procedure entails staining one of the elements of the coupling, for example the base guide, with some Blue pigment, then resting the slide on the surface stained with the pigment.

As the carriage moves along the surface, the Blue is transferred to the contact areas generated by the coupling, thus staining the slide surface with the blue pigment. This allows you to see where the carriage is working. Through manual adjustment operations, the operator then tries to widen the contact surface as much as possible by planing, until it is equal to approximately 80-90% of the theoretical contact surface, also trying to have the contact points evenly distributed along the entire surface.

For some machine tool manufacturers, the coupling is considered acceptable if, after placing a template that leaves a free space of one square inch anywhere on the contact surface to be checked, at least 5 contact points are found. The results of the testing during assembly must also conform to the expected results.

In case of non-conformity, all operations aimed at restoring conformity need to be carried out.

FINAL TEST AND INSPECTION

Basically, the final test and inspection of machine tools consists of a series of actions that can be described as follows:

- FINAL INTERNAL TEST AND INSPECTION
- CONTRACTUAL PRELIMINARY TEST AND INSPECTION WITH THE CUSTOMER AT THE SUPPLIER'S FACILITIES
- CONTRACTUAL FINAL ACCEPTANCE TEST AND INSPECTION WITH THE CUSTOMER AT THE LATTER'S FACILITIES

These are the traditional phases that characterise the final test and inspection of a machine tool; all of these phases have a specific relevance, which we will attempt to identify here below!

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In case of non-conformity, all operations aimed at restoring conformity need to be carried out."

FINAL INTERNAL TEST AND INSPECTION

Extremely important operation that basically has two purposes:

- The first is to check conformity of the construction to the product plan requirements.
- The second concerns the search, if requested by the technical office, for performance levels that are more advanced compared to the ones indicated in the product plan, or for more in-depth information on constructive, functional or performance-related aspects, information that may not have been included in the product plan but that is nevertheless useful for the purpose of continuously improving the company's products.

Clearly, this testing activity is of crucial importance in terms of knowing the quality of the product that has been developed, and it is an activity that basically represents an assessment of the efforts made by all members of the company organization in order to achieve the objective set by the company itself.

During the test, the machine must be analysed in all its aspects with great diligence, intellectual honesty, utmost metrological accuracy and refined methods, of course within the limits of that which is requested by the product plan and by any additional requests made by the technical office.

The conclusive document of this testing cannot be a schematic document but rather a technical report that, considering all the indications and requirements contained in the product plan, points out

whether or not the construction is able to safely meet all such indications and requirements.

Together with this, the technical report also has to provide answers to the technical office's questions. However, in an industrial environment, this activity is very often just an aspiration, since industrial times almost never allow this activity to be carried out in a complete and satisfactory manner; it is nevertheless clear that it is of basic importance in terms of gaining in-depth knowledge of the developed machine, of evaluating its potential capabilities and of understanding its limits and difficulties, consequently obtaining the information needed to improve the quality of future productions.

CONTRACTUAL PRELIMINARY TEST AND INSPECTION WITH THE CUSTOMER AT THE SUPPLIER'S FACILITIES

This is the final test and inspection activity that, for the first time, puts the customer in contact with the object of the supply contract which, if properly drawn up, should specifically indicate in detail the testing conditions which the machine will have to be subjected to during the preliminary test and during the final acceptance test.

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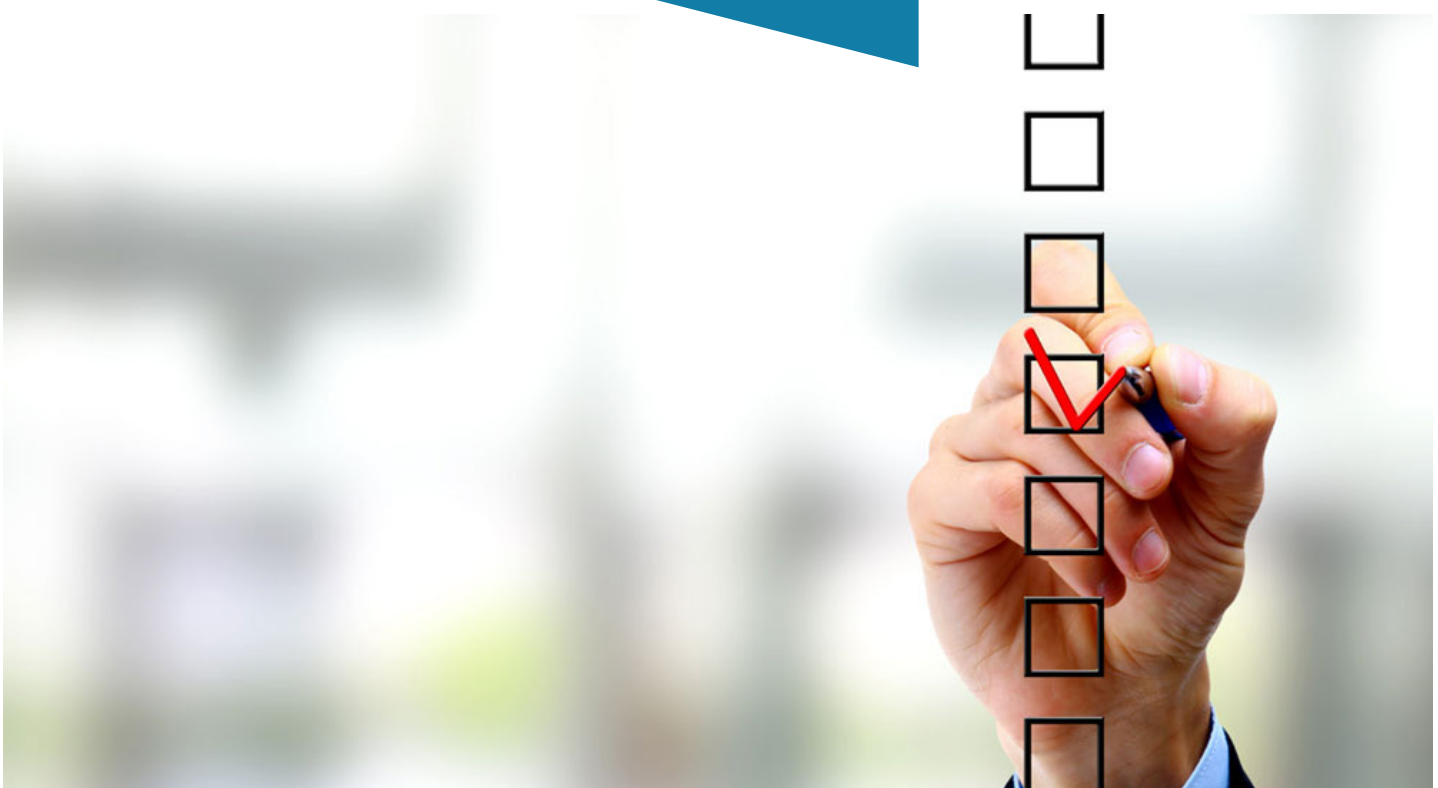
The contract for a machine tool is a complicated topic precisely because the machine tool is a piece of equipment used to produce other pieces of equipment that very often have extremely high qualitative demands and are subjected to stringent tests, which immediately reveal any shortcomings of the production machine.

The contract for a machine tool should start from a well-done product plan in which all the characteristics that the tool machine will be required to meet are identified and defined in detail. Moreover, the contract should only involve those general, functional, performance, safety and testing characteristics that have been clearly and expressly specified in the product plan. If the contract is prepared as described above, the preliminary contractual test becomes part of the final internal test.

Generally speaking, this preliminary test is developed by referring to a set of standards acknowledged at the international level. Once the standards have been established, the preliminary contractual test with the customer at the supplier's facilities is quickly defined.

In other words, it entails subjecting the machine tool to a set of checks which are



defined exactly and in detail by specific standards per machine type, adopting for each check the metrological procedures and the relevant operational methods defined by the procedural standards.

We should point out that, during the contractual testing activity, no change can be allowed with respect to that which has been defined in the contract. This means that, during the course of contractual testing activities, the testing diagrams defined by the specific standards and the measuring methods required by the procedural standards cannot be changed, either in substance or form.

It is important to underscore this aspect since it is easy to witness the onset of disputes generated by different interpretations of the measuring methods.

Upon completion of the preliminary testing activities, which are generally carried out on a fully operational machine but not necessarily set up in its final layout, it is a consolidated practice for the customer's managers and the supplier's manager to sign a document.

This document details the results of the tests carried out are recorded, for any non-conformities to be highlighted, details the jobs to be carried out prior to disassembling and shipping the machine to the customer's facilities, and for the disassembly to be authorised upon completion.

In this way and with this document, the preliminary testing phase of the machine can be considered finished.

This document is then used for those administrative activities which are associated with said document.

CONTRACTUAL FINAL ACCEPTANCE TEST AND INSPECTION WITH THE CUSTOMER AT THE LATTER'S FACILITIES

This is the last testing activity that, once it is completed, results in the following situations:

- THE MACHINE IS DEFINITIVELY ACCEPTED BY THE CUSTOMER
- THE CUSTOMER TAKES CHARGE OF THE MACHINE
- THE CONTRACTUAL WARRANTY PERIOD STARTS
- THE SUPPLIER CAN CONSIDER THE PROJECT COMPLETED

The contractual final acceptance test with the customer at the latter's facilities is carried out once the machine has been shipped and reassembled at the customers' plant.

Prior to reassembling the machine at the customer's plant, if need be, the supplier is required to test the foundations which, together with the elements used to anchor the machine to said foundations, is considered an integral part of the machine itself.

The characteristics of the foundation profile and structure, must be defined during the contract stipulation phase, and they have to establish a testing protocol agreed by the parties in terms of both deformation under load and the control method to be adopted.

Once the foundations have been tested, the supplier signs the testing protocol, declaring their conformity to requirements, then authorises the assembly of the machine on foundations that have been positively tested.

The final testing operations at the customer's facilities are the same as the ones carried out at the supplier's, except for the fact that at the customers, in order for the final testing to be considered conformant, it has to prove that all contractual requirements have been met.

Hence, the final testing of the machine at the customer's is nothing but a complete repetition of the preliminary testing operations, this time carried out on the permanently installed machine and therefore on the machine presented to the customer in its definitive state.