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Technical product documentation — Requirements for digital mock-up virtual assembly test for mechanical products

Documentation technique de produits — Exigences sur les essais d'assemblage virtuel des produits mécaniques

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Foreword

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This document was prepared by Technical Committee ISO/TC 10, *Technical product documentation*, Subcommittee SC 6, *Mechanical engineering documentation*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The digital mock-up virtual assembly test (VAT) is a computer simulation procedure in lieu of performing a physical prototype test for a product to verify the compatibility of the mechanical interface and the feasibility of assembly. This test can be used to explore and resolve interface and/or assembly problems before physical product assembly. VAT activities typically include virtual interference inspection, assembly process analysis and ergonomic evaluation based on 3D nominal models in the design phase. It can be helpful to consider the results of a VAT to predict and provide early warnings regarding the risk of interference or assembly problems, although the VAT cannot completely replace all the tests in on-site assembly testing.

The objectives of the VAT are as follows:

a) verify the mechanical interface compatibility of units, sub-systems and products;

b) ensure that the design output is interference-free and that all contacts or clearances are acceptable;

c) validate layout design at every assembly level;

d) verify assembly feasibility in the manufacturing and operational environments;

e) evaluate the assembly process to optimize the assembly plan.

Technical product documentation — Requirements for digital mock-up virtual assembly test for mechanical products

1 Scope

This document specifies the requirements for a digital mock-up virtual assembly test (VAT) for mechanical products, which is suitable for guiding virtual assembly testing before physical production. The application of this document is intended to result in an effective VAT and efficient on-site assembly. This test is applicable to 3D nominal models with theoretically exact dimensions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17599, *Technical product documentation (TPD) — General requirements of digital mock-up for mechanical products*

ISO 29845, *Technical product documentation — Document types*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17599 and ISO 29845 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
design model
portion of the data set that contains models and supplemental geometry

[SOURCE: ISO 29845:2011, 3.1.8]

3.2
3D nominal model
type of design model that contains three-dimensional geometry with theoretically exact dimensions

3.3
virtual assembly test
VAT
test for examining an assembly process in a virtual environment

3.4
simplification
method which allows some features built without modelling or some parts (or components) without assembling during the modelling process

Note 1 to entry: Through simplification, the geometric detailed representation can be simplified and the model loading efficiency can be improved provided that the simplification does not incur ambiguous understanding or bring about inconvenience to the use of a model.

[SOURCE: ISO 17599:2015, 3.12]

3.5
lightweight
method to extract patches from the product geometry model

Note 1 to entry: It reduces resource expenditure in model loading, and it is suitable for large assembly, assembly simulation, advertising, technical training and so on.

[SOURCE: ISO 17599:2015, 3.13]

3.6
environment model
type of model containing, for example, shop floor or tools and fixtures

3.7
ideal human model
computer-based dummy model in accordance with the actual statistical data set of human body features, typically as a whole-body model or local feature model, inclusive of citizenship or country of residence, gender, height and weight, fatigue and other characteristics

3.8
process model
type of model containing an assembly sequence, path and procedure

3.9
assembly process simulation
simulation of an assembly process in a virtual environment for the purposes of planning, analysis and optimization

3.10
assembly path
movement path of parts or components in an assembly process

3.11
interference
parts of two or more 3D nominal models occupying the same space at the same time

3.12
clearance
two or more adjacent surfaces in the nominal model not touching one another

3.13
contact
two or more surfaces in the nominal model touching one another

4 VAT process

4.1 General principles

A VAT shall be conducted at the design or manufacture start-up phase and shall take into account product peculiarities and complexity; developer and supplier divisions; software and hardware selection; basic library development; test and analysis methodologies; legal restrictions; risk management; cost; schedule; allowable deviations and other constraints. From the unit level through to the integrated product level, the VAT shall be implemented utilizing appropriate technical methods and suitable test tasks shall be performed at each assembly level.

4.2 Workflow process

Generally, the VAT process includes the following preparation, implementation and review phases:

a) In the preparation phase, to certify the interface and assembly designs of the product, a VAT plan shall be developed that includes at minimum the test objectives, test tasks, test methodologies, test process, test bill of material (BOM) and test schedule. Test models shall be prepared, including product models, environment models and virtual operator models, and all models shall be certified. A virtual test environment shall be configured and initialized before moving on to the next phase.

b) In the implementation phase, an interference inspection and assembly feasibility analysis shall be conducted in a virtual assembly environment. The VAT process and all relevant issues shall be documented, and the results verified in a closed-loop check.

c) In the review phase, to validate the test results, a review shall be conducted to establish that the requirements of each of the different phases in the VAT process – preparation, plan, process and report – have been met.

Figure 1 shows a diagram of the VAT workflow process, and Annex A, Figure A.1, shows a VAT aeroplane workflow process.

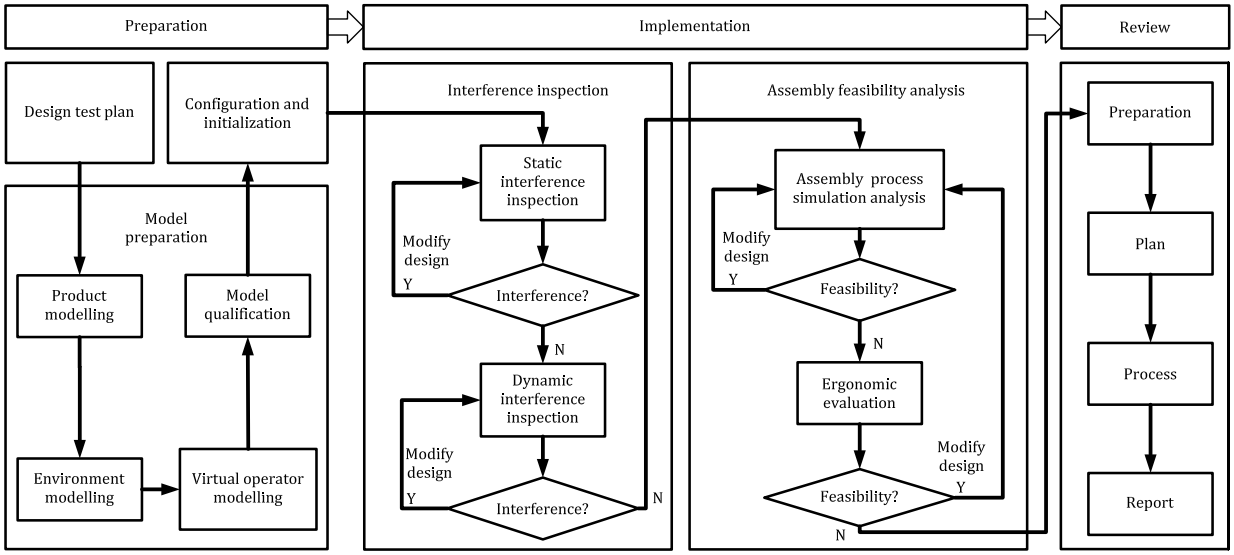

Figure 1 — VAT workflow process

5 VAT preparation requirements

5.1 General

Preparation of a VAT shall comprise the development of a test plan, the preparation of models and the configuration and initialization of a virtual assembly environment. The test plan, models and configuration and initialization statuses shall be documented.

5.2 Test plan

The test plan shall include but not be limited to the following:

a) Test objectives: specification of test objectives to verify that the design meets the interface and assembly requirements when exposed to applicable environments;

b) Test tasks: inspection and analysis tasks developed to meet the test objectives, which shall be incrementally performed at different assembly levels from the unit level to the integrated product level;

c) Test methodologies: a suitable combination of inspection and analysis methods, hardware and software tools and a test process shall be selected or developed to identify latent design defects;

d) Test process: a detailed flow chart of the VAT steps shall be developed to ensure the validity of the test results;

e) Test BOM: a complete BOM for the VAT shall be provided according to the test tasks, test methodologies and test process;

f) Test schedule: a time schedule shall be established to ensure the implementation of the VAT in the appropriate sequence from the unit level to the integrated product level, and the lower-level assembly testing shall be conducted before initiating upper-level testing.

5.3 Model preparation

5.3.1 Product modelling

A product model shall be developed, which may be simplified and/or lightweighted to improve test efficiency without affecting the established test objectives, the details of which are as follows:

a) The general modelling requirements for mechanical products shall be followed according to ISO 17599.

b) The simplified and/or lightweighted models at the unit level for the VAT shall keep their external geometric representation and may contain an empty internal chamber.

c) The simplified and/or lightweighted models at the sub-system level for the VAT shall maintain uniformity of geometry, coordinate information, assembly constraints and other information that serves the test objectives.

d) The integrated product model shall be partially simplified and/or lightweighted according to the speciality of the test task, without affecting the correct function of the movement mechanism.

5.3.2 Environment modelling

Environment modelling shall be used to hierarchically construct a digital workspace and support facilities that reflect the requirements of the desired assembly activities, as follows:

a) The shop floor model shall be consistent with the actual workspace, and an activity boundary and operational space shall be established that provide enough assembly space.

b) Tool and fixture models shall be created according to the actual needs of the assembly activity to verify their practical viability, and the accuracy of the model geometry shall be consistent with that of the product.

5.3.3 Virtual operator modelling

Virtual operator models shall be built on the basis of the ideal human model to accurately reflect the population who will be working in the real operational environment, as follows:

a) The virtual operator model shall be adjusted in accordance with relevant national standards for the human body that are based on human statistical data from the respective country to ensure that they are sufficient to meet test task requirements.

b) The virtual operator model shall consider height, weight and fatigue attributes of the ideal virtual human model as the minimum number of working characteristics to meet simulation and analysis requirements.

5.3.4 Model qualification

Model qualification shall focus on the completeness, conformity and integration of models, as follows:

a) Completeness of models is in accordance with the test BOM.

b) Conformity of models is in accordance with the test plan.

c) Integration of models is in accordance with the modelling requirements, which shall include but not be limited to the software version, templates, coordinate system definition, units of measurement, quality, and colouring and labelling.

5.4 Configuration and initialization

Hardware and software shall be configured and initialized for VAT implementation. It is essential that appropriate parameters be set to ensure the best VAT performance. Configuration and initialization shall be defined by but not be limited to the following:

a) The hardware configuration shall establish and display the running memory capacity.

b) The software configuration shall customize the frequency of automatic backup, display precision, graphic cache management, units of measurement, toolbar and user interface.

c) Assembly initialization shall establish a unified assembly datum, build structure tree and assembly sequence, layout position and record of the initial state.

d) Product model initialization shall include the establishment of the assembly hierarchy, assembly relationship, layout and positions.

e) Environment model initialization shall consist of lightweight settings, hidden simplifications, and transparent settings for fixtures, tools and factory buildings.

f) Operator model initialization shall consist of the initial posture and position coordinates.

6 VAT implementation requirements

6.1 General

VAT implementation shall comprise interference inspection and assembly feasibility analysis. Tasks related to interference inspection generally include static and dynamic interference inspections, whereas tasks related to assembly feasibility analysis generally include assembly process analyses and ergonomics evaluation.