A REVIEW OF FEA TECHNOLOGY ISSUES CONFRONTING THE CONSUMER GOODS INDUSTRY

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SUMMARY
The use of simulation technology varies a lot within the Industry Sectors that have been defined within the FENET project. Thus the Consumer Goods Industry Sector experiences a variety in the use of the technology that reflects the variety of the products in the sector itself.

During the lifetime of the FENET project it became apparent that it was necessary to subdivide the sector into sub sectors. It is obvious that products such as small handheld devices through to televisions and washing machines require different simulation considerations.

The sub areas within the Consumer Goods Industry Sector are defined as:

- White Goods
- Brown Goods
- Small electronics

Medical accessories (decided to be included in small electronics sub group)
This sector is traditionally not considered as an industry with a large use of simulation technology used to design its products. The use of simulation technology has been adopted quite late, compared to other Industry Sectors. Up to now many technical solutions have often been based on visual and ergonomic considerations rather than material optimised design. This has allowed development to be based particularly on experience and prototype testing and an excessive use of plastic materials has allowed the Industry to get product design out of proportion.

However, within the last few years, market demands and competition have forced the Industry to make use of simulation technology to obtain optimised solutions to preserve competitiveness.

Lately, the sector has experienced greater competition in the market and requirements have increased in terms of lower cost, improved reliability and lower time to market.

The industry sector now has a very wide analysis need with respect to manufacturing and product performance. As the industry sector has a time to market demand typically higher than other sectors, it is found that many parts of the sector are still highly reliant upon

prototype/test cycles rather than decision making based on simulation. As a result it is also seen that factors that influence the time taken to get analysis results are very important.

1: IDENTIFICATION OF THE ANALYSIS LEVELS AND NEEDS IN THE INDUSTRY

Various companies within the Consumer Goods Industry sector were asked to give feedback about the analysis challenges in the daily design work prior to the first Industry Workshop in Wiesbaden, Germany, in 2001. This became the foundation for evaluation of the analysis needs and was evaluated at each of the subsequent Industry Workshops held on an annual basis. The time for the latest modification is mentioned in the tables.

All other levels of maturity (MRL) and priority (PRL) from the Industry has been found mainly from the questionnaire send out in 2002 and also reviewed at the later Industry Sector Meetings. The primary message found from the tables listed below is that the actual use of the technology has a higher priority than is actually being used in the daily design and analysis process.

A large gap between the Maturity Level (MRL) and Priority Level (PRL) is an indication of an industry desire that could justify further development in the area. An example of this is the use of non-linear material models that has a significantly higher Priority (PRL) than Maturity (MRL).

On the other hand, the practical use of Quasi static modelling of Impact proves less important to the Industry than its potential, i.e. its MRL is greater than its PRL

For reference of methods and principles behind the questionnaire results, see [1].

Item	*TRL*	*MRL*	*PRL*	*Comments*
Stacking Loads (in packaging)		4.25	5.38	41.2% of Survey
Abuse Loads: Dropping Packaged Appliance Dropping Unpackaged Appliance Installation Shipping Loads		 4.64 4.36 5.00 4.75	 6.27 6.07 5.15 5.23	41.2% of Survey
Use of Quality Measures		4.33	4.54	41.2% of Survey
Use of Cost/Benefit Measures (of Simulation)		3.92	5.77	41.2% of Survey
Assembly Loads in Manufacturing		4.58	5.38	41.2% of Survey
Linear elastic analysis for Plastic Material		4.85	6.14	41.2% of Survey
Non-linear Materials (plasticity) and Contact for catches & snap-fits, inserts (press fits or shrink fits)		4.00	5.93	41.2% of Survey

Impact Analysis modelled Quasi-Statically		3		Prague Industry Workshop Feedback
Modal Analysis		8		Prague Industry Workshop Feedback
Non-linear Dynamic Analysis		4		Prague Industry Workshop Feedback

Table 1: Survey Results, White Goods [1]

Item	*TRL*	*MRL*	*PRL*	*Comments*
Stacking Loads (in packaging)		4.25	5.38	35.2% of Survey
Abuse Loads:				35.2% of Survey
Dropping Packaged Appliance		4.64	6.27	
Dropping Unpackaged Appliance		4.36	6.07	
Installation		5.00	5.15	
Shipping Loads		4.75	5.23	
Use of Quality Measures		4.33	4.54	35.2% of Survey
Use of Cost/Benefit Measures (of Simulation)		3.92	5.77	35.2% of Survey
Assembly Loads in Manufacturing		4.58	5.38	35.2% of Survey
Linear elastic analysis for Plastic Material		4.85	6.14	35.2% of Survey
Non-linear Materials (plasticity) and Contact for catches & snap-fits, inserts (press fits or shrink fits)		4.00	5.93	35.2% of Survey
Impact Analysis modelled Quasi-Statically		3		Prague Industry Workshop Feedback
Modal Analysis		8		Prague Industry Workshop Feedback
Non-linear Dynamic Analysis		4		Prague Industry Workshop Feedback
Acoustical Analysis		6.5	9	Lisbon Industry Workshop Feedback

Table 2: Survey Results, Brown Goods [1]

Item	*TRL*	*MRL*	*PRL*	*Comments*
Stacking Loads (in packaging)		4.25	5.38	23.5% of Survey
Abuse Loads:				23.5% of Survey
Dropping Packaged Appliance		4.64	6.27	
Dropping Unpackaged Appliance		4.36	6.07	

Installation Shipping Loads		5.00 4.75	5.15 5.23	
Use of Quality Measures		4.33	4.54	23.5% of Survey
Use of Cost/Benefit Measures (of Simulation)		3.92	5.77	23.5% of Survey
Assembly Loads in Manufacturing		4.58	5.38	23.5% of Survey
Linear elastic analysis for Plastic Material		4.85	6.14	23.5% of Survey
Non-linear Materials (plasticity) and Contact for catches & snap-fits, inserts (press fits or shrink fits)		4.00	5.93	23.5% of Survey
Impact Analysis modelled Quasi-Statically	8	6	4	Lisbon Industry Workshop Feedback
Linear elastic analysis for Plastic Material for Quality Checking prior to Non-Linear Analysis	9	9	4	Lisbon Industry Workshop Feedback
Non-linear Materials (Plasticity) and Contact for catches & snap-fits, inserts (press fits or shrink fits)	6.5	6	8	Lisbon Industry Workshop Feedback
Thermo-Structural Coupling	7.5	7	5	Lisbon Industry Workshop Feedback
Electronic System Cooling	7	6	6	Lisbon Industry Workshop Feedback
Modal Analysis	9	8	8	Lisbon Industry Workshop Feedback
Non-linear Dynamic Analysis – Drop Testing/Impact Loads	7	6	9	Lisbon Industry Workshop Feedback
Polymeric materials: Rubbers & Foams – lack of data	3	2	6	Lisbon Industry Workshop Feedback
Moldflow Analysis – Plastic Flow Solutions	8	7	9	Lisbon Industry Workshop Feedback
Moldflow Analysis – Warpage Solutions	7	6	8	Lisbon Industry Workshop Feedback
Moldflow Analysis – Residual Stress incorporated in subsequent Solutions	4.5	3	8	Lisbon Industry Workshop Feedback
Acoustical Analysis	5.5	3.5	7	Lisbon Industry Workshop Feedback
Design Optimisation	7	7	7	Lisbon Industry Workshop Feedback

Table 3: Survey Results, Small Electronics [1]

Item	*Analysis*	*Product* area	*TRL*	*PRL*
Packaging impacts	Explicit Dynamics	White & Brown Goods		
Abuse loadings	Explicit Dynamics	White & Brown Goods		
Water sloshing				
Fluid structural interaction				
Non linear Structural Dynamics	Explicit Dynamics	White & Brown Goods		
Multiphysics (Emag/Structural/FSI Coupled Field Solutions)			4.5	5
System Level Packaging (PCB‘s and Even Smaller Component Level)			7	8
Results Post-Processing for Many Analyses (Solvers) for Collaboration			4	7

Table 4: Definitions of State of the Art

2: AREAS OF FUTURE WORK & RESEARCH

The needs for future developments and research are described in the Annual Summary Documents [2] and the most important are listed in Table 5.

Item	*Analysis*	*Product area*
Materials modelling, especially plastics		All
Better CAD integration is strongly needed		All
EMC analysis is difficult and specialized need for user friendly tools		Small electronics and White Goods
Probabilistic Design Analysis		All
Better tools for acoustical analysis is needed		All
Tools for high frequency electro magnetics are needed		All
Multi Disciplinary Solutions coming from different codes (MpCCI)		All
Easier to perform sequential analysis		All
Multiphysics analysis with dissimilar meshes for each physics (multi scale, time & space		All

Table 5: Future development Needs

During the workshops the following additional comments have been made with respect to future requirements:

- Analysis should be used in Risk Reduction at the design stage
- Can Analysis have an impact on Product Liability issues?
- Coupling of Moldflow Analyses and Stress Analyses is a pressing requirement
- Fatigue & Life Predictions are an issue as material data very often not available
- Plastics used are a real problem, data not available again
- Better automated reporting tools are required
- People to use the Technology
  - Typical Ratio of 1 Design Engineer/Analyst vs. 5 Designers
  - EMC – Better to employ specialist in the physics, then teach the FEA Tools

3: CONCLUSIONS

As the results from the survey give a very strong indication of the levels of Maturity and Priority at the time of the survey, the other analysis disciplines that appears from the tables above, reflect the experience and judgement of the Industry Sector participants of the various Industry Workshops mentioned in the tables [2]. From these it appears that both the Technology Readiness Level (TRL) and Maturity Readiness Level (MRL) have increased over the 4 years and this should be seen as a very positive sign as it indicates improved analysis tools and increased competence in using the tools.

The analysis needs described in each sub sector have evolved significantly through the FENET lifetime and is an updated view on the current status. Many analysis topics have changed status from State of the Art to State of Practice, which can be seen as a positive sign of development of analysis software [2].

It seems that the Industry Sector should have had more input from certain areas of the sector especially Brown Goods, which surely has analysis needs regarding both manufacturing and structural related issues. This is an indication of either a limited introduction of new technology or has this Industry Sub Sector been out of reach of FENET?

It is clear that Time to Market is a main driver in the sector and that Time to Analysis demands better CAD integration and easier sequential analysis.

A major obstacle to better analysis results is Material Modelling; a need that has been highlighted through the entire FENET lifetime.

In general the feedback shows a need to perform analysis more continuously. As an example is the transition from Implicit to Explicit analysis, which typically requires different input decks. As time to analysis results is so important, the provision of integrated simulation tools has a high priority. This applies to coupling of different analysis disciplines as well.

From a business point of view it has become clear that there is a need to quantify the Cost of analysis and increase focus on how to benefit most from analysis tools. High end analysis tools are very costly and the feedback shows that this cost is a barrier to increased use.

Education and dissemination has high influence on the success of integrating the simulation tools in a company, and experiences show that simple and linear analysis can be performed by the Design Engineers. However, there is a need to conduct internal courses with company specific problems and it is important that people using the tools must know the physics behind the problems. Correspondingly most analysts are comfortable in Linear Analysis & Mid-range Non-Linear Analysis.

Similarly, it has been found that the practical background of a toolmaker is so essential that it is a good solution to teach this person the FEA tools and benefit from the practical experience of a toolmaker or moulder. This is in contrast to a simulation specialist that should learn about tool making.

Correlation of analysis and test results is as essential as always and specialists are needed in both areas as physical testing also can provide wrong results.

REFERENCES

[1] FENET Questionnaire
[2] Consumer Goods Industry Sector Summary Document, Year 2001-2004