Report of EU/Japan pilot project

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2. Executive Summary

Recently, internationalization develops in diverse field. As to manufacturing business, the factory of large company is built worldwide and people from variant country work together. As to other field, business in world scale develops. And so it is very important to communicate with people from other country. To that end, it is necessary for us to understand not only language but also the culture, history, life and so on about other countries. As well as it is required for us to express own opinions accurately.

I hope that I will work abroad at some future date. However my language skill is not so good and I felt uneasy to live abroad. And so I thought that this project is a good chance to experience overseas life and study language and I applied for this project.

First I studied at Technical University of Berlin. I spent time there for four months, from 1.9.2005 to 31.12.2005. My theme is "Design of connections which are supporting automated disassembly" and I researched with design method by G.Paul and W.Beitz. The purpose of this research is designing the connection components for easy disassembly. I studied about disassembly and cutting of a product in Japan. With that I have chosen this theme. At the beginning, I have read the book written by G.Paul and W.Beiz and the literatures by Dipl. -Ing Jan Klett and I got a quantity of knowledge about design method. As the first step of design method, I performed clarification of the task. This step clarifies the essential problem. Next, conceptual design phase should be performed. In this phase, the essential problem is abstracted and the function structure is established and solution principles to fulfill the function should be searched. In following phase, embodiment design phase, form designs are optimizes and completed. The preliminary parts list and production documents are prepared. In the last phase, detail phase, details are finalized and all documents are checked. I performed step by step with meeting.

Secondly, I studied at Technical University of Denmark for three weeks, from 2.1.2006 to 20.1.2006. I took the intensive course just for three weeks. The course title is "Laboratory Course in Process Simulation." This course is divided into three parts covering simulations of metal casting, plastics casting and metal forming. Each part started with an introduction to the process followed by an exercise where the process is simulated. The reports must be delivered in the end of the course.

3. Travel Schedule

TUB: from 1st of September 2005 to 31st of December 2005

DTU: from 2nd of January 2006 to 31st of January 2006

4. Research or Lecture

Design of connections which are supporting automated disassembly

1. Introduction

For leaving resources and space for future generation, product and material cycles are required. This means, that products, components and materials are reused instead of producing new products and using new materials consuming resources. For this, products have to be easy to maintain and repair, which requires an easy disassembly of product. Easy disassembly depends strongly on the way in which the various components are connected and on the level of flexibility of disassembly tools. Connections are not only essential in the product-using phase, they also play a key role in the (dis) assembly process. Therefore I focused on improving connections, such that the disconnecting process is improved without compromising on the connection requirements.

In this work, it will be focused on the design process to make a connection for easy disassembly.

2. Design Methodology

A design process can be divided into four stages, such as “Clarification of the task”, ”Conceptual design”, “Embodiment design” and “Detail design”. Figure 1 shows this process step by step. Every process can be fed back and it can return to previous step as described figure 1.

The obvious decision to stop a development that may not prove cost-effective has not been described in figure 1.

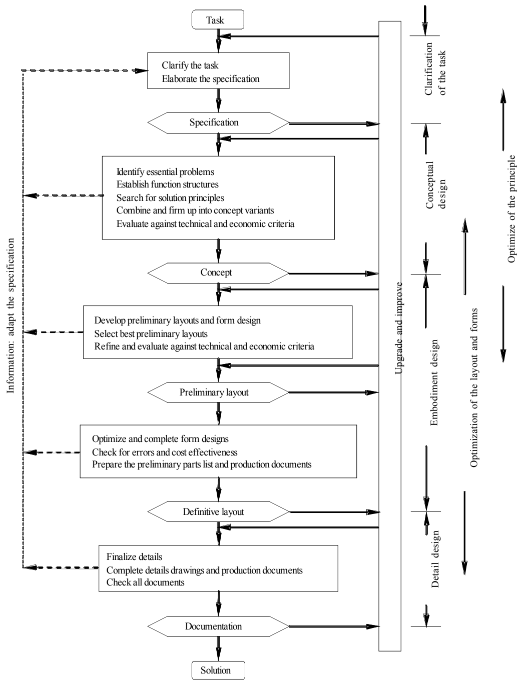


Figure 1. Steps of the design process

2-1. Clarification of the task

This phase involves the collection of information about the requirements to be embodied in the solution and also about the constraints.

When preparing a detailed specification it is essential to state whether the individual items are demand or wishes.

In the case of essential and also of less obvious requirements it is extremely useful to record the source of specific demands or wishes. It is possible to go back to the previous stuff and to enquire into his actual motive. This is particularly important when the question arises of whether or not the demands can be changed in the light of subsequent developments. Therefore, the date of elaborating or modifying requirements should be described in the requirement list.

2-2. Conceptual design

This phase involves the establishment of function structures, the search for suitable solution principles and their combination into concept variants. On the basis of the evaluation the best solution concept can now be selected.

(1) Abstracting to identify the essential problems

The clarification of the task with help of a specification will have helped to focus the designer's attention on the problems involved and will have greatly increased his particular level of information.

(2) Establishing function structure

The requirements determine the function, that is, the relationship between the inputs and outputs of a plant, machine or assembly. Once the crux of the overall problem has been formulated, it is possible to indicate an overall function that, based on the flow of energy, material or signals can, with the use of a block diagram, express the relationship between inputs and outputs independently of the solution. In the case that the problem is complex, a technical system can be divided into sub-systems and elements, so a complexity or overall function can be broken down into sub-functions of lower complexity. The combination of individual sub-functions results in a function structure representing the overall function (see Figure 2).

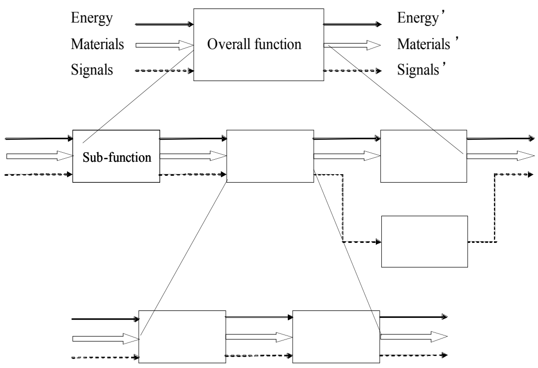


Figure 2. Establishing a function structure by breaking down an overall function into sub-functions

(3) Searching for solution principles to fulfill the sub-functions

Solution principles have to be found for the various sub-functions and these principles must eventually be combined. It should be emphasized that the step of searching for solution principle is intended to lead to several solution variants. A solution field can be constructed by variation of the physical effects and of the form design features. Moreover, to satisfy a particular sub-function, several physical effects may be involved in one or several function carriers.

When solutions to each sub-function are sought, then it is advisable to treat these sub-functions as the classifying criteria for the rows. The appropriate columns are filled with possible solution principles and their characteristics.

(4) Selecting and combining solution principle

After searching the solutions, it is necessary to select suitable solution principle and to elaborate overall solutions from the combination of principles.

(5) Evaluating concept variants against technical and economic criteria

In this step, the solution proposals must be evaluated so as to provide an objective basis for decisions. There are special evaluation procedures to fill this need, all of them so constructed as to lend themselves not only to the evaluation of concept variants, but quite generally of solution variants in every phase of design process.

An evaluation is meant to determine the ‘value’, ’usefulness’ or ‘strength’ of a solution with respect to a given objective. An objective is indispensable since the value of a solution is not absolute, but must be gauged in terms of certain requirements. An evaluation involves a comparison of concept variants or, in the case of a comparison with an imaginary ideal solution, a ‘rating’ or degree of approximation to that ideal.

2-3. Embodiment design

During this phase, the designer, starting from the concept, determines the layout and forms and develops a technical product or system in accordance with technical and economic considerations.

2-4. Detail design

This phase is design process in which the arrangement, form, dimensions and surface properties of all the individual parts are finally laid down, the materials specified, the technical and economic feasibility re-checked and all the drawings and other production documents produced.

3. Designing a connection for easy disassembly

The connection for easy disassembly would be designed in accordance with design methodology as described in chapter 2. At first the specification was prepared and abstracted to clarify the essential problem. The overall function is showed in Figure 3 and could be broken down into sub-functions of lower complexity. Figure 4 shows the function structure.

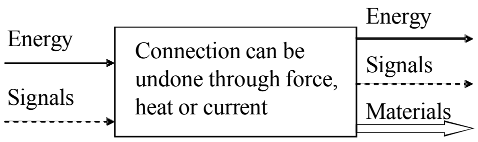


Figure 3. The overall function

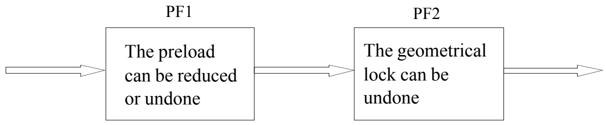


Figure 4. Function structure

For searching solution principles for each sub function, the literature, web-site or patent researches were available and 5 solution principles are below.

S1 The connection is undone by pushing the button.

S2 The catch is fold down and put in by using spring.

S3 The pole is through segments and shaft.

S4 The pole is through segments.

S5 The pipe is put in another pipe and fastened.

Then 5 variants were evaluated. Before evaluation, the objective tree is elaborated according to the requirement list. The first, three criterion were elaborated, such as function, side effect and effort. After that, these criterions were specified and weight factors were defined. Figure 5. shows the objective tree. Having prepared the objective tree, the evaluation was performed. Figure 6. shows the evaluation.

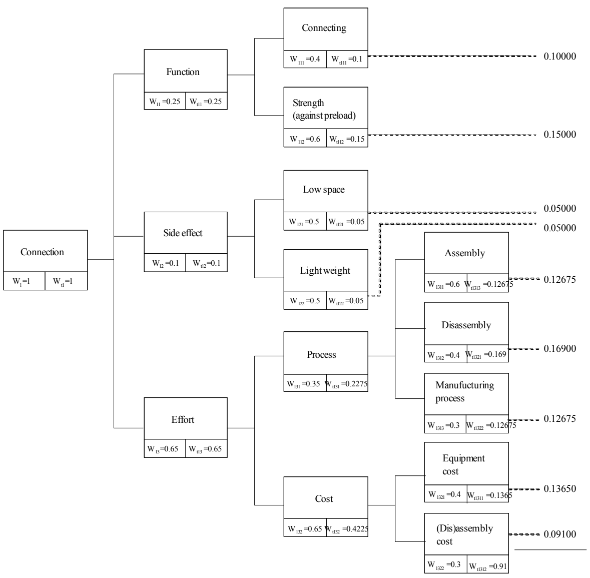


Figure 5. Objective tree

Evaluation criteria			Variants V_1		Variants V_2		Variants V_3		Variants V_4		Variants V_5	
No.		Wt	Value	WV	Value	WV	Value	WV	Value	WV	Value	WV
1	Connecting	0.10000	6	0.60000	6	0.60000	5	0.50000	5	0.50000	5	0.50000
2	Strength (against preload)	Σ 0.15000	4	0.60000	5	0.75000	4	0.60000	4	0.60000	5	0.75000
3	Low space	0.05000	7	0.35000	6	0.30000	6	0.30000	5	0.25000	6	0.30000
4	Light weight	0.05000	7	0.35000	5	0.25000	6	0.30000	6	0.30000	6	0.30000
5	Assembly	0.12675	8	1.01400	6	0.76050	7	0.88725	6	0.76050	7	0.88725
6	Disassembly	0.16900	8	1.35200	7	1.18300	7	1.18300	6	1.01400	7	1.18300
7	Manufucturing process	0.12675	6	0.76050	3	0.38025	4	0.50700	5	0.63375	4	0.50700
8	Equipment cost	0.13650	7	0.96150	5	0.68250	6	0.81900	6	0.81900	3	0.40950
9	(Dis)assembly cost	0.09100	8	0.72800	7	0.63700	7	0.63700	7	0.63700	6	0.54600
			OV_1 61	OWV_1 6.71600	OV_2 50	OWV_2 5.54325	OV_3 52	OWV_3 5.73325	OV_4 50	OWV_4 5.51425	OV_5 49	OWV_5 5.38275

Figure 6. Evaluation of the 5 conceptual variants

4. Conclusion and further work

The design of a connection for easy disassembly was performed through the design methodology. I proposed five solutions. Through the evaluation of solutions in conceptual design phase, valuation 1 was the best overall solution. It is necessary to perform the design method with the embodiment design and the detail design. Then prototype model should be built up. Moreover, the arrangement, form dimensions and materials should be finally determined. In addition, experimental evaluation is essential with the realized prototype model.

Laboratory Course in Process Simulation Course description

This course was composed of three parts covering simulations of metal casting, plastics casting and metal forming. Each part started with an introduction to the process followed by an exercise where the process is simulated.

1. Metal casting

I run a simulation for casting a pipe with flange and analyzed the casting in relation to how solidification proceeds and to get an idea of weather feeder are needed and how a gating system should be designed. The first shape of pipe is shown in Figure 7. The porosities are generated above flange. Next the feeder is attached basing calculation by formula in Figure 8 and the critical porosities in pipe could be decreased. In Figure 9, a gating system would be made to improve the quality of the casting and the gating system would be redesigned in Figure10. Furthermore to improve the position of the feeder would be changed and the pipe would be rotated.

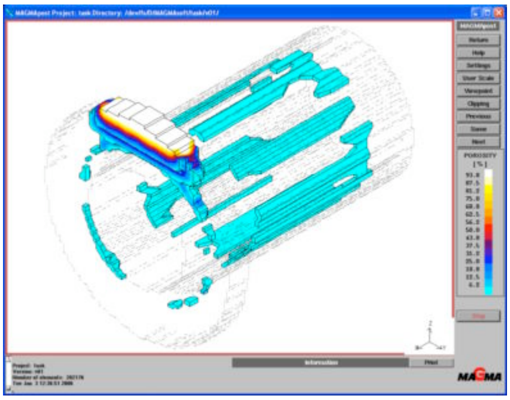


Figure 7. Porosities on the flange

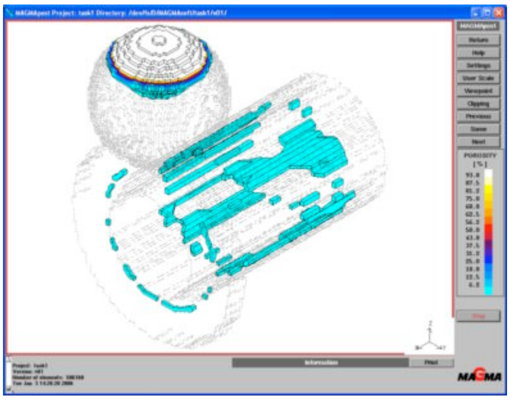


Figure 8. Attaching feeder

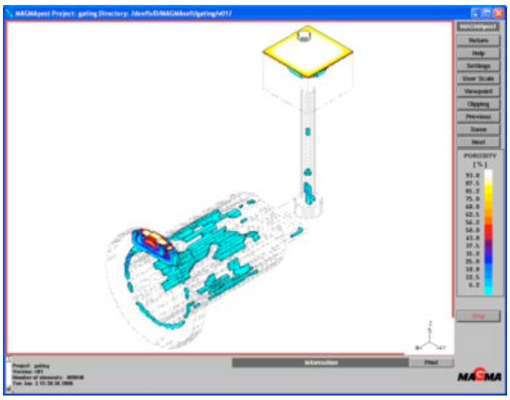


Figure 9. Making a gating system

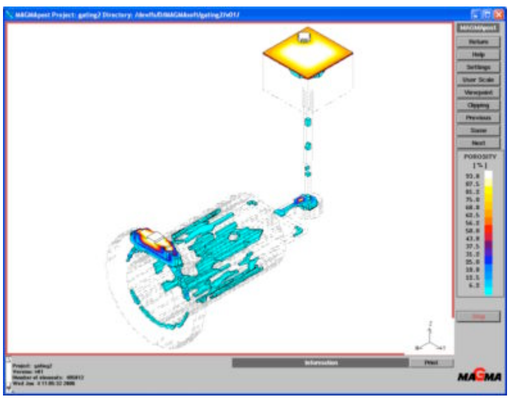


Figure 10. Redesigning the gating system

The liner contraction of a steel and aluminum plate would be analyzed respectively. Only solidification and stress analysis were considered here.

Each of the value of the residual displacement and strain shows about the same comparing of the result from steel and aluminium. However, the value of stress from steel is approximately 2.5 times of that from aluminium. It seems because of Young's module. Because aluminium has low Young's module, it will decrease the stress by temperature and aluminium will cushion the shock.

Next it would deal with the casting of a stress lattice. The purpose of this exercise is to analyze the transient and residual stresses.

2. Plastic casting

It would deal with numerical modeling of injection molding of plastic parts during second week. At first, we discussed filling pattern and where the plastic flow fronts together as shown in Figure 11. The position of the runner was changed to the ends of the flange to disappear the critical area.

The temperature would be observed as the number of element is changed. From figure 12, the computational time was less than about 10minutes, when the slap is divided into 3elemnts in the z-direction, while that was about 20minutes the model is divided into two times in all the direction. When the slap is divided into 12elemnts in the z-direction, the computational time takes about 1 hour, while that was about 20minutes the model is divided into half of the segmentation in all the direction. Therefore, it can be said that computational time is increased rapidly as the cell number increases.

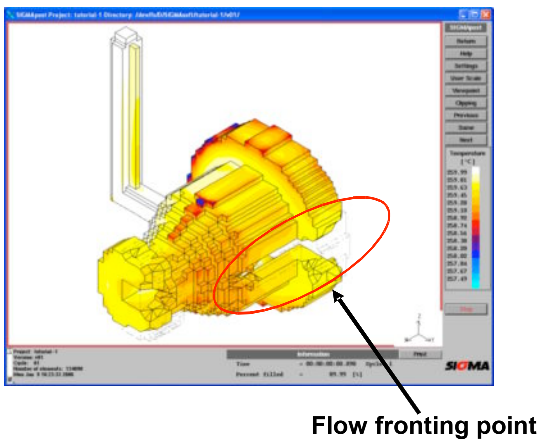


Figure 11. Flow fronting point in plastic part

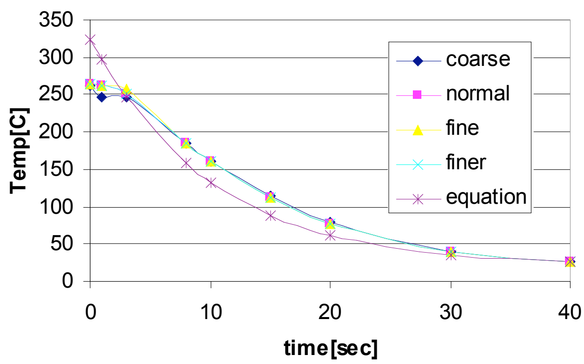
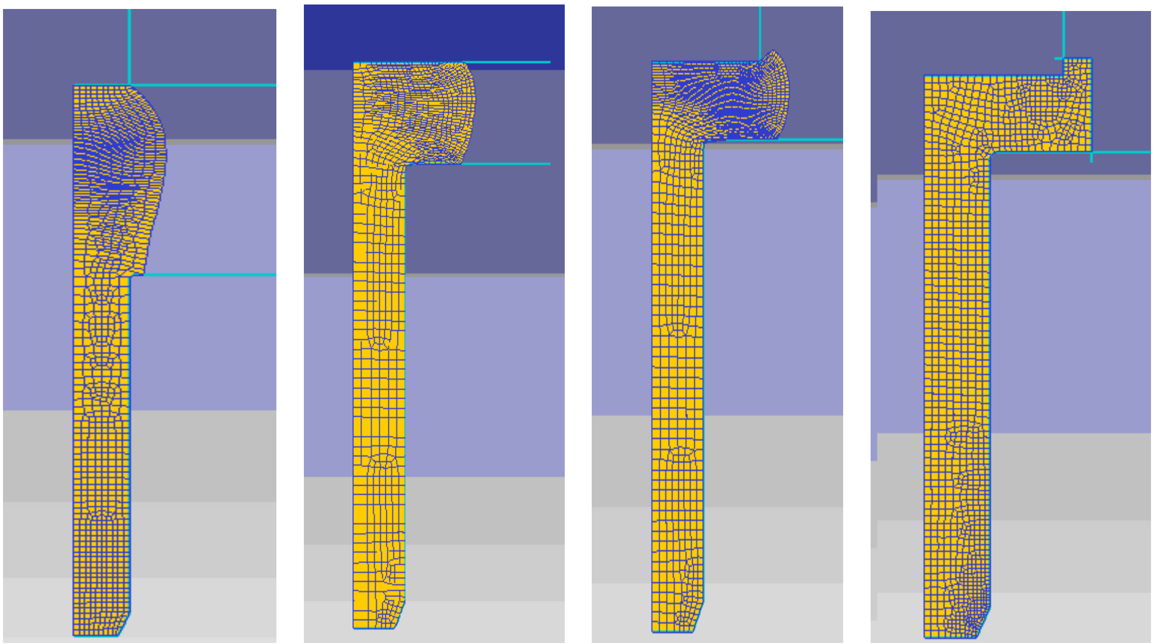


Figure 12. Time-Temperature curve at center point

3. Metal forming

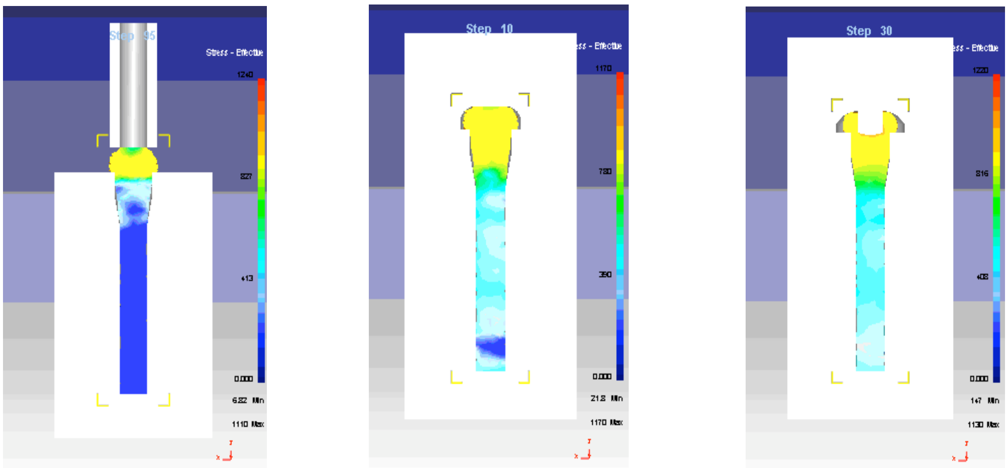
In this section, objective is to obtain an impression of the capabilities of commercial FE-codes for simulation of metal forming process and to improve the understanding of these processes. At first, a screw would be formed in 2D and the stress and the strain would be analyzed. Figure 13.(a) shows the result as the first forming from circle cylinder. Then the support is moved. When the speed of top die is 1.36 mm/s, and that of fix is 0.41 mm/s, they will be at the same position after 10 second. Then the stress of that part become lower and the change of the volume become lower. The next step, figure 13.(b) was to press the figure 13.(a) in z-direction. The model was pressed to which height of the screw head is approximately 4.35[mm]. Figure 13(c) shows the 3rd step of the forming of a screw head. This step was done to make the depressed area which depth is about 1.1[mm]. The last step was done to make the edge of the screw head clear shape, the side die was moved in –x direction.



(a) (b) (c) (d)

Figure 13. The forming of a screw in 2D

Secondly, a screw was formed in 3D. The first step was done mainly to define the down part of the screw and the height of the head of the screw. The simulation was stopped when the height of the screw and the support in the radius direction had come to be the same position, 4[mm]. Figure 14.(a) is the results of the final situation in this phase. The load prediction in the z-direction was $1.96e^4$ [N] when the height of the screw was 4[mm]. It also can be said from the results of strain and stress that the head of the screw, especially in the edge of the head is easy to get the strain and stress. The second step was done to make the clear shape. This case was done to define the final height, 2.43[mm]. This was pressed by complete top die which is needed in this case. This top die was designed by the Pro-Engineering. It can be said from figure 14.(b) that the stress was expanded to the lower part of the screw. The final step was done to make the hole in the upper part. The top die was also made in the Pro-Engineering. What can be seen from figure 14.(c) is that the material of the final shape itself seems not to be enough. The distribution of the strain and stress is almost the same in the second step. Lack of the material is estimated to be the resonance of the residual stress and coarse enmeshment which was 8000. The distribution of the strain and stress is almost the same in the second step, which is higher in the upper part. Therefore, those parts are estimated to be easy to break down or get crack.



(a) (b) (c)

Figure 14. The forming of a screw in 3D

5. Exchange life

First I stayed in Berlin for four months, from September 2005 to December 2005. What I thought about Berlin is written as follows. As to weather, Berlin is much colder than Japan. I heard that at midwinter, temperature in Berlin may come to -20 degree. Actually it snowed almost every day on December and snow would not melt. It is contemplated that because it is very cold and the day is very short. As to function, Berlin is a good city that there are many bars and shops and I can buy anything to need. In addition the price in Berlin is not so high comparing to that in Japan. Especially, the food in supermarket is cheaper. Furthermore, all of the students in TU get the Semester ticket. We can get unlimited ride of the train and the bus in Berlin in the semester. The line of the train and the bus is enough and I could go where I want to go with the semester ticket freely.

Next, I will mention about my life in Berlin. I started to study in TU on September. I was usually in university from 9 o'clock to 17 o'clock weekday. I had a lunch at MENSA, school cafeteria and could eat by about 2 or 3 Euro there. I would usually cook dinner by myself. It is not expensive to cook by myself, because the food in supermarket is cheap as mentioned above. I sometimes cooked with my friends. The meal that foreign people cooked was interesting. I also got a day off on weekend. On weekend I traveled to several cities in Germany and other countries. It was very interesting to find and feel the difference about meal, alcohol beverage, music, building, cityscape or people and so on between countries or cities. I went to the city front onto Baltic Sea on Autobahn. Autobahn means highway in Germany. People can drive by max speed 250 km/h. It was my first experience. I also joined some parties at the night. I enjoyed with people from variant countries. There are also some Christmas markets in each area of Berlin on December. Each market has each mood and it seems that it is usual that we walk around market with Glue wine drunk in Germany. I could get engaged other culture there. By the way I have a bother in Berlin. It is that the international students in my accommodation speak not English, but only German. I can't speak German and it was very difficult to communicate them. I studied German a little and we communicated by mixture of English and German.

The second country is Denmark. Technical University of Denmark is in Lyngby. There is countryside, especially comparing to Berlin. As the transport facilities the bus should be mainly used around DTU. As to weather, in Denmark the day is very short because degree of latitude is high, and it is very cold.

I got the student number and password in DTU and I could use internet in computer room or lecture room by them. Accommodation was clean and laundry, shower, kitchen, and toilet were shared.

I took the intensive course about simulation for three weeks in Technical University of Denmark. The course starts at 9 o'clock and we have to do until the day's exercise is finished. It was hard because I have no experiences about simulation. The supermarket is also closed at 19 o'clock and in case it takes much time to finish the exercise, we can't buy something to eat on that date. Therefore I had very regular habits.

As mentioned above, I had much experience except for research. Almost all of it is my first experience. Therefore I believe that experience help me at the future.

6. Summary

I went to Technical University of Berlin to research for four months, from September 2005 to December 2005 and went to Technical University of Denmark to take the intensive course for three weeks, on January. I regret that my research in Berlin was not finished. I think that is because my English skill is not so good and the subject of the research in Berlin is different from my research in Japan. Therefore it took much time to understand design method in English and I hope I study for longer term. However I also think it is more important that I get much good experience and some friends abroad. I am sure it is crucially important at my future.