JOINTING DESIGN IN OPEN PLAN SYSTEM FOR OFFICE

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ABSTRACT

Most modern offices use open plan office system due to the flexibility of the product. The open plan system (OPS) can be customized from low screen to high screen and can be installed and dismantled according to the office needs. According to MIDA (Malaysian Industrial Development Authority) the total sales for Malaysian office furniture industries was RM1.6 billion in 2003 of which 7.2% (115. million) came from sales generated from the open plan office system. The sales report showed the importance of the open plan office system in creating the office environment. Since the demand of OPS is increasing, effective ways of assembling the system is required. Most OPS uses bolts and nuts to joint the panels. However, this jointing system requires many parts and the assembly process is time consuming. A survey carried out in this study on OPS manufacturers identified the main criteria for the jointing system design which is to increase the efficiency during the assembly process. An important function of the jointing system is to ensure that the system is flexible during the assembly process. Based on these findings, various jointing system that could satisfy all these requirements were considered. Two designs of the jointing system were proposed. Simulation studies were carried out on the proposed designs to determine the ease of assembly, number of parts, weight, time taken for assembly and the strength of the joints. The research was limited to the tile system. Both design concepts were based on the snap fit concept. They were found to be better than the current design not only in terms of ease of assembly but also efficiency.

Keywords:Open Plan System (OPS), Tile System, Jointing System, Efficiency and Snap-fit

1. INTRODUCTION

The Open Plan System (OPS) is widely used in the Malaysian office environment. Miodino (1998) describes the system as one dividing walls and equipment to create, organize and decorate office space with the highest level of practicality and aesthetic value. The material of the frame structure can be made of modular elements from aluminum extrusion and the wall panels can be made of glass, MDF board and metal. The system is flexible and can be modified or extended to meet the changing requirement of the office because it comes in various heights from low, medium, high and full screen. Figure 1 shows an example of OPS manufactured by a local manufacturer.

Figure 1: Open plan office system. (Source: http://www.bristol.com).

The research and development (R&D) in open plan office jointing system is still in the preliminary stages. Most of the present researches emphasize on the physical aspect of the design. Most of the manufacturers and designers are only interested in developing the appearance of the frame rather than the

technical aspect of the product (Raja Azmeer, 2003). Raja Azmeer explains that the team from Herman Miller and Quickborner concentrated on the appearance and the development of a new concept of open plan office. On the other hand, Voss (1999) explains that Vitra Design Center and Haworth Furniture concentrated on the chair component and physical impact on workplaces.

The main issue concerning the OPS is in the effectiveness of the jointing system that can facilitate the installation, improve the quality and enhance the stability of the frame. This paper presents a study that was carried out to develop a new jointing system for open plan office system that complies to the needs of the OPS manufacturers. Identifying the suitable jointing concept and design are factors that could contribute to the quality of the jointing system, facilitating assembly and increasing efficiency.

2. OPS JOINTING SYSTEM

Figure 2 shows the main component of the frame in OPS. Each frame has nine standard components that are made of different materials. The components are assembled to construct a frame. Details of the components, materials and quantity required for a frame is shown in Table 1.

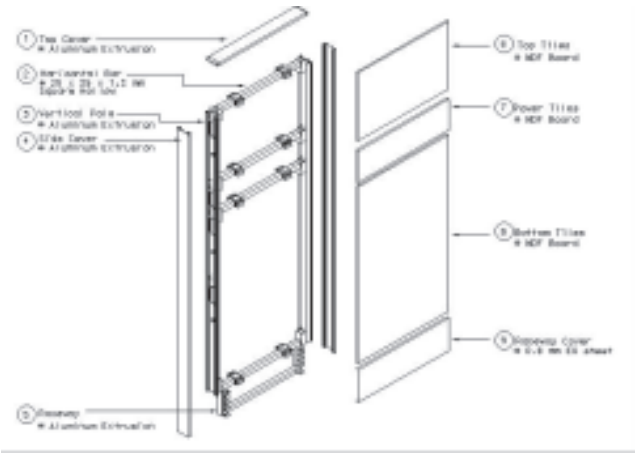

Figure 2: OPS main components. (Source: Bristol Technologies, 2004).

Table 1: OPS Components, Materials and Quantity of Components per Frame (Source: Bristol Technologies, 2004).

	Components name	Materials	Quantity per frame
1	Top cover	Aluminum extrusion	1pc
2	Horizontal bar	25 x 25 x 1.2mm square hollow	4pcs
3	Vertical pole	Aluminum extrusion	2pcs
4	Side cover	Aluminum extrusion	2pcs
5	Raceway	Aluminum extrusion	1set
6	Top tiles	MDF board	2pcs
7	Power tiles	MDF board	2pcs
8	Bottom tiles	MDF board	2pcs
9	Raceway cover	0.8mm EG sheet metal	2pcs

The jointing system is used to connect frame-to-frame and frame to other system or wall. It locks the frame together, forming a paneling system used to arrange the office interior (Bristol Technologies, 2004). The jointing system enhances the stability of the frame. Stability is important to ensure that the frame can stand freely and can be aligned accordingly.

A good jointing system will connect the frames without leaving any gaps between the frames and fit snugly together. It is critical because if the strength of the joint is loose or too tight, both the jointing and frame can be easily damaged (Shigley and Mischke, 1986). The jointing system must also be flexible. This will make the OPS easier and faster to be assembled and disassembled according to the office requirement
However, most OPS manufacturers use bolt and nut as the jointing system. Bolt and nut jointing system requires many components per connection. Many problems are created during the assembly process. According to Ashby and Johnson (2002) and Lesko (1999), the problems in using bolt and nut jointing system are:

i. *Difficult to assemble.* There are too many separate components in each connection and the assembly process involved hand tooling such as power driver or Allen key.
ii. *Has too many parts.* The bolt and nut consist of four non-standard components per connection (bolt, nut and two washers) that make the jointing difficult to handle.
iii. *Takes time.* Insertion of each component is difficult and takes time due to the non standard component in each connection that makes the assembly process slower.

Although bolts and nuts may provide stability, they lack flexibility. The strength of the joints may also be inconsistent. Each frame-to-frame (e.g. the medium screen) will involve three sets of bolts and nuts.

3. METHODOLOGY

Since there are problems encountered with bolt and nut jointing system, a new jointing system for the OPS has to be designed by taking into considerations the requirements of OPS manufacturers. Several steps have been taken to meet the objectives of the study.

3.1 Questionnaire Development and Sampling

To determine these requirements a questionnaire was developed to identify the main problems and the level of importance of current jointing system in open plan office system. The close-ended questions were adopted with the key questions covering types of jointing need, range of OPS and the design factors. Multiple-choice questions were provided in the questionnaire to identify the current problems and the characteristic of the jointing system required. The questionnaires focused on the tile system model, medium screen frame and restricted to the frame-to-frame connection. All 43 OPS manufacturers in Malaysia were invited to be the respondents of the questionnaire. The questionnaires were sent via e-mail, telephone call and direct interview.

3.2 Literature review of jointing methods (material)

Literature review on the various types of jointing method used in the furniture industry was conducted. The advantages, disadvantages, types of joint and usage were analysed. This was then compared with the requirements identified by the OPS manufacturers and evaluated for their feasibility. The materials to be used were also evaluated for their properties.

3.3 Conceptual design

The next step was to develop the conceptual design. Once the conceptual design was established, a 3-D model was developed using SolidWorks 2003 software. The 3-D models were then converted into CosmoXpress and simulated for their performance and compared with that of bolt and nut jointing system.

3. 4 Testing and Analysis

The conceptual designs were tested for their ease of assembly, time taken, strength, number of parts and weight. The results were compared with the current jointing system.

4. RESULTS AND DISCUSSION

Out of the 43 OPS manufacturers in Malaysia, only 26 (60%) responded. As shown in Table 2, the respondents identified the following factors as the highest priority: easy to assemble (88.5%), reduce time (81%), and less part (77%). Similarly, the following factors were considered as priority: mobility (77%), working posture (69.5%) and light weight (54%). 81% of the respondents deemed cost as not priority. The criteria identified by the respondents to be considered as effective jointing design factors were those that make the operations easier, faster, increase efficiency and facilitate assembly.

Table 2: Questionnaire Analysis

Design factor	Manufacturer's Opinion			
	High priority	Priority	Not priority	Not sure
Easy to assemble	**88.5 %**	11.5 %	0.0 %	0 %
Less part	**77.0 %**	19.0 %	4.0 %	0 %
Light weight	8.0 %	**54.0 %**	38.0 %	0 %
Mobility	11.5 %	**77.0 %**	11.5 %	0 %
Reduce time	**81.0 %**	19.0 %	0.0 %	0 %
Working posture	19.0 %	**69.5 %**	11.5 %	0 %
Cost	4.0 %	15.0 %	**81.0 %**	0 %

4.1 Jointing System in the Furniture Industry

There are various types of jointing method for assembly processes used in furniture industries. The selection of joints depends on the product to be joined and the importance of the jointing in contributing to better assemblies (Ashby and Johnson, 2002; Lesko, 1999; Chapman and Peace, 1995). There are three types of jointing method: adhesive jointing, wood jointing and mechanical jointing. A summary of the different methods is presented in Table 3.

Table 3 indicates the advantages and disadvantages of the jointing method in the furniture industry. The comparison of the different types of jointing system

shows that the Snap fit jointing system fits all the requirements specified by the respondents of the questionnaire. A snap fit is the simplest, quickest and most cost effective method of assembling processes (Bonenberger, 2003; Spahr, 1991; Pont, 1990).

Table 3: Advantages and Disadvantages of Different Jointing Method

	Type of jointing	Advantages	Disadvantages	Usage
1	Adhesives jointing - Hot melt - Polyurethane. - Silicon	- Fast and easy to used - Bond to a wide range of material - Tough and flexible.	- Cannot be disassembled	- As a sealant
2	Wood jointing	- Provide strength	- Suitable for wood-to-wood joint	- Chair structure
3	Mechanical jointing			
	- Staple and rivet	- Cheap, fast, joint different material, easy to use	- Permanent joint	- Chairs, OPS panels
	-Treaded fastener/ bolt and nut	- Cheap, joint different material, easy to use	- Critical in tightening, many part, difficult to assemble and disassemble takes time	- OPS jointing, chair, table
	- Snap fit	- Fast, cheap, reduce time, easy to use, joint different material, can replace bolt and nut, no fastener	- Involved tooling, can be damage by mishandling	- Caster wheel, door handle, gear, chairs
	- Metal bracket	- Joint different material, rigid	- Many parts, difficult to assemble and disassemble, takes time	- OPS jointing, chair, table

4.2 Design proposal

As suggested by Crowe and Feinberg (2001) and Heskett (1980), sketches have to be done manually in order to get the basic design in the early stage of the design proposals. A basic sketch of the jointing system was made based on the findings from literature using a sample frame from a manufacturer as a reference. The location of the jointing and how the jointing system should be assembled were the main considerations. The jointing designs to be developed must meet the requirement specified by the respondents of the questionnaire.

4.3. Proposed Jointing Concept

Once the snap fit jointing system had been chosen, the design dimensions were specified and drawn accurately and coded into a surface 3D modeling. Nylon plastic was chosen to be used in designing the jointing system. Data gathered from literature revealed that nylon is the most suitable material to be used in developing furniture product due to its characteristic which is elastic, tough, recyclable, and widely used in furniture and many plastic industries (Ashby and Johnson, 2002). Two design concepts were developed testing,

Design Concept 1. Design proposal 1 (see Figure 3) is based on cylindrical or annular snap fit joint. The cylindrical concept can be designed to dismantle with ease or not at all depending on the shaft lead and hub return angle (Bonenberger, 2003; Lesko, 1999; Pont, 1990).

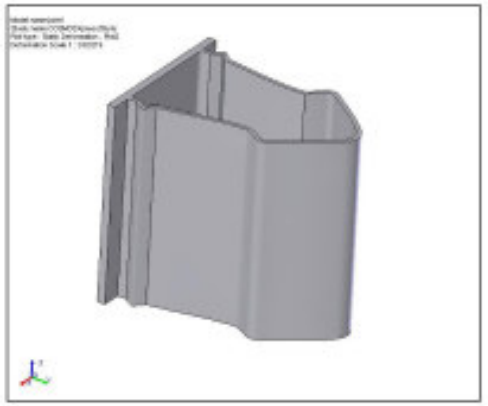

Figure 3: 3D solid modeling showing a cylindrical snap fit design.

Design Concept 2. Design proposal 2 (see Figure 4) is based on a cantilever lug concept. The cantilever lug concept is actually a spring application which is subjected to high bending stress during assembly. Similar to the cylindrical snap fit, cantilevered lugs joint can also be designed to disassemble easily or not at all by adjusting the return angle (Lesko, 1999; Pont, 1990).

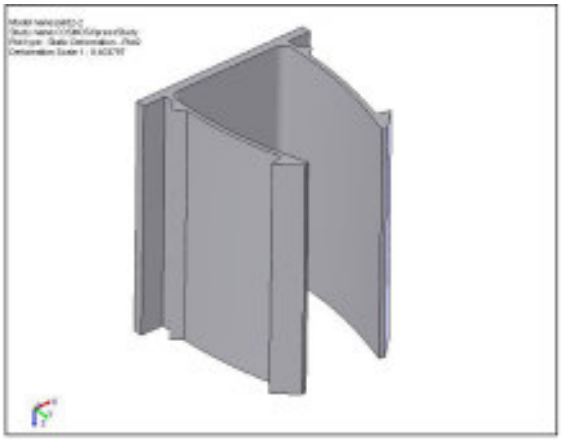

Figure 4: 3D solid modeling showing a cantilever lug design.

4.4 Testing And Analysis

SolidWorks 2003 software was used to build-up the 3D solid models and proposed materials were added to the product. The models were transferred to COSMOSXpress software to run the computer simulation. The computer simulation evaluated the model numerically, and data were gathered in order to estimate the desired true characteristics of the models. The new design proposals were tested using computer simulation to determine whether they met the requirements specified by the respondents. The design was tested on the following design factors: assembly ease, fewer parts, light weight, short assembly time and strength. Table 4 shows the comparison between the current jointing system (bolt and nut) and the new plastic jointing designs. The results showed that both the new designs were able to overcome the problems posed by designs using conventional bolts and nuts.

Table 4: Comparison between (Bolt and Nut) with the New Designs

Test/analysis	Current jointing system	Design Proposal 1(P1)and 2(P2)
Easy of assembly	No (involved hand tools)	Yes (without hand tools)
Number of parts	Four parts	One part
Light weight	50 gram	14 gram (P1) 16 gram (P2)
Assembly time	120 second per joint.	5 second per joint
Strength	Failed under 50kg force	Passed under 50kg force

5. CONCLUSION

This research has proposed an alternative jointing system from the bolt and nut jointing system currently used in OPS. By identifying the problems with the current design and requirements of the manufacturers, the snap fit jointing system concept has been proposed. The snap fit concept uses less part, thus making it easier to assemble with lesser time, weigh less and can probably improve the working posture of the workers. Since less time is taken, workers can be spared from maintaining awkward postures for long durations. Based on the simulation results, the proposed jointing system is feasible to be used. However, further work is required to fabricate the proposed jointing system and measure their performance in the OPS.

6. ACKNOWLEDGEMENT

This study is part of a Master of Science thesis by the first author at the Department of Mechanical and Manufacturing Engineering, Faculty of Engineering UPM, sponsored by University Putra Malaysia (UPM). This is an extended poster paper presented at the 17th International Innovation, Invention and Industrial Design Technology Exhibition (ITEX 2006) Kuala Lumpur Malaysia, 19-21 May 2006. We acknowledge the contributions of Mr. Fuad Yusof and Mr. Azmi Abdullah in this study.

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