DEVELOPMENT OF REINFORCED PMMA SHEETS FOR OFFICE FURNITURES & A NEW JUNCTION DETAIL PROPOSAL

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ABSTRACT

DEVELOPMENT OF REINFORCED PMMA SHEETS FOR OFFICE FURNITURES & A NEW JUNCTION DETAIL PROPOSAL

Nowadays life styles are changing and more modern than before, for that reason peoples furniture desires are different. In this modern world; furniture using gain a meaning and play important role than before, it defines peopele’s social status and their posion in this life.

Design criteria are changing and improving everyday because of this designers use different equipments for their desingns. Glass production which is diffucult to take a shape hence plastic meterials were common after World War II. Modern views and their strength transperent materials satisfied designers desires. After gained environment conclousness same plastics which are non recyling products were gave up to use. Light and high strength plastic which is a recyling material PMMA is very common to use PMMA as known as a brand which name is plexiglass in Turkey. Also this plastic materials have very effective features than others….

İn this study, transparent sheets, glass and PMMA which are used furniture production were studied. As a designer approach different examples and combine details are given.Combine details which are used furniture production were researched and PMMA panel's strength,variety and flexibility were suggested as an beneficial metarial. After the performance, for the office furnitures, there had been a suggestion on a material that brings positive reaction for its endurance, variation and elasticity to the PMMA plate which is more frequently preferred compared with glass. In the suggested material, putting galvanized matting string between the two PMMA plates resulted in stronger and more elasticity characteristics,compared to the standart PMMA plate. After the compose of the material, it had been put through durability test.As a result the material's bending durability had been calculated, too.

ÖZET

OFİS MOBİLYALARI İÇİN GÜÇLENDİRİLMİŞ PMMA LEVHALARIN GELİŞTİRİLMESİ VE YENİ BİR BİRLEŞİM DETAYI ÖNERİSİ

Günümüzde değişen ve modern bir anlayış kazanan yaşam tarzları insanların mobilyalardan beklenti ve isteklerini farklılaştırmıştır. Modern dünyada mobilyadan beklenen geçmişteki gibi sadece bir statü göstergesi olması ya da işlevsel olması değil, bunun yanında insanların yaşadığı ortama anlam katma ve kimlik kazandırma özelliklerine de sahip olması insanların kendinden bir şeyler bulacağı arzu nesnesi haline gelmesidir.

Zamanla değişen beklentiler doğrultusunda gelişen tasarım kriterleri tasarımcıları geleneksel malzemeler dışındaki malzemelerin araştırılıp kullanılmasına yönlendirmiştir. Camın üretimi ve şekillendirilmesindeki zorluklardan dolayı İkinci Dünya Savaşı sonrası dönemde plastik esaslı şeffaf malzemelerin kullanımı yaygınlaşmıştır. Modern görünüşleri ve dayanıklılıklarıyla saydam malzemeler tasarımcıların oluşan bu beklentilerini karşılamalarına olanak vermiştir. Çevre bilincinin gelişmesiyle çoğu geri dönüşümlü olmayan plastiklerin gözden düşmesine karşın, hafif ve yüksek mukavemete sahip olan ama bunun yanında da geri dönüşümlü bir malzeme olan, Türkiye'de Pleksiglas markasıyla tanınan Polimetilmetakrilat (PMMA), bu özellikleriyle diğer plastik esaslı malzemelerin arasından sivrilmiş ve mobilyalarda olduğu kadar günlük hayatın da birçok alanında yer almıştır.

Bu çalışmada mobilya üretiminde kullanılan şeffaf malzemelerden cam ve PMMA yapısal ve birleşim detayları açısından örneklerle karşılaştırılarak bir tasarımcı yaklaşımıyla incelenip, mobilya üretiminde kullanılmakta olan birleşim detayları hakkında bir araştırma yapılmıştır. Çalışmanın sonunda ise ofis mobilyalarında cama oranla daha çok tercih edilen pmma levhaya dayanım, çeşitlilik ve esneklik açıdan artılar getiren bir malzeme önerisinde bulunulmuştur. Önerilen üründe iki pmma levha arasına konan galvaniz hasır tel sayesinde standart pmma levhaya oranla daha güçlü, daha esnek özelliklere ulaşmaktadır. Malzemenin oluşturulmasından sonra malzeme, dayanıklılık testine tabi tutulmuştur. Sonuç olarak malzemenin eğilme dayanımı da hesaplanmıştır.

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CHAPTER 1

INTRODUCTION

Throughout history, men tried to add details to facilitate their life for differentiate and beautify their living spaces. While doing this, they used their intelligence and skills. The material is used both in shaped order and combining with different materials. The first applied shaping methods simple cutting and chipping were developed after invention of fire, and lead to bending and firing methods. When it comes to junction details, the first recognized simple fixing or telescoping methods are changed into knotting techniques and ribbed dovetailed systems which minimize sliding. Later the usages of materials which are liquefied with water and solidified when contact with air are realized.

During history the oldest material which draws people's attention is glass. It attracts attention with transparency and light reflection features.

Men who shaped the environment by taking samples from nature, has first used natural glasses formed in volcanic region and than key started to form glass by melting sand in these areas. Antique age people, attracted by glass which is a transparent and colorless material as air and water, in addition, due to the difficulty of manucturing and processing of the material they used it to vow and in sacred ceremonies. During their lifetimes, they used the glass to have access to light and keep their foods and beverages.

After developments in technology they used to glass more commonly in their living spaces with the ability of producing glass layers. Hence the difficulties in manufacturing and the fragility of glass, it couldn't meet the requirements of furniture usage.

The plastic researches made on productivity in early 1935. They used the plastics in military fields after the start of Second World War. During the war, designers had an opportunity to make researches and developments on plastics. Due to the strength and lightness of plastic, it was used in production of aircraft equipments. After the war, with the consequence of decreasing demands from military, plastics first used in small households, therefore it's started to be used in our daily lives. According to structural features PMMA is included in plastics. It's light, flexible, transparent and easy to recycle and is preferred to be used instead of glass in furniture manufacturing.

1.1. Definition of Problem

In our developing and changing world, the demands and needs of people had changed and developed. Especially during manufacturing of furniture which were used in every step of life and designed not only for function but also for statute and as desire object, different materials are started to be used.

Due to the usage of glass is old established, the studies on glass are started in 20^{th} century and it was chosen during the research of different kind of material. Transparent materials which had attracted people because of glitter and transparency features; they were used as window, furniture and ornament articles.

By developments in recent technologic conditions, the disadvantages of glass was taken into consideration and PMMA which has minimized fragility, permeable, opaque and more flexible than glass, was started to be chosen instead. Certainly, the most important thing while using both materials is to analyze the differences and similarities between them and make it possible to be used properly.

1.2. Aims of Study

At the end of technologic developments, PMMA and glass get into our lives and they are started to be used individually besides with other materials in decoration and furniture manufacturing. The weak sides of glass and PMMA are supported by proper materials. The junction detail of materials, which has different components and structures, has a very important role.

The purpose of this thesis is, to evaluate the usage of transparent materials, especially glass and PMMA, in decoration and furniture manufacturing, besides the extended presentation and comparative observation of these two, and the evaluation of junction details with other kinds of materials.

1.3. Methods of the Study

In the second chapter, PMMA, being a plastic based material, has been defined, and the chemical characteristics of the thermoplastics PMMA belongs to and other materials that belong to this group has been stated.

The place, form and development of PMMA in the world and Turkey have been observed. The materials in PMMA, chemical reactions, reactions and physical characteristics have been studied. And, its turning into panels, being shaped and applications have been illustrated and evaluated. As an addition to all these characteristics, the maintenance, protection, stocking and carrying methods of PMMA has also been examined.

And as the last bit in this chapter, the production and panelling of PMMA's in our country have been examined in their production areas. Interviews have been done with producer firm authorities and the production levels have been noted with photography and explained.

In the third chapter, the development and general form of the glass, compared to PMMA, is examined. Glasses have been classified by materials that form the glass. The production, production methods and shaping processes have been examined. There's also information given about the cleansing, carrying and stocking of glass. In this chapter, just like in the second, the production methods in our country related to glass production have been examined. The glass production and processes are being observed on the place in the glass furnace.

In the fourth chapter, the similarities and differences and physical and chemical reactions of PMMA and glass have been evaluated with the aid of certain graphs. While doing the evaluation between two materials, they have also been compared with other different materials. Many PMMA and glass furniture applications in internal space design have been illustrated with photos and evaluated individually.

In the fifth chapter, the merging details of the houses, offices and city furniture that have glass and PMMA as main materials have been examined aided by photos and drawings. Afterwards, there has been a detail study about PMMA that is more preferred in use compared to glass. And also, drawings and merging details about this study are also in this chapter.

In the last chapter, the PMMA and glass materials examined one by one and illustrated in other chapters will be considered and the applicability of the merging details in furniture usage will be discussed. The advantages and disadvantages of using the materials in the proposed detail study will be examined. The junction materials to be used in the merging points of the PMMA and glass materials with other materials (wood, metal, plastic… etc) have been illustrated.

1.4. Limitations

When transparent materials are mentioned, many different materials come to mind. During this thesis study, the study has focused on two materials. The first of these materials is PMMA and the second is glass.

While examining PMMA and glass, the characteristics, reactions, panelling, cleanliness and stockings of materials have been researched. After this research, the production of both materials in our country has been examined, and as an extension of this illustrations from both our country and abroad have taken place. It has been made sure that the examples given due to the thesis topic being about the merging details of furniture that consist of transparent materials include these merging details.

After examining these materials, there’s a material offer that creates pluses in terms of the PMMA panel’s endurance, variety and aesthetic.

CHAPTER 2

PROPERTIES OF PMMA MATERIAL (POLYMETHLYMETHACRYLATE)

Plastics, which are newer and still developing when compared to other materials used in furniture, are much more complex and confusing than traditional materials. Plastics are synthetic materials that could be obtained with many chemical formulas. Therefore it's difficult to generalise about plastics and it's necessary to define which production method it's been formed by and which plastic formula has been used when talking about plastic materials. Though, the fact that naming plastics hasn't exactly been standardised yet creates a bit of trouble; given names are far too long and not memorable. Besides, a product could be associated with one or more producer or marketing firms in the market. Therefore, while the actual name sounds too foreigner, the same material could be defined with many names. Polymethylmethacrylate (PMMA), being the registered trademark of several producers with names such as Plexiglas and Lucite, is thermoplastic.

2.1. Plastic

Plastics are organic polymer materials which generally stays in the form of solid at a normal temperature and can be pressed under the pressure and temperature. The name of the plastic comes from its own mechanics features. Plastics display special and big changes when they meet metalic supplies. Plastic materials show sensitivity when is is applied tension to these materials. The plastic materials have very much sensitivity when they compare with the metals. The chemical structure of plastics is composed of a large number of "Mer" molecules which are tied to each other as a chain of molecules. The new structure is named as a polymer and it consist of long molecules. Because of the different chemical structure of polymers, plastics show different physical features "(Guy 2004)".

A large number of plastics are colourless. They can be made colourful with using livening up substances in order to acquire the desired colour. Plastics can be coloured opaque with pigments or they can be coloured transparent with dissolving organic paints. The surface of plastic materials are soft and the resistance of them against scratches is not much. Plastics are less harder than glass, seramics and metals. Opaque is harder than coloured plastics and the ones which their surfaces are covered with paints.

Plastic materials are heavier than all other materials except from the firewood. The density of plastics is between 0.9 – 2.5 g/cm ^{3}. Because of that plastics are not used when the weight of the material is important. The feature of plastics which is related with heat is one of the important charestics of plastics. Plastics become softer between the high temperatures. Because of the lower heat conductivity, the friction and the repeated tensions cause increasing of the heat. And so that the heat collects inside the material. According to their reaction against the temperature plastics are divided into three basic group: Elastomers (elastoplastics), Termosets, Termoplastic "(Berins 1991)".

2.1.1. Elastomers

The elastomers are plastic materials which are their molecule structure is a network. This structure provides flexibility, softness and pressurability to the material. The rubber is a kind of elastomers. But it is necessary to take into consideration the before and the after of the reaction of rubbers with sulfur. The features of rubbers before the vulcanization of rubbers with sulfurs resemble termoplastics and their features after the vulcanization of rubbers with sulfur resemble termosets. Elastomers are connected to each other diagonally like the termosets with the process of vulcarization and then they become elastic "(Akkurt 1991)". Butil, neopren, nitril, stiren butadien, silicon are kinds of the elastomers.

2.1.2. Termoset Plastics

The termoset plastics have three – dimensional network. Macromoleculer structure of termoset plastics is supported by strong networks. Because the softening temperature is higher than the dissolving temperature when the termoset plastics are heated once for to be shaped, they become more polymer and they generally form crosswise links. Because of that reason once they are heated the possibility of recyling them disappears. When the termosets are cooked, they become solid and hard like an egg, their chemical structure changes and they become a undissolved matter.

The equipments which are made of termosets preserve their structures. But the equipments which are in the form of rod, band, panel and can be made of termosets and the logs which are made of termosets can be processed by the machines like the lathe and the freze. Because they are resistant to heat, they can preserve their structure in a long period of time. Aminoplastlar, poliester, fenolic, epocsi, dialiltalat, alkid and polyurethane are kinds of termosets “(Kaya 2005, Akkurt 1991)”.

2.1.3. Termoplastics

These kind of plastics can be shaped under the temperature and the pressure because under these conditions termoplastics become soft and flowy and also when they are cooled, they can toughen. The chemical structure of termoplastics is composed of long fiber molecules which are not tied to each other crosswisely. Because of that reason this material softens above the temperature of glass-melting and under the higher temperatures they become liquid without any spoiling. And also their chemical structure do not change in this shaping process “(Akkurt 1991)”.

The termoplastics are widely used becuse of their features such as low density, good electrical features, easily shaping, lower eroding and colouring. However low elasticity module (low elasticity under electric charge, easily passing to plastic zone), low temperature resistance and high heat dilatation coefficient are disadvantages of termoplastics.

Asetal, acrilic, celluloses, fluoroplastics, naylon, polycarbonate, polyethylene, polypropylene, polystyrene, polyamide, polyphenilenether, polyphenilensulfide, polysulfide, polyvinylchloride, polyurethan are kinds of termoplastics “(Berins 1991)”.

2.2. Polymethlymethacrylate (PMMA)

Polymethylmethacrylate (PMMA) is known as perspex, acrilicsheet, lucite etc. in many places of the world and it is known as plecsiglas in Turkey and it is a kind of acrilics of the termoplastics. Polymethylmethacrylate is commonly used in designing sector “(Web_3, 2006)”.

Polymethylmethacrylate which is its original is a metacrilic resin is a colorless and solid matter. This matter varies colourful, opaque, transparent and half – transparent. This matter can be easily processed, can be cut, can be holed and it is light. This matter is generally used as an alternative product in the areas where the glass is used. The principal features of Polymethylmethacrylate are its high elasticity and its resistance to the exterior effects and the some atmospheric effects like ozone, oxygen and chlorine. Also this material has an extraordinary feature of filtering the light and carrying the light along its surfaces, cross sections and corners.

Polymetilmetacrilat is generally found as smooth panels which are their thickness are 1.5–25 mm in the market. They can be softened in the water at the temperature of 90^0 C or in the drying oven (incubator) at the temperature of between 90^0 C and 115^0 C and so that it can be pressed and shaped. Altough it is more enduring and lighter than the glass, it can easily burn up because its resistance to burning is less.

The PMMA is a termoplast material. The white - light permeability of this material is % 92. The PMMA which is used as coloured and opaque, are not affected by the light and the weather conditions when it is used as tranparent even though coloured plastics are affected by the light and the weather conditions. The hazy of this material is nearly % 1 and the refraction index of this material is 1.49. The pulling resistance is 700 gr / cm^3, the value of stroke resistance and the stiren copolymers are same. The density of this material is between 1.17 and 1.28 gr / cm^3. The deformation temperature is between 73^0 C and 97^0 C “(Kaya 2005, Akkurt 1991, Web_1, 2005)”.

2.2.1. Development of PMMA

The inventors of Polymethylmethacrylate (PMMA), Otto Röhm and Otto Haas founded at the early years of twentieth century Rohm & Haas Company in Germany. In 1909 Otto Haas moved to Philadelphia to establish the American branch of Rohm & Haas Company, and in 1917 he founded Bristol Plant where he began to research about PMMA. By the same years because of the tension of the World War I, the plant became an independent company from German branch. PMMA introduced to public under the name of Plexiglas© in 1936 as an alternative to glass. Plexiglas© was a material lighter about less then a half of glass yet seventeen times stronger. In 1943 the demand for Plexiglas© rose obviously and became a popular material to use on military aircraft on cock-pit canopies, windows, gun turrets and bombardier enclosure. After the World

War II the demands toward the materials dropped dramatically, that's why they produced Plexiglas© in different colours. The coloured Plexiglas© became popular on the construction of jukeboxes. In 1948 the UL49 released and became the sign standard in industry, the name Plexiglas© used as signage since then. In 1992 Rohm & Haas makes a joint venture with Elf Atochem North American Inc and changed its name as AtoHaas, by the end of the same decade, at 1998 Elf Atochem North American Inc purchases Plexiglas© totally fron Rohm & Haas. Next year Totalfina and Elf Aquitane reorgnized under the name of the TotalFinaElf and became the fourth largest oil company across the world. The chemical operations branch of the company named as Atofina, and in a short time Elf Atochem North American Inc changed its name in Atofina Chemicals Inc. Despite of these major changes occurring less than a decade the name Plexiglas© still remained unchanged. In 2001 the global business branch producing Plexiglas© Atoglas is founded, and after changing the name of firm from Atofina to Arkema, in 2005 the name of the company changed in to Altuglass International, and procures Plexiglas© of high quality since them "(Web_2, 2005, Web_5, 2005)".

2.2.2. General Properties

Chemistic materials of in PMMA sheets:

- metil metakrilat monomer (MMA)
- Catalyst :AZON (2,2 azodi-isobutyroitrils)
  TBHP (tersiyer butil hidroperoksit)
  Maleik asid esteri
- Plastifiyan : DOP (dilaktik ptalat)
  DBP (dimetil ptalat)
- Mold Testing Reagent: stearik acid
- Activator: 2 etil hexyl thioglikolat
- Ultraviolet absorbent: tinüvin p
- Colorful: various colors

The PMMA panel has a quite high resistance against the chemicals such as the alifatic hydrocarbons; inorganic alkalis (ammonnium, sulfuric asid etc.), acids, hegza, octane and VM&P naphtha. The PMMA panels which can be produced different qualities show different resistances to determined chemical matters. Firstly, the PMMA panels can be united with aromatic hydrocarbons and then they can be solved in organic compounds like acetone, benzene, toluen. The PMMA panels can crack under determined conditions when they touch some gasket and stuffing materials except from the stresses which results from the chemical resistance, fabrication processes and temperature changes etc. The total stress on the PMMA panel and the duration of being exposed to this stress affect the sterss cracks on the panel and the glaze cracks.

The density:	1.189 gr/cm3
The light permeability:	92%
The breakage:	1.489
The vicat softening point:	114 C
The water absorption:	0.21% (Web_6, 2006)

The PMMA can be colourized, it can be turned on a lathe and it can be polished. And also the PMMA can be used in the production of traffic lights, the traffic signboards, the electrical decoration lambs, the headlights and reflectors of cars, the lights of cars, contact lenses, transparent pushbuttons of panels and in the place of glass. Because it is a hard material, it do not have resistance to strokes. On the other hand, in order to increase its stroke - resistance, it can be added high - resistance modified acrilics. Altough it is advised that not to use this material in the equipments which need high stroke – resistance. Because the PMMA do not transmit electric, it can be used in the electrical fields. The feature of absorbing the humidity insreases its transmitting of electricity "(Web_1, 2005., Savaşçı 2002, Dekker 2000)".

2.2.3. The Kinds of the PMMA Panels

The PMMA panels, except from colourless panel, can be produced in these colours; half – transparent, transparent, opaque and solar control together with varying in quality several different surface models as shown in figure 2.1.

Figure 2.1. PMMA Colour Chart
(source: Web_8, 2006)

It can be found queue standard white and half – transparent coloured PMMA panels at the level of extensive density. And also PMMA panels have the features of transmitting of light in different proportions, diffusion and the power of saving light. The white half – transparent panels are rather used in the areas of lighting and the advertisement products.

There are found matte standard coloured PMMA panels of the half – transparent PMMA panels except from the glossy ones which transmits and spreads the light. The objects which stays behind these panels are not easily distinquished. The transmitting of light is not related with the thickness of the panel.

There are found standard coloured kinds of the transparent PMMA panels which provides transparency, colour filter, solar temperature and the flash control. The transmission of light changes from colour to colour. But the transmission of light has the equal value for the same coloured panels without looking the thickness of panel. The PMMA panels can be produced both transparent colours and opaque colours which is named impermeable. It is produced standart opaque low – chrome colours for the unenlightened decorative panels.

The solar - control coloured panels solve the problems about solar temperature and brightness control. These panels exist in bronze and gray hues and provide high preservation in architectural and transportation sheen, encirclings, protection from the sun. Like the other transparent coloured panels, the transmission of light changes from colour to colour but the same coloured panels (of the solar contol coloured panels) transmit the light at the same density without looking the thickness of panel.

An other kind of PMMA panels, the surface texture of the figured panel refract and deflect the light. To add special textures provides decorative effects and privacy in locations, and diffuse the unwanted reflections. The determined figures can be embroidered on one side or both sides of transparent, half tranparent and opaque coloured panels.

The colourless PMMA panels transmits most of the invisible infrared energy. But some PMMA panels prevent the visible light and transmits the infrared light with separating it. This operation includes remote control equipments, laser lenses and heat sensors. The some PMMA panels which are produced high quality standards, prevent UV rays with providing maxiumum absorbation of UV rays. The standard PMMA panels can absorb only the short wave lenght UV rays. Because of that reason, the PMMA panels are used for to exhibit historical documents and works of art in order to minimize the bad effects of ultraviolet rays "(Web_1, 2005)".

2.2.4. Properties of the PMMA Sheets

2.2.4.1. Stroke Resistance

The PMMA panels which have different thicknesses, have more stroke resistance than all the kinds of glasses even hardened glass when it is compared to various kinds of glasses. The data on the Table 2.1. which is related to this situation is received from the test samples which are their edges are compessed as a fit square. The hardeness of an object affects the stroke resistance of the PMMA panels. At the test of air – gun, it is received information about the practic measure of stroke resistance in the use of PMMA panels. This process measures the height of the air – gun in order to break a sample and the necessary energy and the speed for the misilse. The samples for the datas at the Table 2.1 are the 14 x 20 PMMA panels which are their peaks are compessed. The refraction resistance is maxiumum if there are sawde and punched holes without dents on the panel.

Table 2.1. The Resistance of PMMA Panels and the Other Materials

“(source: Web_1, 2005)”

Product	**Norminal thickness mm**		**Weight of free-failling stell ball /lb**	**F\50energy to break / ft-lb**
PMMA Sheet	**.098**	**2.5**	**.25**	**3.0**
PMMA Sheet	**.118**	**3.0**	**2.00**	**4.7**
PMMA Sheet	**.177**	**4.5**	**2.00**	**11.1**
PMMA Sheet	**.236**	**6.0**	**5.00**	**18.1**
Window glass				
Single Strength	**100**		**.25**	**0.8**
Doble Strength	**125**		**.25**	**1.8**
Plate glass	**.187**		**.25**	
Plate Glass	**.250**		**.25**	
Laminated Glass	**.250**		**.25**	**1.1**
Rouge Wire Glass			**.25**	
Impact Rough Side	**.250**		**.25**	**2.2**
Impact Smooth Side	**.250**		**.25**	**0.2**
Polished Wire Glass	**.250**		**.25**	**0.4**

2.2.4.2. Dimensional Stability

The PMMA acrilic panels can widen and can shrink because of the change of temperature and humidity. Because of the different temperature and humidity conditions of the inside and outside surfaces of the PMMA panels cause the act of bending through the higher temperature and the dampness. But this kind of bending can be reversed. When the differences of temperature and dampness decrease to zero, the panel returns to its real smooth form.

The act of bending do not affect the visibility via the smooth permeable PMMA panel but it can distort the reflections. The texture of the surfaces or the formed designs for the translucent and opaque panels which is unnecessary to see the objects behind the panel provide hidining of the flashing reflection distortions. At the field of architecture, the PMMA panel is generally used with the other materials which are exposed to less expansion and contradiction. The ranking compares the thermal dilation factors of the PMMA panel to the other common construction materials.

product	**İnches**
PMMA sheet	**.0000410**
Aluminum	**.0000129**
Cooper	**.0000091**
Stell	**.00000063**
Glasss sheet	**.0000050**

In order to provide good performance in the environments where the temperature rather changes, the PMMA panel should be installed around a frame of a channel which enables freely dilation and shrinking. The frame of the channel should be deep enough for to pucker freely and to stand firm inside the frame. (for the panel) It is better not to use the unflexible nuts which prevent dilation and shrinking. The bants and the stuffing material which are pasted on the acrilic panel and the frame must be flexible in order to be harmonized the thermal dilation of the panel and the frame "(Web_1, 2005, Jaeger 1969)".

2.2.4.3. The Electrical Conductivity

Because of being the high dielectric stability, the PMMA panels are also used as an electrical insulator. But this feature causes static charging on the surface of the panel which absorbs the mote and the lint to itself. When the static accumulation and the high density of mote cause a cleanliness problem, anti – static compounds can be used.

The PMMA panels can develop permanent deformations under the long duration and constant charging. This cold flowing characteristic can be decreased to the lower values with decreasing the measurement of the unsupported areas, using a thicker panel or using heat – shaped configurations "(Akkurt 1991)".

2.2.4.4. The Transmission of Visible Light

The colourless PMMA panel is permeable like the thinnest optic glass. And its total transmission of light is 92% and its average haziness is 1%. The wave lenght of the visible light is between 400 nanometre and 700 nanometre at the electromagnetic spectrum. The electromagnetic energy which comes from the sun to the earth is great at these wave lenghts and it is seen reduction in the ultraviolet and infrared areas.

When the light energy strikes the colourless PMMA panel which stays vertical to the ground (at the angle of 0), the most of the energy is transmitted and is reflected at the both sides and the neglected part of it is absorbed. The teoric maxiumum transmission of the unabsorbable optic medium is tied to the ray refraction index. The refraction index of the PMMA panel is 1.49 so that the counted teoric maxiumum transmission of this medium is 92.3%. The six milimetre PMMA panel transmits the 92% percentage of the vertical rays. The perfect optic medium of this ray refraction index represents all the light which can be transmitted **“**(Guy 2004)”.

With the 8% percentage of refraction loss, the 4% percentage of vertical rays are reflected at the both sides of PMMA panel. When the angle changes, the reflection increases and the transmission decreases. It is not important the absorbation of the colorless PMMA panel whichever its thickness is. The absorbation is lower than 0.5% at the one-inched thickness.

The transparent and translucent coloured PMMA panels prevents the bad effects of the sun light and the other elements. At a result, the PMMA panels which provide well – protection are very effective at the open and close lighing and the application of images “(Web_1, 2005)”.

2.2.4.5. The Transmission of the Sound

The PMMA panels have the feature of preventing the sound like the glass and even more better than the glass. And because the PMMA panel is resistant to breaking, it can be used as a transparent sound barrier which enables both the decrease of the level of noise and the increase of the security. At the Table 2.3, it is seen that the PMMA panels and the other construction materials’reduction points of sound and the frequency spectrum proportion of the source of the noise.

Table 2.2. The Sound Reduction Values for The PMMA Panels
(The test panels 750mmx1000mm) "(source: Web_1, 2005)"

Frequency spectrum of noise source	Approximate noise reduction dB				
	.118 (3mm)	.236 (6mm)	.472 (12mm)	.944 (24mm)	Double glazed
Low frequencies predominant	15	21	26	30	34
Flat frequency spectrum	25	29	33	35	38
Hıgh frequencies predominant	28	31	34	36	40

2.2.4.6. The Value of Hardness

The PMMA panels are not as hard as the other materials which are used in the buildings and the constructions. It can be bended and can be shrinked under the load. Because of its features of bending and shrinking, it must be taken some measures.

The channels of the PMMA panels which provide the insertion of the peaks of the PMMA panels must be deep enough. Because these channels can be departed from each other under the conditions of the heat dilations and the smashings.

The shaping of the PMMA panel increases the hardness of the panel. The shaped PMMA panels should be used in the places where the wind is a lot and the snow is loaded and the large unbacked places. If it is impossible to shape the PMMA panel, the thickness of the PMMA panel must be expanded so it becomes more harder.

Table 2.3. The Average Features of the PMMA Panels
"(source: Web_1, 2005)"

Properties	ASTM Method	Units	PMMA Sheet
Compressive strength (0.05\ min) max.\ modulus of elasticitiy	**D695**	**psi**	**18.000 \ 450.000**
Compressive deformation under load 2.000 psi at 122 °F'24hrs.\ 4.000 psi - 122 °F' 24 hrs (conditioned 48 hrs at 122 F)	**D621**	**%**	**0.2 \ 0.5**
Shear strength	**D732**	**psi**	**9.000**
Shear modulus		**psi**	**167.000**
İmpact strength	**D256**	**Ft-lb\½''x 1''sect**	**7.0**
Rockwell hardness	**D785**	**-**	**M-100**
Barcol number	**D2583**	**-**	**49**
Resistance to stres\ critical at crazing □tres	**ARTC Mod.**	**Psi**	**2.100\1.700**
Hot forming temperature		**F**	**290-300**
Deflection temperature under load 3.6 F \ min-264 psi maximum recommended\ continuous service tempreture	**D648**	**F**	**205**
Coefficient of thermal expansion	**E831**	**İn\Fx10**	
Coefficient of thermal conductivity	**Cenco-fitch**	**BTU**	**1.3**
Specific head 77F		**BTU**	**0.35**
Dielectric strength short time test	**D149**	**Volts\mil**	**500**
Dielectric constant 60hz\1000hz	**D150**		**3.7\3.7\3.3**

Table 2.4. The Average Features of the PMMA Panels
"(source:www.plexiglas.com)"

Properties	ASTM Method	Units	PMMA Sheet
Specific gravity	**D792**	**N.A.**	**1.19**
Refractive index	**D542**	**N.A.**	**1.49**
Light transmittance and haze 'as recerved' Paralell\ total \ haze	**D1003**	**%**	**91 \ 92 \ 1**
After 5 years outdoor exposure, Bristol, Pa 45 angel, facing south Paralell\ total \ haze		**%**	**90 \ 92 \ 2**
After 240 hours artificial exposure, Carbon Arc Type, ASTM G-23 Paralel \ haze		**%**	**90 \ 2**
Artifical weathearing, fluorescent sunlamp with dew, 10 cycles, 240 hours exposure Crazing Warpıng	**D1501** **Std. 406 \ 6024**		**NONE**
Instrumental measurement change in yellowness index after artificial weathearing	**D1925**	**N.A.**	**1.0**
Ultraviolet transmisson, 320 mm	**DU 792**	**%**	**0**
Tenstle strength (0.25" numune-0.2"/min.) Maximum Rupture Elonngation maximum Elongation rupture Modulus of elasticity	**D638**	 **psi** **psi** **%** **%** **psi**	 **10.500** **10.500** **4.9** **4.9** **450.000**
Poisson's ratio		**0.35**	**-**

Table 2.5. The Average Features of the PMMA Panels
"(source: Web_1, 2005)"

Properties	**ASIM methode**	**Units**	**PMMA sheet**
Power factor	D150		
60 Hz			0.05
1.000 Hz			0.04
1.000.000 Hz			0.03
Low factor	D150		
60 Hz			0.19
1.000 Hz			0.13
1.000.000 Hz			0.08
Arc resistance	D495		No tracking
Volume resistivity	D257	Ohm-cm	6 x 10"
Surface resistivitiy	D257	Ohm-sq cm	2 x 10"
Horizontal burning test avg.	D635	Cm/min	2.8
Burning rate		(in\ min)	1.0
Smooke density	D2843	%	4-10
Flammability classification		UL 94	94HB
Water absorption, 24 hrs at 73 F	D570	%	0.1
Weigth loos on dry		%	0.2
Weight gain on immersion		%	0.0
Soluble matter lost		%	0.2
Dimentional changes on impersion		%	0.0
Water absorption after immersion for,1 day, 2days, 7days, 28 days, 56 days, 84days	D229 and D570	% % % % % %	0.2 0.3 0.4 0.8 1.1 1.3
Humidity expansion, change in length on going from 20%to 90% relative humidity at equllibrium,74F		mil/in	3
odor			none
taste			none

2.2.4.7. The Burning Reactions

The combustion point of the PMMA panels is more higher than the other wooden materials. But it has still the feature of combustion. Also the PMMA panels burn powerfully and it sets free the heat speedly. The PMMA panels can soften above the temperature of 260^0 F. This degree is almost near the burning point, 300^0 F. During the burning it is occured fire drops from the PMMA panels. When the PMMA panels are used as a wall or ceiling covering material or they are used between the two materials, they provide a good and smooth surface for the other plates. And they provide the rising of the heat and the gases. The burning PMMA panels leave less than the poisonous smoke and gas which come from the burning wood or the piece of paper. The density of carbon monoxide and carbon dioxide is related with the amount of the PMMA panels and the burning conditions.

Because the PMMA panel is a combustible material, this feature of them must be taken into consideration at the application of these panels. Because of this, it must be considered that the PMMA panels do not touch any flammable material when carrying, storing or using them. The necessarry measures against any fire must be taken into condideration during these processes.

The primary measure is existing of the special fire protection systems and the fire exits in these fields or buildings and the inside areas (decorations, plates, furnishings etc.). There must be used a spray cooling system (water foundations for the fires), an otomatic discharging system of heat and smoke, a distant early warning instrument, an inundation system or a water aprons at these special fire protection systems.

The PMMA panels must be installed well away from the dense heat sources and the flammable objects. The edge of the PMMA panels are closed. It is not installed more PMMA panels than the necessary amount. As it is pointed out before, the protection systems such as the spray cooling systems (water foundations for the fires), the fire detectors, the otomatic discharging system of heat and smoke must be established. The PMMA panels must not be used as a backing equipment and in the places where the fire measures are necessarry.

At the ceiling lightings at the buildings, the PMMA panels must be installed from the empty channel spaces so that the combustion can be prevented. The PMMA panels of the window systems are installed in not to be fire and the combusting PMMA panels put out with some water or a fire extinguisher. It is forbidden to use the PMMA panels as a wall or ceiling covering material or a plate (covering material) between the floors at the large inside surfaces without protecting the buildings with the spray cooling systems and receiving approval at a result of legal controls.

2.2.5. The Application of the PMMA Panels

Because the PMMA panel is a multi – dimensional material, it can be used in the wide fields which related with the residences and the locations, the commerce, the industry and the Professional. The main areas which the PMMA panels are used, are arcitectural polishing, the exhibition of retail sale, the signboards, the lightning, the reduction of noise, the equipments, the industrial storage, the accessories of the restaurants and the protection of the documents. And also it is used in many areas.

The exhibition of purchasing points, The barriers for the noise, The commercial exhibitions which aims displaying the products, The covers of the maps and the photographs, The architectural polishing, The protection of the pictures and the documents, The contact lenses, The pediatry incubators, The accessory of the restaurants, The industrial storages for security, The transparent tanks, The accessory of lightning, The framing equipment, The electronic eqıipmant panels, The polishing of the machines, The models, The outside lightning signboards, The transparent lids, The protection polishing, The infrared glasses, The exhibition equipments for the retail sale, The pamphlets, The food containers (dishes, plates) "(Web_9, 2006)".

2.2.5.1. The Production of the PMMA Panels

Both sides of the PMMA panels are covered resistant polyethylen concealing paper. This paper has been covered with a glue which do not cause any harm to the surface of the panel and also it has sensitivity to the pressure. So that the polyethylene can be sticked to the surface of the panel without using any glue. Because of that reason this paper can be easily removed from the panel and then it can be easily installed to its place.

The concealing layer prevents the scratches or the corrosions which ocur wrongly during the transportation and the installing processes. And it is necessary not to remove this layer in the cutting processes and the proceses related with the machine. Even though the layer provide a great protection against the strikes, the people who use these panels do not scroll them or to rub them to the rough and grounded surfaces.Before the heat shaping process and the storing them outside, both paper layers of the panel must be removed.

The covered PMMA panels can be preserved best at the framed hangers as it is dispayed at the Figure 2.2. These framed hangers are made up from the plywood and are tied to each other with the holed angle irons. These ½ inch thick plywoods play the role of the backing base. The panel of the base can be covered with the galvanized metal against the resistance of erosion. The a shape of the framed hanger provides the equalization of the weight and it prevents the extra load to the walls of the building. This frame provides full support to the panels and makes easy to take the panels from the frames one by one.

Figure 2.2. System of PMMA Store

When it is necessary to store the covered panels on the ground, it must be careful about the shavings and the fragments. It ıs not done a store with the PMMA panels which are higher than 18 inch. Fort o prevent the unsupported load, the small PMMA panels must be stowed above the bigger PMMA panels. It provides convenience to parcel up the similar panels, the same coloured panels and the ones which of their thicknesses are same. It must be taken into consideration these knowledge in the covering processes of the panels. So it becomes easy to find them when they are needed.

The glue of the paper layer of the PMMA panels increase timely and it becomes difficult to remove it. Because of that reason the storage must be finished off at first. And the new panels must be stored behind the old ones. The covered or layered PMMA panels must not be stored outside. Because, if the panels have been exposed to the sun light and the weather situations for more than several days, it becomes difficult to remove the covering paper or the layer. But, if you have to store the PMMA panels outside, you must remove the covering paper and then you must cover them with a protective band or a protective covering material.

The covering paper of the PMMA panels is not a matter which is resistant to water. When the PMMA panels get wet with water, after removing of the paper, there have been white sediment on thesurfaces of the panel. For to prevent this bad situation, the PMMA panels must be stored remote places from the water. When there have been white sediment on the surface of the panels, this surface must be wipen with a clean, soft and wet piece of cloth and then it must be mopped with a soft, cotton piece of cloth.

The covering paper on the PMMA panels can be removed with holding one point of the paper and wrapping the paper on a rol lor a piece of cardboard. The paper must be rolled onto the roll as the following sheets and the points must be tightened with the help of the sticky panel. When removing the covering, all the wastes of the glue must be cleaned. And the rest of the waste matters can be wipen with a clean and soft piece of cloth and some isopropyl alcohol. When the covering paper is removing, there have been eloctrostatic load on the surface of the PMMA panel. This eloctrostatic load draws the dust and the piles on the surface of the panel. This eloctrostatic load can be prevented with wipening the surface of the panel with a wet piece of cloth after removing of the covering paper.

It can be removed only the paper of the surface of the panel where the heating, the laying cement or the applying an undercoat processes are done. It must be careful and not to scratch and to graze the PMMA panel when cutting off small pieces from the covering sheet. Because the scratching of the panel causes the fall of the resistance of the panel. In order to decrease the possibility of scratching and harming of the PMMA panel when removing small pieces of covering sheet, it can be used some special equipments. If these equipment is used regularly with the appropriate solvent, they prevent the scratching and the cracking of the PMMA panel. It can be difficult to remove the covering sheet when the PMMA panels are stored outside and they are exposed to the sun light and the humidity or they are stored inside and they are exposed to high temperature and humidity.

At the situations of the heat - shaping and the covering sheet is not fixed vet strongly, the application of heat of 350^0 F during 60 seconds provides the loosening and solving of the paper. At the situations which the paper is fixed very strongly, in order to loosen the covering paper, it is necessarry to use more powerful solvent. All of the paper is dampened with the solvent and it is stayed 10 minutes in order to permeate the paper. After that it can be removed as it is told above.

The covering sheet of the PMMA panels can be changed if you want to change it. The covering of film can not be applied again. And the glue provides a strict protection but the covered parts of the sheet are not touched each other. The covering paper can be rolled onto the pipes and it can be hanged in a clean, dry place. It must be careful for the cleanliness of the covering paper because, when the covering paper is applied again, it can scratch the panel. The ready covering sheets can be obtained from a lot of places and they are used for covering again. But before using these products, it can be controlled that these covering sheets do not contain a harmful glue for the PMMA panels. There are also covering compounds which can be sprayed onto the PMMA panels and these compounds can be removed later. These products are very useful fort he covering of the shaped panels.

It must be used the spray covering which is tested and approved and can be used only acrilic panels. Some covering matters can be used inside areas during 12 months. Generally, it is advised that not to use any kind of covering matter on the panels which will be stored outside more than two months. When using the spray covering materials, it must be applied a covering between 3 milimetre and 5 milimetre. Because, if thecovering is very thick, it is difficult to remove it. Also the covering must be a whole one piece, it must not be done like a patchwork. In order to remove the spray coverings from the PMMA panels, it must be provide crumbling of the spray cover or to pump a pressurized air from the one point of the spay cover. If the spray cover is very thin and because of that reason it is difficult to remove it, it must be applied a new film and be waited for drying of it. And then the thicked film can be removed. At several situations, it is necessary to cover the new spray film with a piece of fine muslin. Because the fine muslin strenghten the film and so it becomes easy to remove the covering.

If the covering film is spoiled because of storing the panels outside, the covered parts can be waited inside the cold water during 24 or 48 hours, so that the spray film can soften and loosen. Also the despoiling matters which are produced by the prodecers of the spray covering materials, can be used provided that not to give any harm to the panels. Before the process of installing the protection spray films must be wipen. Otherwise there can be occured optic defects on the surfaces of panels where the unsymmetrical covered areas on the panel “(Web_1, 2005)”.

2.2.5.2. The Shaping

PMMA panels could be reshaped through several ways.

***The Cold Shaping*;** PMMA panels, being held in a straight arc, exposing the material with the support of a curved canal, and being kept in a radius, can be shaped coolly (bent in room temperature). The minimum radius values for cold-shaped PMMA's are stated below on Table 2.6.

Table 2.6. Minimum Radius Value
"(source: Web_1, 2005)"

Normal Sheet Thicness min.radius

inch	psi	PMMA
0.060	1,500	11
0.098	2,500	17,5
0.118	3,000	21
0.177	4,500	32
0.236	6,000	42,5
0.354	8,500	60
0.472	12,000	86

Lower radius slopes than those stated here could cause cracks and expand the designed stress limits for the material "(Pile 1990)".

The Heat Shaping; In hot shaping cases PMMA panels become soft and flexural in the shaping warmth; approx. 325 ^{o}F. After shaping, the panel cools and hardens into its new shape.

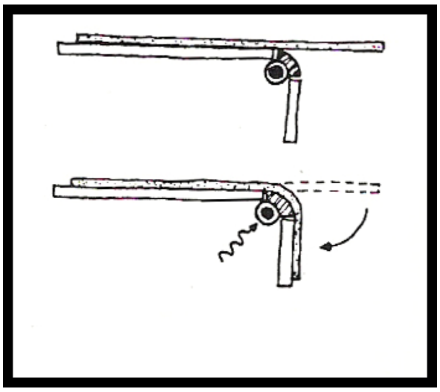

Figure 2.3. The Heat Shaping
(source:Pıle1990)

Since PMMA panels get shaped in low pressure, the moulding could be handled with low cost wood and plastic. These fairly low equipment costs allow panels to be involved in small numbers of intricate and custom made designs. In the polished part, without any loss of quality, hundreds of panels could be formed with the same mould "(Pile 1990)".

2.2.5.3. The Utilization Heat

The appropriate usage heat for PMMA panels is 200F, which will be enough for fluorescent lightning and external appliances. Unless certain precautions are taken by the designer, PMMA panels should not be used in environments that exceed these limits, emits ultraviolet rays and mercurial lamps are used. In case PMMA panels are left under heat that exceeds 200F for a long enough time, the panel's physical attributes and external outlook will be deformed.

2.2.5.4. The Stocking and The Transportation

PMMA panels can be transported in curved fiber cartoons, wood-supported fiber-carton boxes with a brut weight of 400 libres or more, or palettes the weight of approx. 2.000 libres. PMMA panels are packed in standard boxes. The numbers of panels per box differ depending on the thickness and the size of the panels. To prevent the PMMA panels from getting any damage, they have to be carried very carefully doing transport. If possible forklifts should be used to carry the containers. PMMA panel boxes can be transported quite safely with a special towing vehicle for hand use. Stocking environments should be ventilated well. Air circulation should be well and adequate moisture and coolness should be provided. The heat shouldn't exceed 125^{o}F. If PMMA panels are kept in warm and dry environments or kept in closed spaces for too long, the paste on the cover papers could dry in time and it will be difficult to remove. Too much moisture could conclude in the paper deforming and the PMMA panel losing its protective effect.

Confinement environments of the PMMA panels should most definitely be separated from areas which are spray painted or include other solvent gas sources. Otherwise these gases could soften the panel surfaces and deform them. The PMMA panel packages should be made with 10 degrees of space from the corners vertically. Boards about 3-4 cm in height should be put under the package so it stands higher from the ground. Through doing this, both the deformation of the corners will be prevented and the loading of the forklifts will be easier. Especially the shaped parts of the PMMA should be kept in cool environments. If the parts have to be stacked, they shouldn't be stacked onto one another, but should be stacked as simple frames that will provide full support or shelves so that the parts will not be deformed.

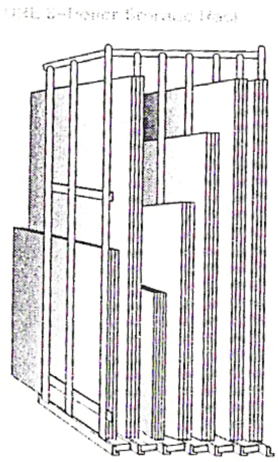

Figure 2.4. The Stocking of PMMA

2.2.5.5. The Maintenance of PMMA Panels

PMMA panels should be washed with soaps or detergents that aren't corrosive and with a lot of water. To feel & cleanse any dirt layers or mud the panel should be washed with bare hands. Only to carry water onto the panel could a soft, smooth cloth or sponge be used. Hard, rough cloths should which could scratch the PMMA panels not be used. The panels should be dried with a clean, cotton cloth. In enclosed spaces where water cannot be used freely, PMMA panels should first be dusted with a soft and clean cloth. Afterwards the surface should be cleaned carefully with a soft & moist cloth. The cloth or sponge should be cleansed in clean water frequently.

Oil can be removed with kerosene or aliphatic naphtha. Solvents such as acetone, benzene, carbon tetrachloride, fire distinguisher liquids, dry cleaning liquids and varnish thinners should not be used, because these damage the PMMA panels' surfaces. Window cleaning sprays and corrosive kitchen cleaning materials should not be used either. Some of the chemicals and solvents stated here have the possibility of poisoning if inhaled for a long space of time or swallowed. Adequate and constant ventilation of the workplace should be provided. Workers should use protective outfit such as waterproof gloves, aprons and goggles, and avoid any exposure of these materials to skin and eyes. Before starting to use any kind of solvents or commercial cleansers adequate information about the attributes and usage should be gained. After cleansing the PMMA panel, if not that many scratches can be found on the surface, PMMA panels can be polished with a good quality polish. Doing this allows the small scratches to fill up and the surface outlook to improve. The polish can be applied as a thin layer, and even rubbed gently with a dry and soft cotton cloth.

Rubbing exceedingly with a dry cloth will both cause scratches and form electrostatic charge over the panel, gathering the dust particles. Cleansing with a clean and moist cloth removes this charge and prevents the dust from gathering over the panel. After washing, if little scratches and cracks are visible over the PMMA panels, most of these are remediable and lessened by polishing. A soft, small cotton cloth is used to apply polish. Rubbing is done through back-and-forth (or circular) movements over the scratches or cracks. Rubbing too much over a single point should be avoided. A few applies might prove necessary, but most of the little scratches will lessen and in a fairly short time a smoother surface will be obtained. After the scratches have disappeared or lessened significantly, the panel should be cleaned with a clean, soft cloth and an anti-static covering should be applied.

Anti-static coverings prevent the electrostatic charge over PMMA's which have been used in enclosed spaces for several months. Cleansing the surface with a damp cloth also prevents electrostatic charge. Between anti-static covering applications, cleansing the pieces with a soft and clean cloth also provides a fine look. Anti static coverings can be applied before montage for PMMA plates used outdoors. This prevents static charge that might form when cleansed after montage. There's no need for additional coverings, because the occasional rain and moisture prevents static charge, but if external acrylic parts are dry cleansed frequently, additional anti-static coverings can prove helpful.

PMMA panels can be put under protection safely and completely by using commercial germicidal materials. One of the advantages of these high factor germicidal materials is that they're also effective in room temperatures. In this case there's also no need to heat up the PMMA panels. Heating can cause unwanted levels of softening. 15 psi also isn't very appropriate for traditional steam cleansing applications, because too much heat can deform the shaped pieces of the PMMA panels. A few differences made in the general procedure could form an operable system. If the appropriate support frame is provided with a relatively short and continuous application, a satisfying result can be obtained for the PMMA panel parts.

Alcohol solutions that include more than 10% of alcohol or crecylic acid germicides can damage the PMMA panel surfaces. Strong alkali solutions (lye, sodium, ammonium, hydroxide etc.) are highly effective germicides. Since PMMA panels are fairly resistant to strong alkali solutions, they can be used freely "(Web_1, 2005, Web_4, 2005)".

2.3. The Production of PMMA in Our Country

In our country, the production stages and conditions of PMMA panels haven't been applied as professional as abroad works. The conditions and possibilities haven't let this yet.

At first stage of PMMA production, the raw materials of supplies are turned into a mixture of liquid phase. This prepared mixture is preserved in store units according to their colours in the production place. By taking out these units, the needed colourful liquid is prepared for hardening stage.

Figure 2.5. The liquid mixture is poured out the glass moulds.

This mixture is poured out the big glass panels. At the next stage, in order to prevent the liquid's flowing from the mould, wicks are put to the edges of the glass panels.

Figure 2.6. The moulds are rested in water pool.

Moulds, which are full of liquid, are waited until they lose the mixture features by being rested in the pools which are full of water in a vertical way. The aim of this is providing the raw material mixture's, which is liquid, seperating equally in the mould by means of the pressure that the water pool's has made to the glass moulds. Moreover, the other aim is preventing the substance' flowing from the mould by pressing the liquid mixture and hydraulic pressure moulds which are found in water pool.

Figure 2.7**.** The moulds are rested in water pool.

PMMA which provides the target freezing coefficient by being rested in moulds is taken out from the inside of glass moulds. At the end of this stage, wicks, which are applied to the moulds in order to preventing the liquid PMMA’ flowing, stay adhesive to the supply.

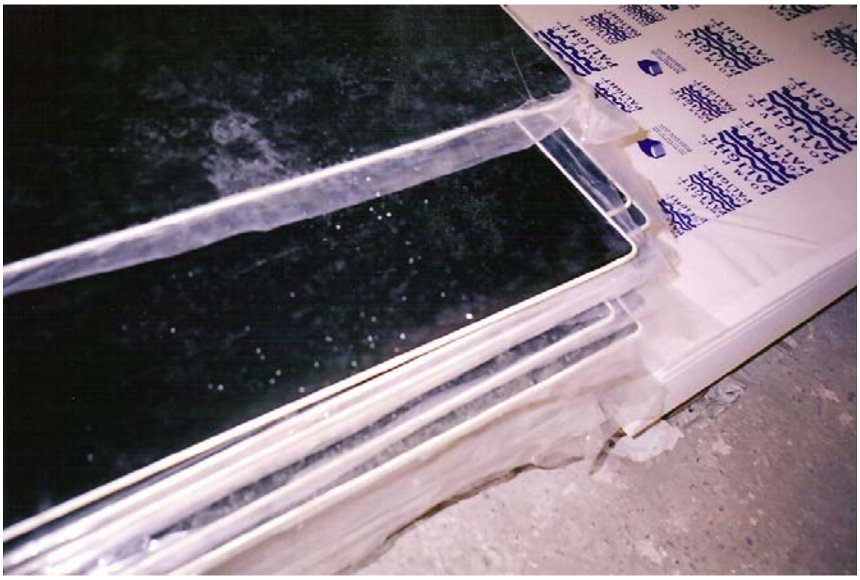

Figure 2.8. The wicks stay around the PMMA panels which are taken out from the mould.

PMMA, which are produced as big panels, are cut as wanted dimensions according to the wishes of the product producers before being wrapped up.

Figure 2.9. PMMA panels are cut as wanted dimensions.

Figure 2.10. PMMA panels, which are cut, are wrapped up.

After being applied to the cutting and wrapping process, the products, which are got, are stored in a proper way (vertical or horizontal) according to keeping conditions before being arrived to the furniture producer.

Figure 2.11. PMMA panels, which are wrapped up, are stored.

The supply producer has prepared a colour catalogue consisting of PMMA in every colour for presenting the colour alternetives which they can present to the product producer (Figure 2.11.).

PMMA panels whose production stages are described above, have been arrived to the producer workshop in order to be made as product by applying. In producer workshop, these panels are passed on the next stage-giving shapes by cutting- according to the plans of the product which will be prepared. Before being passed to the series-production, a prototype is made in order to see the finished form and when it is attained the wished form, it is passed on series-production.

In the big producer firms which are abroad, although this shapening has been made in a more professional and quicker way by means of technological machines; in the most producer workshop which are in our country, this shapening process has been made by handmade labour in a simplier condition. The shapening stages which are applied in our country was studied in an example bellow.

2.3.1. The Conventional Production

With the main lines; we can summary the prosedure of production made in workshops that are applied by handmade labour as;

- cutting
- twisting
- drilling
- having tissue
- emerying
- combining
- the last emerying

The product whose production stages are studied is a commercial make-up stand. In the first stage of production, PMMA panel is cut by proper measures according to technical drawings which the designer has given before.

Figure 2.12. PMMA panels are shapened by cutting as wanted dimensions.

At the first stage, the part which is cutted, is shapened with the help of the heat. The process has been made on a platform which has electric wires transmitting the heat. In this process, ıt has been provided that the twisted part of the material which will be shapened, has elasticity owing to the electric wires which there is on the mechanism. After that, the twisting process happens by the effect of gravity or a mechanic effect. In this process, the shapening has been made with a mechanic power application, by hand.

Figure 2.13. PMMA, which has been turned into panels, is shapened by cutting.

After the product is twisted by means of heat, in the places which are stated in the draft, pourings out are made, directed at the usage of the session-aimed or the final product by being used the drill's tips in proper dimensions.

Figure 2.14. The holes are opened by means of the drill.

In order to produce a make-up stand, the wanted dimensions have been signed on the materials which turn into the parts. By providing electric to the electric wires which are fixed on a wooden platform, it has been brought in a certain heat. The point which is wanted to be twisted has been placed on this cable. Thanks to the heat, the material which has got the elasticity has come into the wanted shape easily by twisting without being broken.

During the product's the first cutting and the first drilling, the rough surfaces are occured on the product' cross-section. At the next stage-combining stage, in order not to make troubles and the final product's not to be affected negatively, the roughnesses, which have occurred after the mentioned processes, have to be removed by a emery machine with foam rubber.

Figure 2.15. The rough surfaces are straightened by the emery machine

The process of combining of the parts which have been shapened and removed from roughnesses on the cutt-off of the product has been materialized in a different way. At the first method- plastering-, because two PMMA surfaces which are base of 'acrilic', can be plastered eachother by only 'chloroform', the chloroform which is liquidis injected between two surfaces to be conbined. In order to remove the probable moving risk on the surfaces to be plastered, two parts which are used with the chloroform are waited until they plaster by fixing in prepared moulds.

Figure 2.16. By plastering, the moulds are being put among.

The other method- screwing has been used for increasing the endurance in the details of conbining which has to be provided balance and transportering.

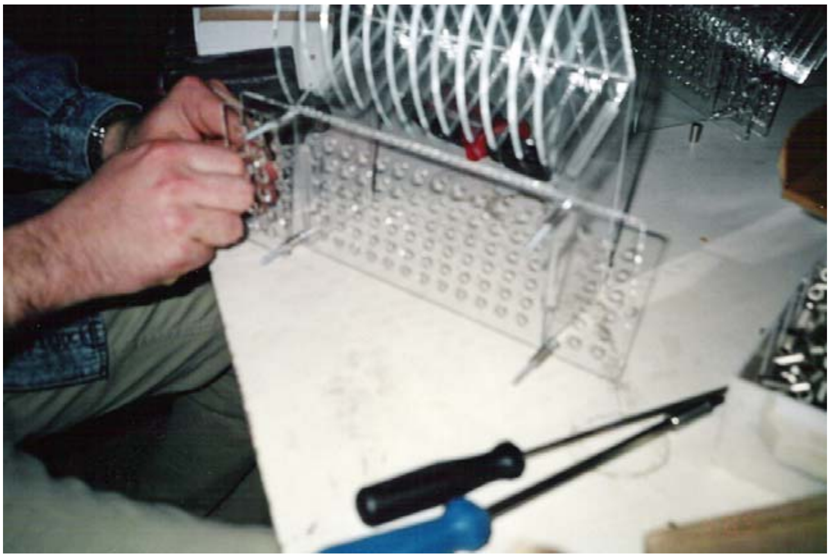

Figure 2.17. Screw has been used to conbine.

After all this processes have finished, the product which has been got is controlled and after the last probable roughnesses have been emeried during the combining process, the product is ready to usage.

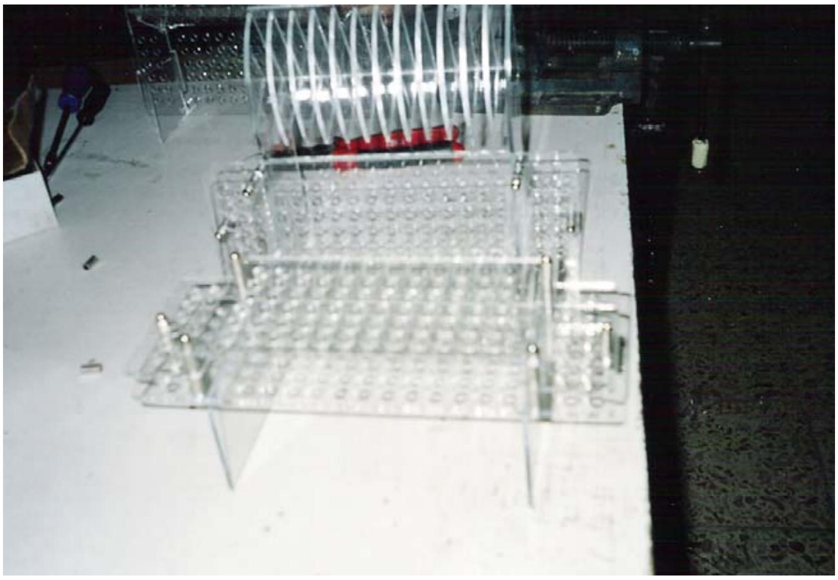

Figure 2.18. The make-up stand is to be ready.

2.3.2. The Production Supported by Computer

Before it is passed on the production of the model which has designed, the production drawings are done by the designer; At the stage that is finished the production measures, thanks to laser machines which are connected to the computer, it is passed on the production.

Figure 2.19. The Laser Machine (Laser Promercury fast cut laser system 100W)

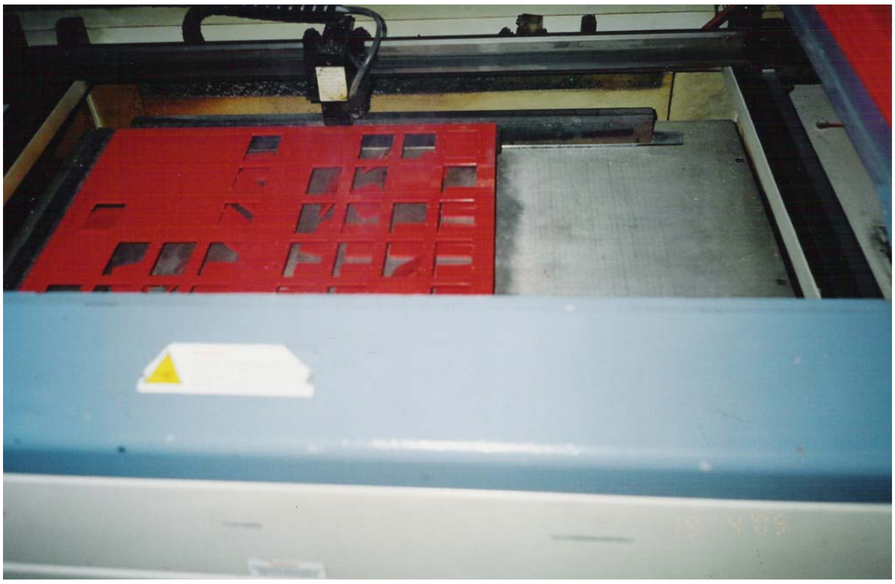

Figure 2.20. The cutting process on the laser machine

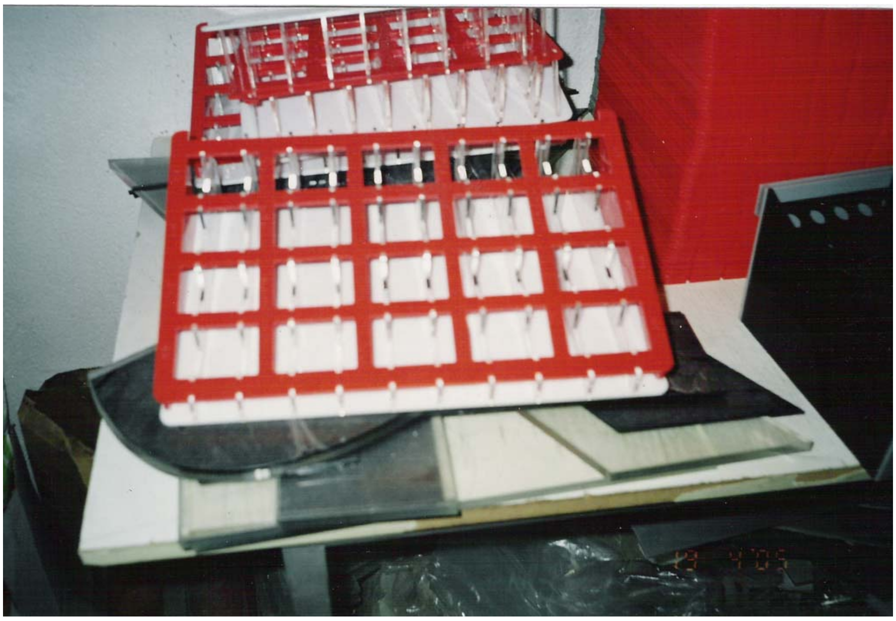

Figure 2.21. The last condition of the material after taking out the machine.

Thickness of the material can be increased by being conbined of two materials. So, it can be done the digital press on. The way of writing on the PMMA panel by craving is called ‘engraving’.

Figure 2.22. The state which was written

Before the firm which will carry out, doesnt pass on the design to the serial-production; it has been done a prototype of the model. These models which are controlled on have been passed on the production with being completed of the lackings.

Figure 2.23. The examples of the prototypes

CHAPTER 3

PROPERTIES OF GLASS MATERIAL

Glass is an important material used in today's modern world. Its applicability range is wide; from a plain glass vase to technical hardware. The usage of glass is so widespread in our daily life that we notice glass instead of our natural surroundings. Even though it's artificial material, it has taken its place in our lives easily.

Glass is hard and solid to the touch. It has a crisp form, and tends to break when suddenly exposed to hard surfaces. Still it's described as liquid in chemical terminologies. Therefore most glasses designed to withhold liquid are in fact liquid's own form. Glass carries these characteristics when cooled to harden, but takes on utterly different characteristics when heated. It begins to soften to the degree of ductility and if heated enough it turns into fluid such as that of water.

3.1. DEVELOPMENT OF GLASS

The history of glass and glass gear is as old as the civilization's history. Archaeological findings prove that glass cases were first seen around 2000 BC. With the recent studies, the idea glass has first appeared in North Mesopotamia, particularly the Hurri-Mitanni area before Egypt is also among the claims.

Glass has first been found in its natural form, called Züccağı Bürkani (volcanic glass), as a dark colored, glass-like and very hard material that is obsidian or black cornelian. The making of artificial glass goes back to about four thousand years. Glass, which is found to have been discovered by Phoenicians, is known to have originated from Mesopotamia. Even though it has about four thousand years on its side it's never become a very wide-spread and cheap object. The methods and the raw material and the equipment used for glass making have reached up to this day, going through very little transformation. The most important progress in glass making is the discovery of the blowing technique "(Revi 1967)".

It's said that this technique was discovered by the Phoenicians. The thing in common with the Seljuk, Artuk and Ottoman glasses is that they've been made with this blowing technique. With this technique, which depends on blowing the hot glass through a tube called a pipe, bloating & shaping it, both table accessories and window glasses have been made.

Even though the glass has been known about for years, research on the subject starts at around 20th century. In our day, glass is being used in all areas of life "(Doremus 1994)".

3.2. GENERAL PROPERTIES

3.2.1. The Structure of The Glass

Glasses usually used in everyday life are hard, fragile and usually transparent material. They're products formed by the liquid, which is created by the crystal-formed materials melting or merging in high temperatures, transforming into the hardened state without crystallizing. Their chemical form is mostly inorganic and their most important ingredient is silicon. Some organic materials and metals that go into the hardened state directly from the molten state without crystallizing are also counted as to have vitrified. From the engineering view, the one thing that separates glass from other inorganic materials is that it doesn't have a certain melting point. When the glass is heated, it deforms slowly and becomes viscous "(Mysen and Richet 2005)".

Figure 3.1. The Proses of Shaping Glass
(source: Web_11, 2006)

From the thermodynamic aspect, a material's crystallized state in low temperatures is much more determined than its amorph state. Glasses transform into a heat that allow crystallization while cooling off from its molted state. But due to most glasses' high "viscosity" and the low activity, this crystallization process operates very very slowly. Due to this slowness, the fact that there's no crystallization or de-vitrification during the cooling process is an important spot in producing glass. Devitrification can occur when the cooling process is too slow or the glass is re-heated. The heat that allows crystallization in glass is called the "liquidus" heat. To prevent crystallization or devitrification, the liquidus heat of a certain solution should be higher than the viscosity temperature during shaping. Therefore a formula that's appropriate for a form might not prove useful in processes that require higher viscosity. Glass is a liquid formed through the dissolution of alkali and earth alkali metal oxides, as well as some other metal oxides which's main ingredient is (SiO_2) silicon, is a fluid material. Glasses can be described as inorganic objects that harden reserving their molted amorph form. During production due to the speedy cooling an amorph form is obtained instead of a crystal form. This form gives its strength and transparency to glass "(Doremus 1973)".

When we look around us it's quite obvious that glass is used in almost every single area. Glass has morphed itself into our everyday life so much so that even though it's an artificial material, it's blended with the natural settings easily. Glass has a hard and inactive form when held in hand. Due to its fragile form it breaks in case it collides with a hard surface. In higher temperatures attributes of glass differ dramatically. It starts softening first & then turns into liquid. Due to this characteristic, it's a point that allows several methods of shaping. Glass in reality is liquid. Its transparency is derived from this fact. A ray of light going through the glass doesn't have any breaking or reflecting. This ray only breaks very slightly as it goes through the glass surface. But this characteristic only counts for transparent and quality glasses.

3.2.2. The Ingredients of The Glass

There are three groups of materials that make their way into the combination of the ordinary glass. These are materials called oxides, flux and stabilizers that could be formed into glass. These materials could be called the sand-soda-lime. Except these materials in the ordinary glass, there are some aiding materials that give glass important attributes and provide benefits in production.

These vitrifiable materials are usually some oxides that form a web. Quarts sand leads these. The most important of the web-forming oxides are SiO_2, B_2O_3 and P_2O_5 (phosphorus).

The substance that's added to glass combinations to make it easy for the web-forming and vitrifiable oxides to melt are called fluxes. These substances lower the vitrifiers' melting point, making it easier for them to melt. Especially the silicon melting point, 1713^{o}C, lowers down to 1500^{o}C. Since fluxes enter the web and transform it, they're also called modificators. Some of the most important fluxes are Na_2O, K_2O, and Li_2O "(McLellan and Shand 1984, Hunter 1950)".

Stabilizers have effect on the chemical resistance, breaking point and the dielectric attributes of the glass. A glass which doesn't have a stabilizer added to its formula won't be stabilized against water. These glasses are called water glasses. The main substances used as stabilizers are CaO, BaO, PbO, MgO and ZnO. CaO is formed by adding the lime stone ($CaCO_3$), and MgO is formed by adding dolomite ($MgCO_3$) into the glass formula. Through heating these two substances, the CO_2 they include is removed and only oxides remain (Eg.: $CaCO_3 = CaO + CO_2\uparrow$ (g)) "(McLellan and Shand 1984, Hunter 1950, Armstock 1997)".

3.2.2.1. The Subsidiary Components (Secondary Components)

These components usually aren't included in the ordinary glass formula, but they're oxides used to create different effects on different glass types. For example;

- Mangan dioxide (MnO_2): Bleaches the glass' colour
- Arsenic (As_2O_3): colouring agent, purifier
- Sulfur (Na_2SO_4): reducer
- Potassium nitrate (KNO_3): reduces transparency of glass

Silicat glasses and minerals consist of 3-d webs. The base silicat web is a silicon-oxygen tetrahedron that forms through 4 oxygen atoms tying to a silicon. Silica tetrahedrons are tied together with an oxygen shared by two silicon atoms. Every oxygen tetrahedron creates a 3-d web form that's shared by others. These shared oxygen atoms are called bridge oxygens. When atoms like sodium tie to oxygens with their ions its continuity's broken down and some oxygens cannot be shared between two tetrahedrons. These atoms are called un-bridge-forming oxygens "(McLellan and Shand 1984, Mysen and Richet 2005)".

3.3. The Glass Types

The Soda Calcite Glass; Ninty percentage of the glasses created in the world are soda calcite glasses. They're easily molted and cheap. Though they can be used everywhere except cases like thermal endurance shocks and chemical resistance. They're used in making materials such as normal electric bulbs, fluorescent bulbs, window glasses etc. Includes 5% of CaO in its substance "(Doremus 1973)".

The Lead Glasses (Crystal Glasses); When PbO replaces lime in soda calcite glass, lead glasses are obtained. Includes 80% and in some cases even more lead oxide. Lead oxide lowers the melting point of the glass and drops the softening point below the CaO glasses. It also provides easy processing, reflecting & emitting light to the glass. The types of glass where lead oxide exceeds 80% are used for protection from gamma and X-rays. Since this one's a fairly expensive glass, barium oxide glasses are used. Due to the lead oxide's form that doesn't lessen electric resistance, these are also used in electronic industries. They're used in colour TV funnels and places which are supposed to be reserved from x-rays. Due to the highly breakable characteristic of lead oxide they're used in optic systems. Lead oxide glasses have been used in handmade dinner sets & artworks for centuries "(McLellan and Shand 1984)".

The Borosilicate Glass; Borosilicate glasses have a high melting point. Nevertheless, it has attributes such as a huge dilation factor that allows high resistance to thermal shocks, high endurance to water and acids and superior electrical attributes. Due to these reasons they're used as laboratory (technical) glasses. They're also used in kitchen furniture and bigger-sized astronomical gear "(Doremus 1994, Eitel 1964)".

The Aluminiumsilicat Glass; Includes more than 20% of aluminum, a little amount of boron, some lime and very little alkali. Although when there's no alkali included melting and shaping the glass gets harder. Due to the fact that the softening point is high and the dilation factor is quite low, it's used in thermometers, combustion tubes and in the making of any part that's going to have direct exposure to fire. When aluminum oxide's added to a formula this allows more viscose in higher temperatures. Can be used without deformation in higher temperatures than most of the lime and borosilicate glasses in the market. It's used in the electric-electronic industry, fiber glasses, chemically strengthened glasses and glass ceramics "(McLellan and Shand 1984)".

The Silicon Glass (96% SiO_2) and (99% SiO_2); This glass, including 96% silicon, is usually shaped through the blowing technique. Dilation factor is small. This type of glass, due to its high transparency, let UV rays through quite well. Therefore they're usually used in the making of UV lamps and special bacteria eliminating lamps.

Is obtained by melting the highly pure quartz sand without any fluxes. The production and shaping of this glass happens at a very high temperature (1750˚C). Therefore the shape and size of the product has to be limited. It has positive qualities such as a low dilation factor, a high softening point and letting UV rays through fairly well. Dielectric qualities are also quite well. Although due to the high cost practices in electrotechnics are limited. It's the glass with the highest thermal shock endurance "(Web_11, 2006, McLellan and Shand 1984)".

Glasslike Silicates; Is formed by heating the silica sand or quartz crystals above the melting point (1725^{o}C). The formed glass is highly viscose and the gas bubbles created during the melting cannot remove themselves from the glass. Glasslike silica has a very low thermal dilation factors and are preferred for use in spacecraft windows, astronomical mirrors and other areas where thermal shock endurance is required "(Doremus 1994, Eitel 1964)".

The Alkali Silicates; Alkali metal oxide's added in to lower the viscosity of the molted silicate glass, therefore the glass' form softens. Adding alkali lowers the chemical resistance of the glass according to the silicate. Adding high amounts of alkali allows glass to dissolve in water. Dissolvent silicates are sold as water based solutions and are used in pastes, cleaners or protective coverings "(Eitel 1964, Fonderlik 1991)".

The Lime Glasses; To reduce the dissolving of silicate glasses in water, and still allow melting easily, calcium and magnesium oxides are used as stabilizers. Lime glass, which has first been founded by Egyptians, now are used in most of the bottles, jars, window glasses, bulbs and fluorescents. In these combinations lime forms 8% and 12%, and alkali about 12% or 17% of the weight. A small piece of aluminum is used to increase the working characteristics of the formula and the chemical resistance.

3.4. The Producing Glass Material

Glass material production consists of 4 continuous phases (two levels – obtaining melted glass and shaping of the glass, polishing and cutting).

3.4.1. The Preparation of The Main İngredients

The main ingredients that will go into the glass combination should first off have been neutralized from foreign bodies and should be grained well. Main ingredients that have been grained in institutions that produce one kind of glass are stocked in silos and the desired amount of ingredient is taken onto a scaled car by opening the valves on the bottom of the silos.

3.4.2. The Melting

For the production of a glass object, such a liquid should be formed into glass objects by using little amounts of other refractory additive materials that will be used in the sand and glass molt. Properly used additive materials are calculated in proportional weights to obtain the desired attributes. These weight proportions are mixed as if to homogenate and put into the melting unit. The first phase consists of processes such as blowing, rolling and pulling. After that the object usually goes through the annealing lehr process to lessen the internal tension. In cases of production with mechanical units, melting and primary production processes are closely connected to each other "(McLellan and Shand 1984, Gunter 1958)".

The primary shaping process, mechanically shaping glass objects in the melting tank, and the old hand-production are modified versions of the pot-melted glass methods. Secondary or finishing processes are done on produced objects. While most of the time these processes are separated from the primary processes by time and place, sometimes a completely different factory's required for secondary processes.

Table 3.1. Glassmaking materials
(source: Mclellon and Shand, 1984, p.74)

Raw material	Chemical composition	Glassmaking oxide	Percent of oxide
Sand	SiO	SiO_2	99.8
Soda ash	Na_2CO_3	Na_2O	58.5
Limestone	$CaCO_3$	CaO	56.0
Dolomite	$CaCO_3$–$MgCO_3$	CaO	30.5
		MgO	21.5
Feldspar	$K_2(Na_2)O$–Al_2O_3–$6SiO_2$	SiO_2	68.0
		Al_2O_3	18.5
		$K_2(Na_2)O$	12.8
		SiO_2	68.0
Nepheline	$NaAlSiO_4$	SiO_2	60.6
Syenite		Al_2O_3	23.3
		$Na_2(K_2)O$	14.8
Borax, 5-Mol	$Na_2B_4O_7$–$5H_2O$	Na_2O	21.8
		B_2O_3	48.8
Boric acid	H_3BO_3	B_2O_3	56.3
Litharge	PbO	PbO	99.9
Potash, anhydrous	K_2CO_3	K_2O	68.0
Fluorspar	CaF_2	CaO	69.9
		F^-	47.1
Zinc oxide	ZnO	ZnO	100.0
Barium carbonate	$BaCO_3$	BaO	76.9

3.4.2.1. Ovens

The continuous melting process does huge amounts of melting, but supported units do little amounts of melting, and these glasses are usually glasses with certain attributes. While continuous melting tanks have a capacity of 1 tons to 1000 tons, supported melting tanks are limited to a few tons. The required energy for the melting process is usually provided through fossil fuel, but in the recently formed factories electrical ovens are preferred because of their cost and effecting the environment less.

In our day the melting process is done in cruses (pot-ovens) or in pool ovens with a capacity of around 1000 tons. High quality refractory fireproof materials such as silicon, aluminum and zircon are used in the making of these ovens “(Gunter 1958, McLellan and Shand 1984)”.

Pool Ovens; They’ve been called pool ovens because they resemble swimming pools. High amounts of glass are used in the necessary production processes. There lies about 800-1000 tons of glass in this oven. The main ingredients for the glass are pushed through the opening of the oven with a special propulsive mechanism and melting begins “(McLellan and Shand 1984, Kocabağ 2000)”.

Pot-Ovens; They include separate ovens where materials belonging to different types of glasses are being melted. In production processes where there are many glass types but little amount of glass in total, the pool ovens aren’t very appropriate. Therefore pot-ovens are utilized. The main ingredient amount is around 2000 kgs in the pot-ovens “(McLellan and Shand 1984, Kocabağ 2000)”.

3.4.3. The Shaping

After the preparation of the main ingredients and melting stages, it’s then the turn for shaping of the rested glass paste. Glass materials are shaped through 8 methods:

* Blowing (Bloating) Method
* Pressing Method
* Pouring-Cylindering Method
* Pulling Method
* Floatation Method
* Method of Transforming into Fiber
* Method of Transforming into Foam
* Other shaping methods

For the blowing technique, for the most part hinged systems are preferred and the mold’s opened to get the product out. Paste molds are always shaped in a round cut and covered with a water-absorbent layer. Therefore a layer of steam is created between the covering and the glass that allows the glass to be spinned as it's being blowed. Hot iron covers can be quadrangular or irregular in shape. Since the glass surface touches the iron cover directly, the surface quality of the glass isn't as high as the "paste mold". In both molds the product's open entrance should be cut & smoothed "(Kocabağ 2000, Doremus 1994, Küçükerman 1985, Gürler 2000)".

The pressing mold consists of 3 pieces; bottom mold, diver piston – "plunger" and the ring. In the hand-pressing adequate amount of glass solution is separated from the bar with the hand scissors and pushed into the piston mold and therefore the solution fills the closed mold. When all the empty spaces are full, pushing is stopped and when the glass "hardens into its shape" – "sets up", the piston's pulled back and the glass is separated from the mold. The same principles apply in the mechanical method "(Doremus 1994)".

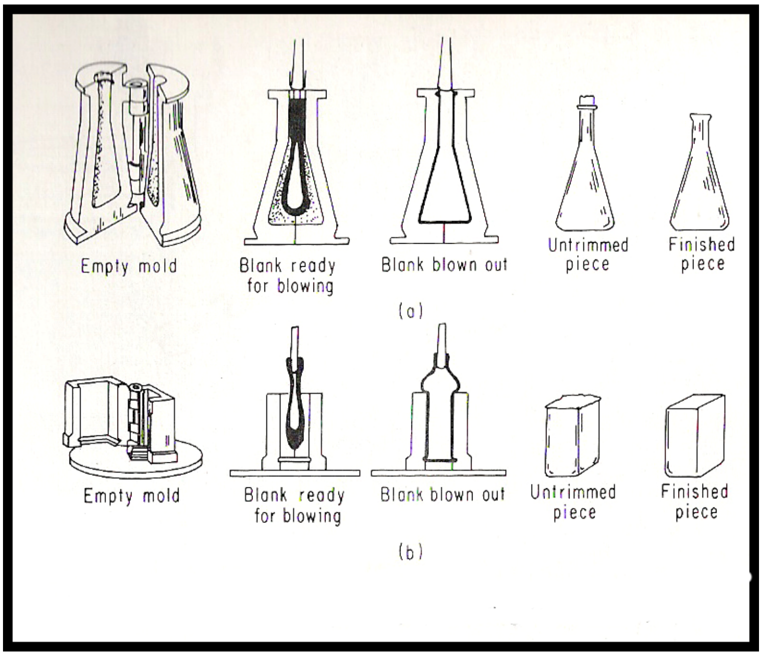

Figure 3.2. Blown Glass

(source: Mclellon, Shand 1984 p.85)

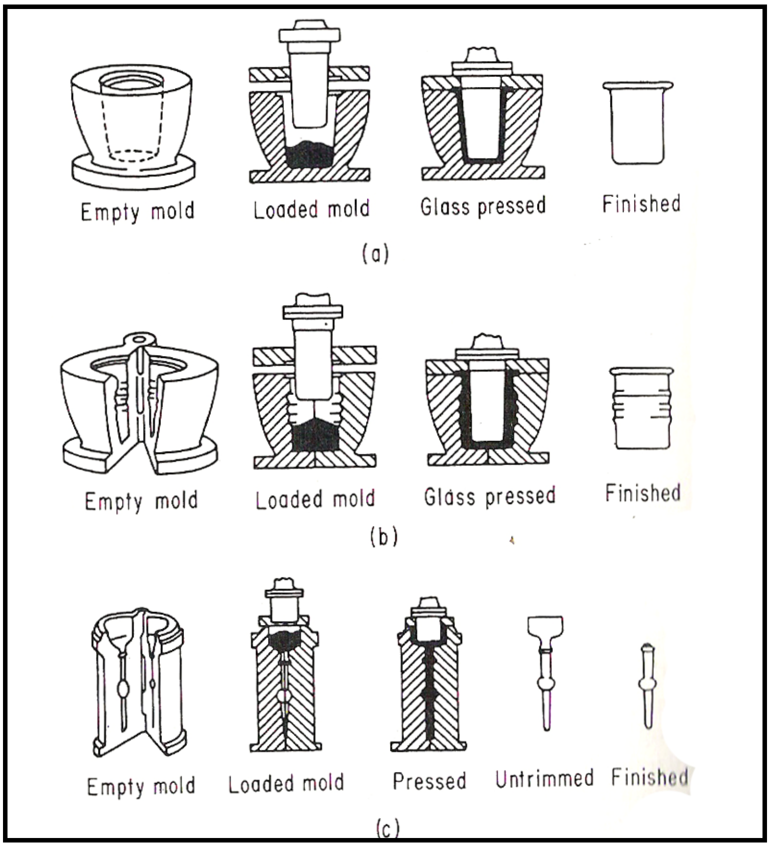

Figure 3.3. Pressed Glass
(source: Mclellon, Shand 1984 p.82)

The aim of this phase is to eliminate the internal stretching that forms while the glass is cooling in fabrication production. It's applied by heating the glass again in a canal heated from above until the internal stretching has disappeared and then slowly cooling the glass again "(Kocabağ 2000, Doremus 1994, Küçükerman 1985)".

3.5. The Production of Glass in Our Country

There is no much studios where we can see all processes and give examples related to glass. At "Glass Furnace" studio opened at May 2002 in İstanbul-Beykoz, as well as producing glasswares, trainings regarding glass are given. Different studios were builded, and the processes were seperated from each others. At Glass Furnace, the fusing, mixed media, hot glass blowing and kilncasting processes are done and taught.

In Mixed Media process, the glass is shaped by different materials. The glass is decorated with some materials such as metal, wood or bead. And in fusing studio, the desired pattern or figure is drawn on a glass plate by means of different size and various colour glass pieces.

Figure 3.4. Sample Works from glass furnace

Figure 3.5. A sample narghile work

The liquid glass takes the shape of a flat plate by casting into moulds. The obtained plates are given the desired thickness. The flat plates are used in the fusing and mixed media studios.

Figure 3.6. Forming glass plates

Figure 3.7. Ovens

In hot glass blowing studio, the hot glass called as "fiska" (the glass piece) constituting the glass is taken out from the kilns by means of a metal blowing stick called as pipe whose center has cavity. The other unused pipes are put onto the stand prepared for them horizontally.

Figure 3.8. The stand where the pipes are put onto

Figure 3.9. Taking out the mixture from the kiln.

The liquid taken out from the kiln by means of the pipe must immediately be put onto the setup where the blowing and shaping processes were performed which was existing just beside by moving fastly. The shaping is done by tools on this setup which provides two people work together.

Figure 3.10. The blowing, cutting, and shaping setup

By blowing from one end of the pipe to its other end, shaping and cooling is started. And by means of the ladle existing on the same setup, the rolling process is performed.

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Figure 3.11. Blowing Process

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And in ladling method, the glass is cooled while forming a ball within the ladle, and the desired form is given to glass within the ladle by continuously turning the pipe.

Figure 3.12. Shaping by means of a ladle

Since the liquid trying to be formed is started to cool down shortly, by heating it frequently during the process, the hot and fluid state of it is tried to be maintained. This tool where it is reheated is called as “trammel”. While completing the shaping process, the excess part of the glass formed at the end of the pipe is cut when it is hot.

Figure 3.13. Reheating

Figure 3.14. Cutting Process

The Turkish traditional glassware “Çeşm-i bülbül” in particular or the Turkish filigree produced in “facon de Venice”, is also called as Beykoz ware. Similar high quality ware is still produced at Murano in Venice. Apart from traditional filigree work Çeşm-i bülbül, Turkish glassware appears mainly to have favoured forms and styles suitable for applied and brushwork decoration, and it is known that many forms inherited from the art of ceramics were particularly dominant.

“Çeşm-i bülbül” is the Turkish name given to filigree work technique. Other kinds of filigree technique are known in various glass centers throughout the world. Çeşm-i bülbül is a product of Anatolian workshops. It is a technique that even the technological advances of modern glass industry can not surpass the finest filigree craftmanship of the past.

Çeşm-i bülbül is a highly skilled technique. Each stage of the formation of the vessel is carried out in strict sequence, and must be completed in a very short time. The technique generally may not differ, but each craftman' s approach to it, in other words style will be different. There is also no room for error with this technique. Once an error has been made, it is almost impossible to correct it, so all the technical rules of glassmaking must be carried out with great precision. “(Web_12, 2005)”.

Figure 3.15. Red mould releasing agent

The technique is as follows:

* An iron rod, in other words, the pipe is plunged into the melting glass existing in the kiln.
* The pipe is turned to gather whole glass.
* The glass is removed from the crucible and shaped and cooled outside the furnace.
* At this stage, the gathered glass which is now slightly cooled is dipped into a mould prepared with coloured glass rods arranged around it is blown, and the rods fuse to the glass.
* The obtained form is returned to the crucible to ensure the glass rods completely fused.
* The last shaping of vessel is given in the mould, the required twist at this stage is given to the filigree by hand turning, this is a process requiring considerable skill.
* The finished product is cooled and severed from the rod.

Apart from the blowing and free-shaping, one of the common methods used is the casting method (casting of the glass into a mould). "(Web_12, 2005)".

Figure 3.16. Ice bucket mould

In another process existing at Glass Furnace, the moulds are casted into sand, and the glass is shaped by means of the moulds. At studio, the glasswares produced in different methods are finally put into cooling kiln after the process completed. This kiln is called as “karkez”.

Figure 3.17. Cooling kiln

In another workshop done at Glass Furnace, the heat-shaping process on a table is done. In this section where more small and thiny objects were worked with, detail requiring Works are done.

Figure 3.18. Shaping by heating on table.

Figure 3.19. Model works on the desktop

CHAPTER 4

SAMPLE APLICATIONS OF GLASS AND PMMA MATERİALS IN FURNITURE DESIGN

4.1. Comparing PMMA than Glass

When we compare the PMMA with glass, the PMMA is more enduring. But it's surface's drawing seems as a big disadvantage. It's absorbing the water is low; it is strong against the electric and it has enough capasity about hauling resistance. The PMMA, lens, the cover of the reflector cars' lamp, buton, transparent panel buttons have been used at the applications and cars instead of that glass.

Plastics widen much more than metals and glass with heat. Especially, the termoplastics' widening is much more between twice and ten times. Widening with heat, can be defined as an alteration which an alteration at one degree in heat causes on the length of plastic substance. The dilation coefficient of every plastic substance with heat is different. In the systems that are designed by using two different substances; Being known of these values is important for not being negativenesses such as the last product's being torn, broken, dwindled.

Polymers, because of being viscoelastic materials, can be liquid as they can turn into a tough and rubbery structure from a glassy structure dependent on the heat. When all plastics are cooled till below of a certain heat; the heat which has a feature like a rough and fragile glass is glassy -transition heat (Tg). Under this heat, polimer's getting longer and flexibility are little; it's roughness is too much. At the glassy-transition heat, termoplastic substances have had a high viskozite. At the heat over this heat, polimer has a shape like rubber. Here, the plastic substance is solid and soft; it's hauling resistance is high and has a softer and elastic structure. Some plastics are used under the glassy-transition heat; some are used over the glassy-transition heat "(Hanser and Gardner 2003)"

The reactions that thermoplastics show against the heat display differencies with the plastics which have amorf and crystal structure. Under the glassy-transition heat, the roughness and fragileness of the plastic rise;getting longer and flexibility of the plastic lessen. At the glassy-transition heat, thermoplastic substance has a high viskozite as it can be said it is solid. Plastics which has amorf structure have a fragile glassy and filled material features at low heat and at a high heat they turn into a soft, rubbery, defected easily structure.

The glassy-transition heats of plastics:

Polymer	Tg
Natural Rubber	-72
PVC	82
Poluzobutilene	-70
Polyester	100
Polypropilen	5
PVA	29
Polymethylmethacrylate	105

Not even all but some of plastics permeate light. This feature has been provided not only with addition materials mixed to the plastics but also by itself. Beside good mechanic features, it's permeating the light has provided plastics usage instead of glasses. The light permeability of some plastics have been given below.

Glass	92%
Polymethylmethacrylate	92%
Polycarbonate	90%
Polystrene	90%
Selüloz asetat	89%

The other optical feature of the plastics which permeate the light and are transparent is the light's refraction. Light refracts while it permeates from weather to glass or water or a transparent place. The same thing is in use also for the plastics. This feature of the plastics, in optical systems, is taken as a very important feature when they are used instead of glass.

Plastic	Refreaction İndex
Celulose-acetate	1.46
Acrilic	1.49
Polymethylmethacrylate	1.49
Polypropilen	1.49
Polybutilene	1.50
Polyetilen (low density)	1.51
PVC	1.52
Polyamide	1.53
Ure formaldehyde	1.54
Polystrene	1.57
Polycarbonate	1.63
Glass	1.52

The hazeness, is another optical feature of the plastics and this feature is that transparency lessens and the light doesnt pass exactly. Because of the moleculer structure , being crystal of the polimer and the impurenesses inside polimer, hazynesses occurs as a result of the light's dispersing. The slimmer film plastics are made to the same degree, hazynesses lessens and becomes invisible. Some plastics films and panels which are thick seem hazy and they cant pass the light. When looked outside, it is wanted that it can be seen the inner sides of the plastic matters, films and panels. The hazynesses prevent this situation. The hazeness in glass is at minimum or zero level.

Glass	0.0% \ 0.17%
Polystrene	0.1% \ 3.0%
Celulose-acetate	0.5% \ 0.5%
Polymethylmethacrylate	1.0 % \ 3.0 %

"(source: Kaya 2005, Akkurt 1991, Berins 1991, Mysen and Richet 2005 McLellan and Shand 1984, Hodge 1958)"

4.2. The Sample Aplications of PMMA Furniture Design

Figure 4.1. Round Table
(source: Web_13, 2006)

The balance factor is crucial in the use of the horizontal and vertical elements of the table in this example Figure 4.1. The four equal stands which constitute the vertical elements are in junction with a conjunctive element of the balance centre; the conjunctive element has become a new balance centre. The related conjunctive element which has become the balance center of the round table and the constituted group, has been placed in the same projection which causes both a visual and physical balance.

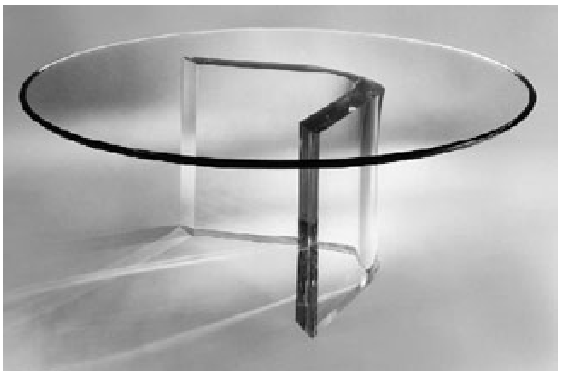

Figure 4.2. Round Table -a
(source: Web_14, 2006)

The carrier feature of the PMMA material has been crucial in this example. The carrying stand which consists of one stand with a wide cross section resembles here solidness. This image of solidness is strengthened with the contrast which is formed by the plate with a narrow cross section, which is used on the table tray. Although its stands have a static appearance with their wide cross section and because they're made out of a single piece, they have reached a visual harmony with the round table tray, because the stand is formed with a soft fold.

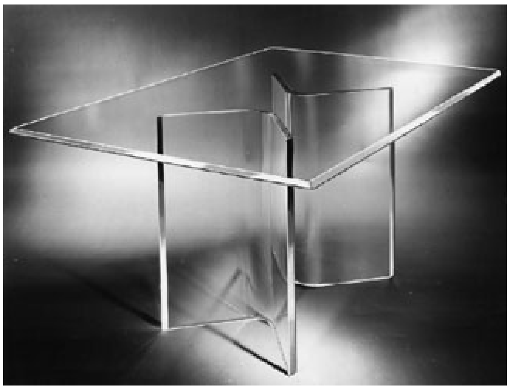

Figure 4.3. Rectangle Table-b
(source: Web_13, 2006)

The sharp lines are crucial in this example. Although there is no sharp refraction in the stands because of the structural essence of the PMMA material, the stand has an appearance as if it is sharp with its wings which have perpendicular angles, the length of the wings, the narrow cross section of the plate, and the radius (which has been kept at the minimum value) of the folding area. As we take a look at the planned appearance of the table, we notice that the extended parts of the stands meet the corners of the rectangles and that the perpendicular angles which are placed back to back and which parallel to the margins of the table, form a static balance in the concept of the table in visual sense.

Figure 4.4. Daffodil Chair Designer Etselle and Erwine Laverne
(Source: Charlotte and Peter 1991)

PMMA was one of the first exemplars which was structurally used in the Lilly chair which was made in 1958. It was an item of the organic shaped "Invisible" serial of Estelle & Erwin Lavern "(Source: Charlotte and Peter 1991)". PMMA has been used in this concept as a material which eases shaping for organic concepts, its transparency resembles modernism and its characteristic of being a burden holder has been effectively used.

Figure 4.5. Zig Zag Chair
(Source: Web_15, 2006)

The Zig Zag chair of Gerret Rietvelt has been interpreted in a modern way by using PMMA (Source: Sembach 1991). The rough corners in the concept of Rietveld, resemble different four plans. A single piece of plate has been used in this exemplar and the folding diameters have been kept wide to perform a visual flow.

Figure 4.6. PMMA Three Chairs
(Source: Web_15, 2006, Web_16, 2005)

The common point of these three exemplars is that only the equipments of the traditional wooden chairs are replaced by PMMA. In all the exemplars which were observed previously, surfaces with folds were shaped by using PMMA, plates of two dimensions were folded to form a shape of three dimensions. The parts which are used in the related exemplars were cut to be adhered as if wooden material was united, or it was brought together with active conjunction units. The traditional methods and forms in these concepts constitute contrast with the modernism of the transparent PMMA.

In the first example, the traditional chair with cushion has been considered. PMMA are united by screwing it on the back of the chair and adhering it on the sitting place. The cushion is filled with classical cover materials like sponge. The little detail in the back of the chair is strengthening the reference to traditional chairs.

In the second example the traditional folding chair has been remade. All the connections in the chair are fixed with screws. In the third example there are shapes formed to reflect the period it resembles, different from the other two examples.

Figure 4.7. Chair -a
(source: Web_15, 2006)

Chair shown in Figure 4.7. is an example for the dimensioning a single piece of plate which has been shaped with heat. A holder of PMMA, a cushion and wheels which cause it to be mobile are used in this office type chair which was designed with a minimalist approach. This is a good example of uniting PMMA and wheels.

Figure 4.8. Chair-b

(source: Web_15, 2006)

This chair has been designed in the style of classical kitchen chairs, shapings proper to the body have been carried out with vacuum on the back side and bottom of the chair to prevent discomfort caused by the hard and flat surface of PMMA more comfortable.

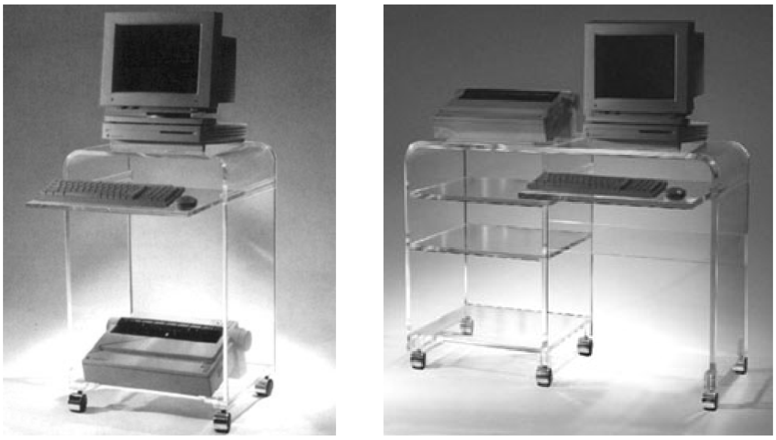

Figure 4.9. PC Table

(source: Web_18, 2006)

Although PMMA isn't used very much as material for carriers / holders of technological devices, it's transparency which is in contrast with the massive, heavy and cold appearance of technologic hardware, the lightness, the application of soft lines in convolutions because of the structural essence of the material makes it suitable for offices and rooms which are decorated in a modern and minimalist style.

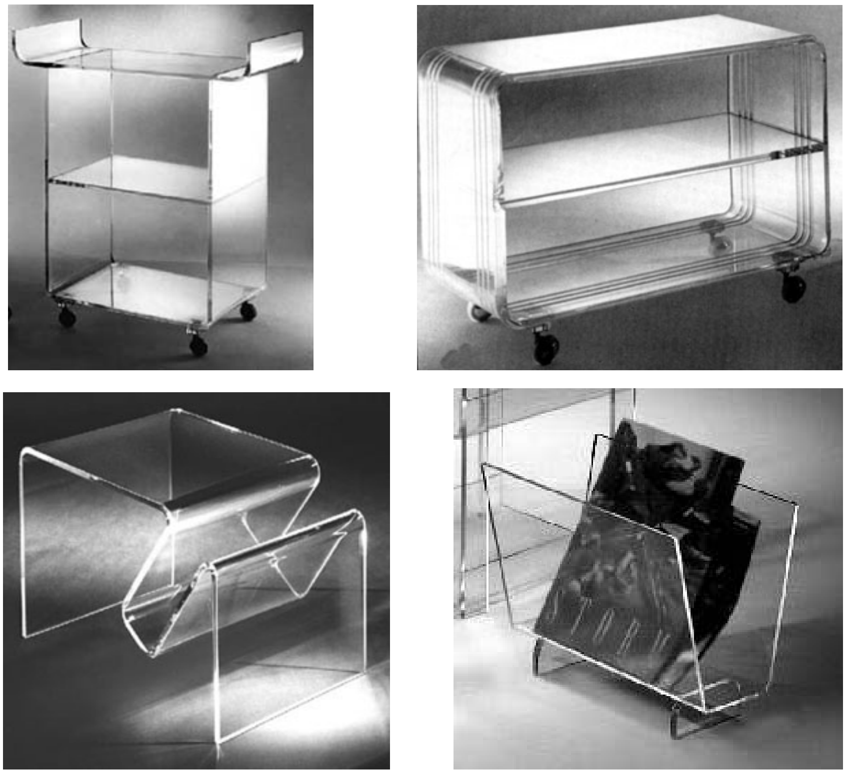

Figure 4.10. Various Usages
(source: Web_17, 2006, Web_19, 2006)

PMMA is a material which is mostly preferred as house accessory because it is easy to shape, it's transparent, it has a wide range of colour and it is light. It can be proper for any kind of atmosphere, especially in spaces which are decorated in a minimalist style. That this material is active and that it can be transported easily is a crucial matter.

Figure 4.11. Different Applications
(source:Web_20, 2006, Web_21, 2006)

PMMA applications in make- up desks are especially preferred in hotelrooms, office showers and coulisses because it causes the space to appear bigger and spacious.

4.3. The Sample Aplications of Glass Furniture Design

Figure 4.12. Glass Coffee Table
(source: Web_22, 2006)

This concept is an example which is shaped to be used as an end chair and it is created by putting a single piece of glass in a press process. The glass is solid and it can't be scratched, this feature causes it to be preferred with furniture which can horizontally function. The structural colour of the glass which has been used in this furniture, causes the furniture to be noticed in the area and although the furniture is transparent, it won't have a fading feature in that circumstance.

Figure 4.13. Glass Table
(source: Web_22, 2006)

The detail as the junction formed by the carrying bases and the tray and the weight of the glass material which is balanced has been observed very good in this example. The balancing forces which have to support the center of gravity of the glass tray won't be sufficient because the distance between the two bases which hold the table is too long. A tendency towards the center of gravity of the glass, will be prevented by constituting an opposite force with burdens which have been placed as outlets of the stands, which are caused to be in equal forms by the junction details Figure 4.14.

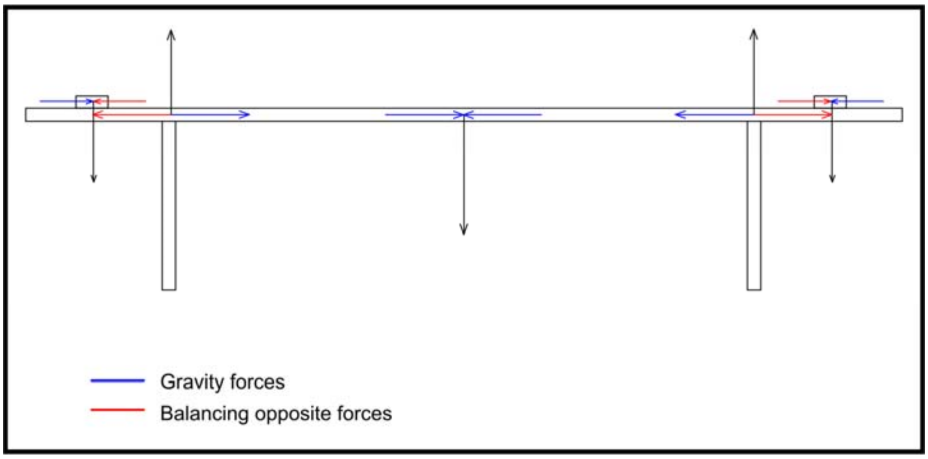

Figure 4.14. The Burden Diagram of the Glass Table

Figure 4.15. Application of the Glass Coffee Table
(source: Web_24, 2006)

The main reasons of preferring glass for central tripods; the compatibility between futures as: glass suits other furniture materials as wood and metal, glass exposes itself and the inactivity of the central tripods caused by the weight of the glass.

Figure 4.16. Application of the Glass Coffee Table
(source: Web_24, 2006)

Glass is currently used indoors as surfaces of horizontal carriers. Although glass is used in furniture since ancient times, it has only been used as a vertical separator till the previous century. Using glass on horizontal surfaces has been possible by using technology in process for increasing the resistance of glass. Using glass as surfaces of horizontal carriers has become a feature of modern architecture. The common characteristics of the surfaces of these tripods are that they are inactive.

Figure 4.17. Applications of Glass Shelves
(source: Web_22, 2006)

.

 

Figure 4.18. Applications of Glass Shelves

(source: Web_13, 2006)

 

Figure 4.19. Applications of TV Units

(source: Web_13, 2006)

 

Figure 4.20. Applications of TV Units

(source: Web_13, 2006)

2. TV units, one of the internal space uses, has been made by using the flexibility characteristic of glass. In the examples in Figure 4.19, by shaping the glass during production, it's been created by using merely the glass itself, the metal merger elements and metal footings. This has, through the designer view, has provided the furniture with a lighter and more flexible outlook.

In Figure 4.20, metal construction and wood has been used besides glass in the TV unit, and a more modern and flexible outlook has been given by breaking through the designer weight of the traditional wood furniture. In these two examples, the furniture's carrier construction is of metal and wood, and glass has been used as an extra as an addition to the furniture look.

Figure 4.21. Applications of computer and TV Units
(source: Web_13, 2006)

In Figure 4.21. and 4.22., the carrier parts of the furniture used only on horizontal surfaces, have been made by chromium pipes and footing. This chromium construction has been merged with the glass surfaces by screwing and laser gluing.

Figure 4.22.Using Glass in Office Furniture
(source: Web_26, 2005)

The main reasons of using glass in office furniture are; glass has a surface which can't be scratched, it's smooth surface is suitable for horizontal working areas and it transmits light. It causes the presence of a desired privacy especially with the sub-transparency of sandy glass, it doesn't constitute a depressing press on personnel on the contrary of opaque.

Figure 4.23. Using Glass in Office Furniture
(source: Web_26, 2005)

Figure 4.24. FIAM Coffee Table Concepts
(source: Web_22, 2006)

Forming a single piece of glass via molds by increasing its viscosity in ovens, is the crucial evolution after it's horizontally usage in furniture which glass has undergone. This has caused glass to be formed in a shorter time and in a more flexible way than it happened with the application of casual methods, and statuesque results were obtained. The exemplars which are exposed here, are the concepts of FIAM which was experienced in shaping single glasses and which was founded by Antonio Livi's who has discovered this method (Picture 4.24.).

Figure 4.25. FIAM Coffee Table Concepts
(source: Web_23, 2006, Web_24, 2006, Web_25, 2006)

Figure 4.26. Glass Table
(source: Web_22, 2006)

Glass is also used as a surface protector in furniture concepts. Previously it was generally used as vertical surfaces in picture frames to protect pictures from climatic conditions, in cabindoors to protect it from dust, now it's used in horizontal surfaces to prevent them from being scratched, dusty and dirty (Picture 4.27.). The advantage of using glass as a protecting separator is that although it's preventing dust, heat, scratching and dirt, it can expose the beauty of the surface or the object which is protected by its transparency.

Figure 4.27. Glass Dressoires
(source: Web_26, 2005)

Figure 4.28. Glass Table
(source: Web_26, 2005)

CHAPTER 5

JUNCTION DETAILS OF GLASS AND PMMA IN FURNITURE DESIGN

5.1. Junction Details Commonly Used in Furniture Design

5.1.1. Pieces in Junction Details

Telescopic drawer hinge used in PMAA cupboards and drawers is a mechanism which provides the connection of the drawers with the body and movement of the lapels. Figure 5.1. It facilitates forward-backward movement by the roller.

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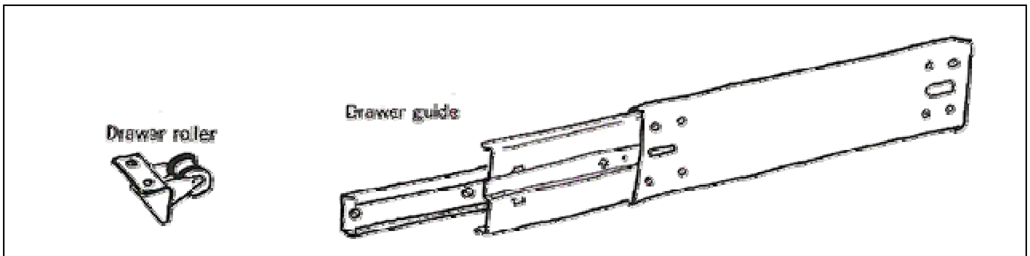


Figure 5.1. Drawer Roller and Guides
(source: Pile 1990)

It's a mechanism that keeps horizantal movement in the cupboard's lid. The scissors keeps the lid from falling down and make it stay 90 degrees causing it to be safe.

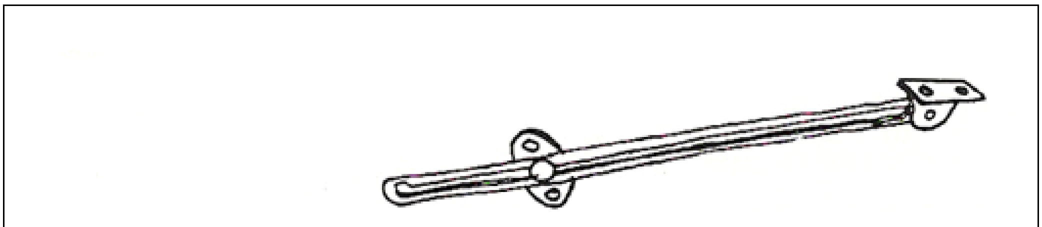


Figure 5.2. Lid Support
(source: Pile 1990)

In two-piece tables it provides extension of the table by the additional piece after separating the table parts. It provides the movement of two parts sliding over each other. It can be made of chrome, galvanized metal sheet or stainless steel.

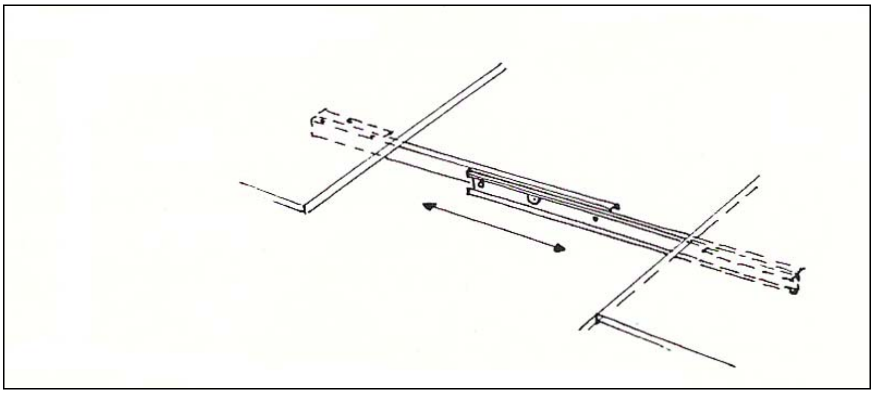


Figure 5.3. Extension Table Hardware

(source: Pile 1990)

It is the locking mechanism of the cupboard lapels. However, this mechanism is not for locking but for keeping the closed lapel remain so. While some of them use spring system for locking, other use magnets.

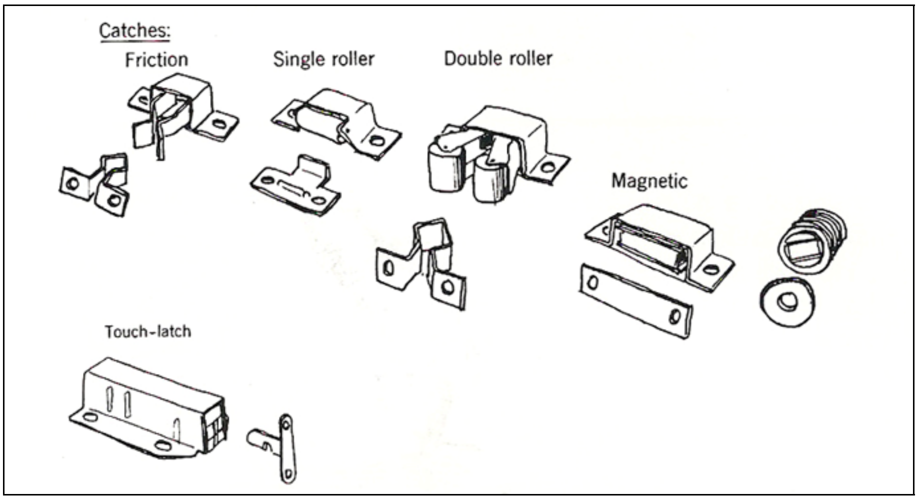


Figure 5.4. Catches

(source: Pile 1990)

These are the mechanism made of chrome, stainless steel or galvanized metal sheet, which provide different height adjustments allowed by the mounting or function of the shelves in the cupboard.

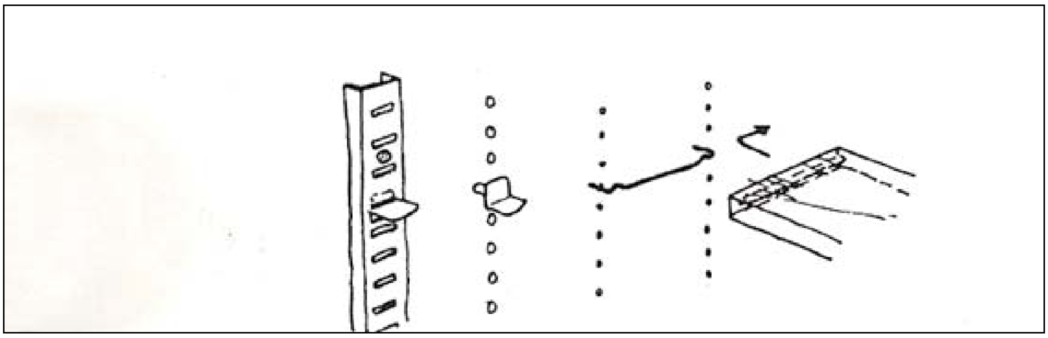


Figure 5.5. Shelf Support
(source: Pile 1990)

These are the rails which help the bolted cover system of the cupboards function. Depending on the size of the furniture, it provides options of different lengths and widths depending on the thickness of the cover. They are generally made of metal.

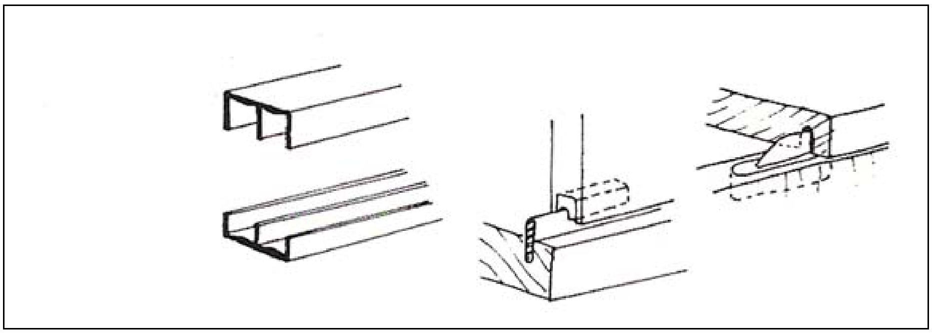


Figure 5.6. Siliding door hardware
(source: Pile 1990)

Wheeled foot components used in furniture helps the furniture move. Wheeled foot components are produced in different sizes. In some furniture, fixed feet with adjustable height and adjustable moving wheels are preferred.

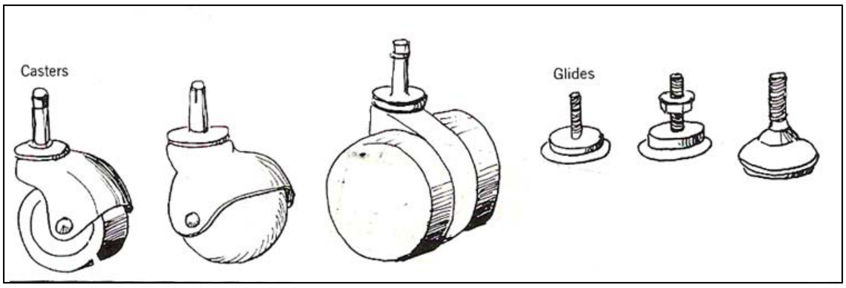


Figure 5.7. Casters and Glides
(source: Pile 1990)

These are the mechanisms which provide locking of the cupboard units for safety. Generally mounted to the lapel.

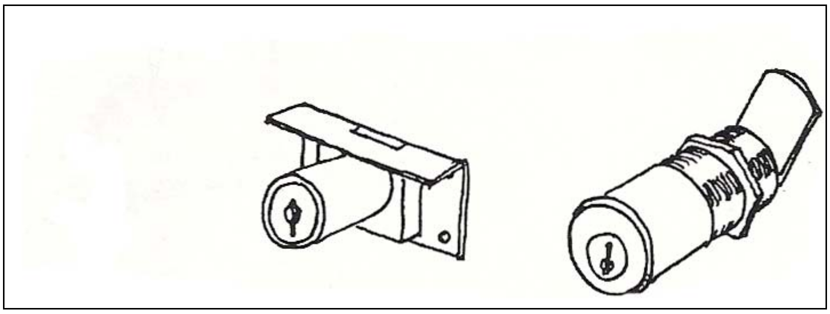


Figure 5.8. Cabinet Lock

(source: Pile 1990)

Hinges are the connection elements that allow the covers or mobile parts of furniture move within a certain axis. The hinges are chosen according to the cover detail and different opening-closing methods of the furniture.

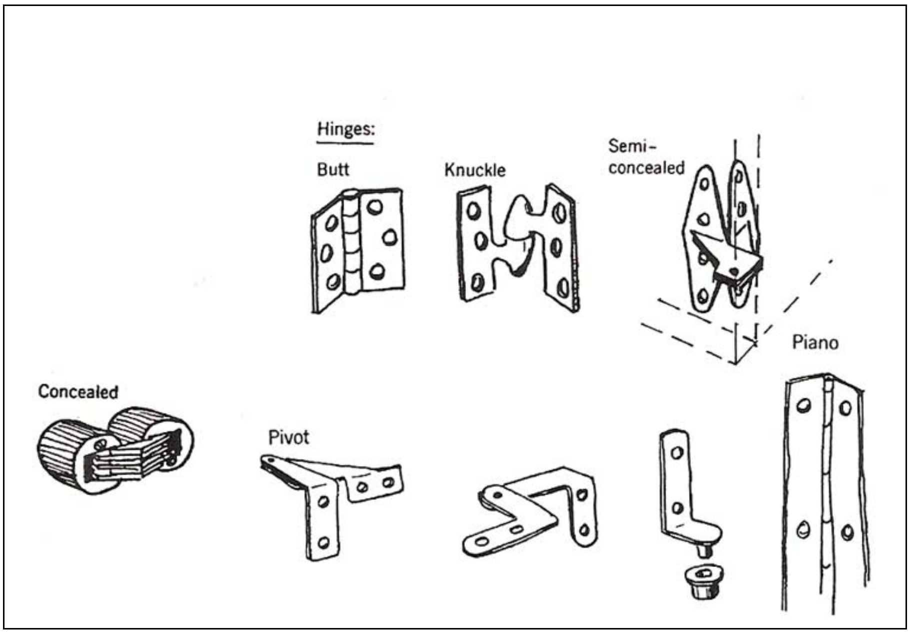


Figure 5.9. Hinges

(source: Pile 1990)

These are the elements that allow certain surfaces to connect to each other and solidify in furniture. The first four elements are used to screw and unscrew the bolts several times and prevent the bolt from deforming the furniture material.

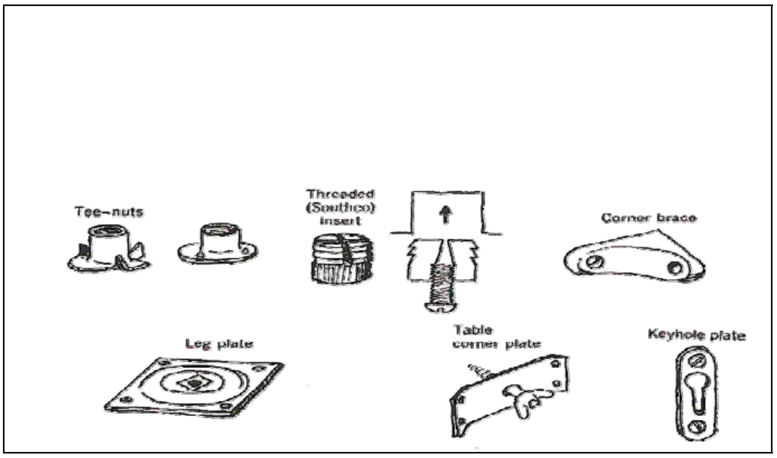


Figure 5.10. Fastening and Hardware

(source: Pile 1990)

The first of these elements is used to allow the chair to turn square to the footing axis. The second connection element is the element that allows the up-and-down height adjustment and the leaning-setting upright of the chair.

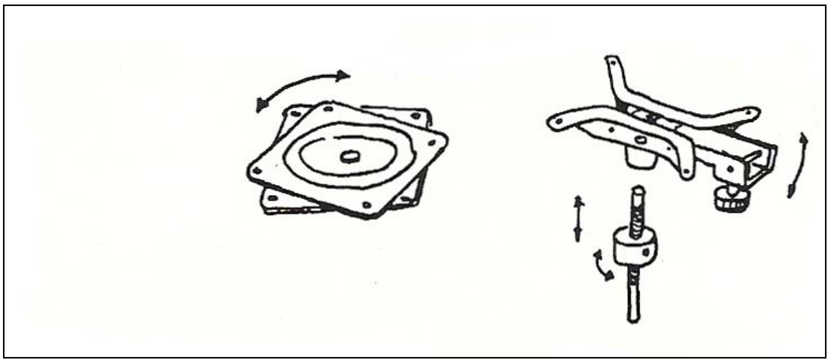


Figure 5.11. Chair Swivels and Controls

(source: Pile 1990)

The footing is the one placed right under the mobile footing axis. Any of the footing elements in Figure 5.7. could be placed in the point where the multi-armed part of the footing touches the ground.

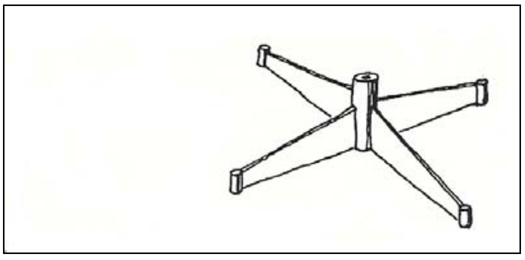


Figure 5.12. Chair Bases

(source: Pile 1990)

5.1.2. Sample Applications

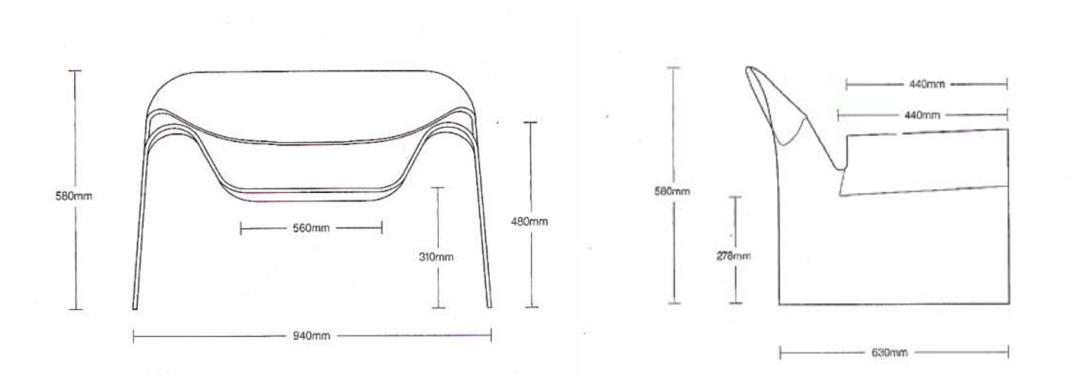


Figure 5.13. Ghost Chair

(source: Mcneil 1990)

Ghost Chair which was produced by Fiam Company during the production of glass and because of their flexibility, this chair looks like a statue. Only glass was only glass was used in this object and it’s very functional and light chair design.

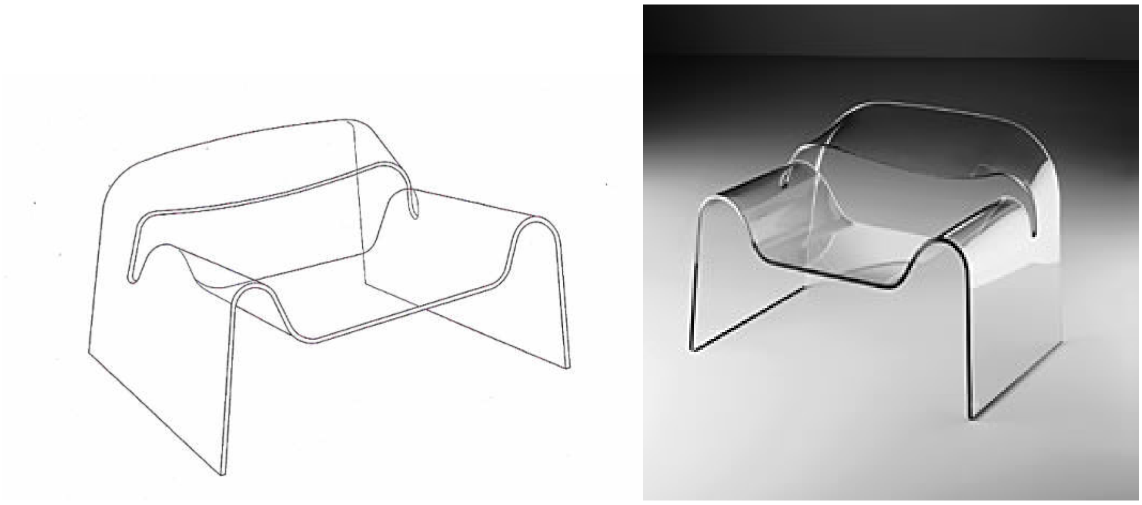


Figure 5.14. FIAM Ghost Chair, Cini Boeri and Tomu Katayanagi

(source: Mcneil 1990, Web_24, 2006)

Figure 5.15. So Table
(source: Web_27, 2006)

The trestle called “So” which is designed by Andrew Tye in 1996 is a good example for combining PMMA with different materials. The designer has combined flat and curled 5 mm thick PMMA plates with aluminium pipes, stainless steel screws and strong double side band. On the top structure platform which it is combined on wide surfaces strong double band is used for combining. Between de structure and base aluminium pipe has been combined to the PMMA plates’ holes with stainless screws.

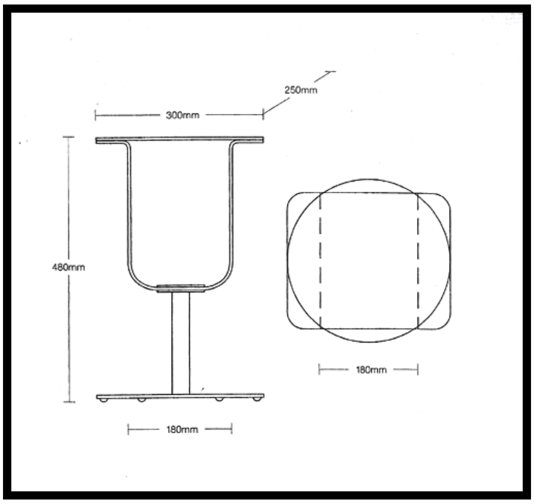


Figure 5.16. So Table Section
(source: Web_27, 2006)

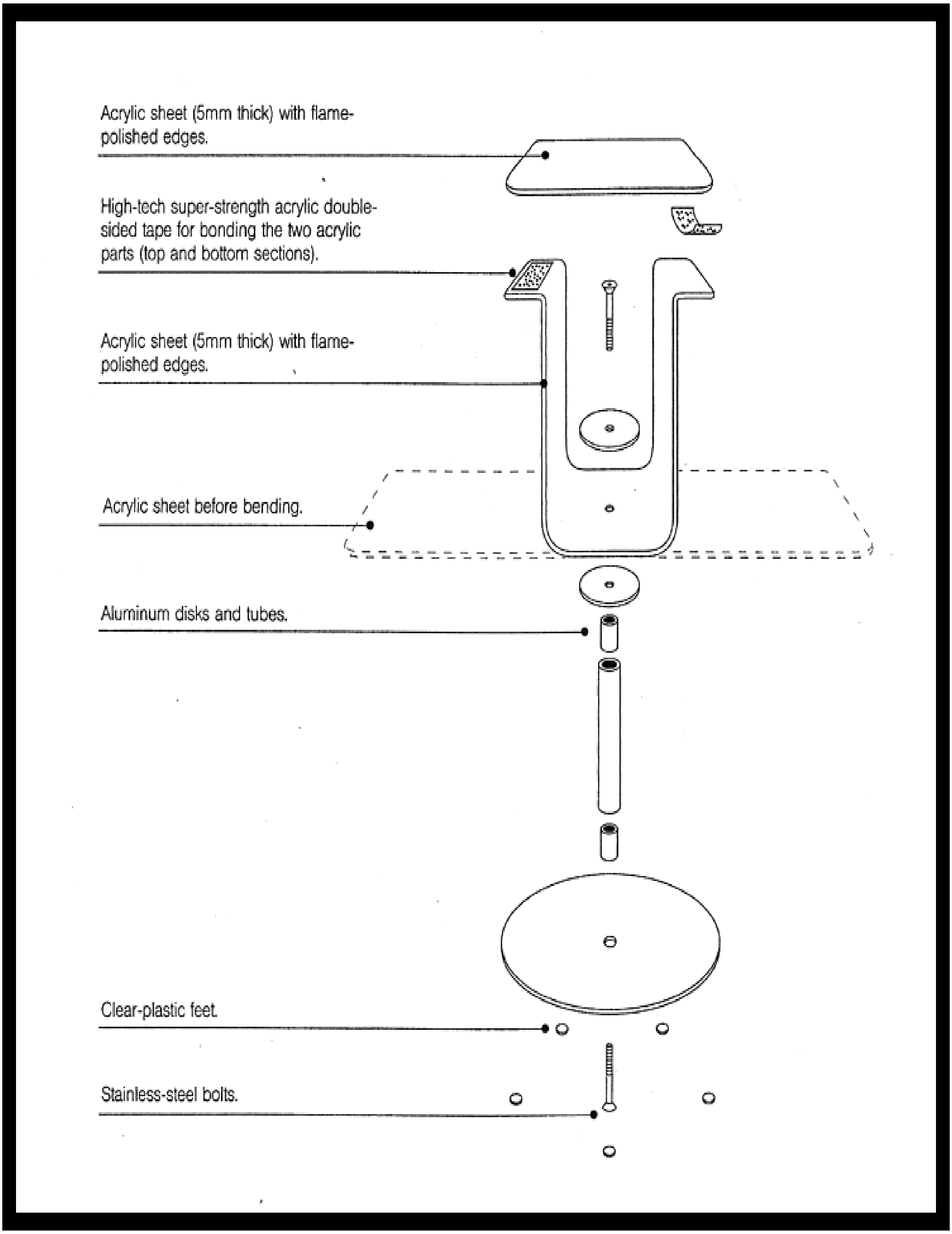


Figure 5.17. So Table Details

(source: Byars 1997)

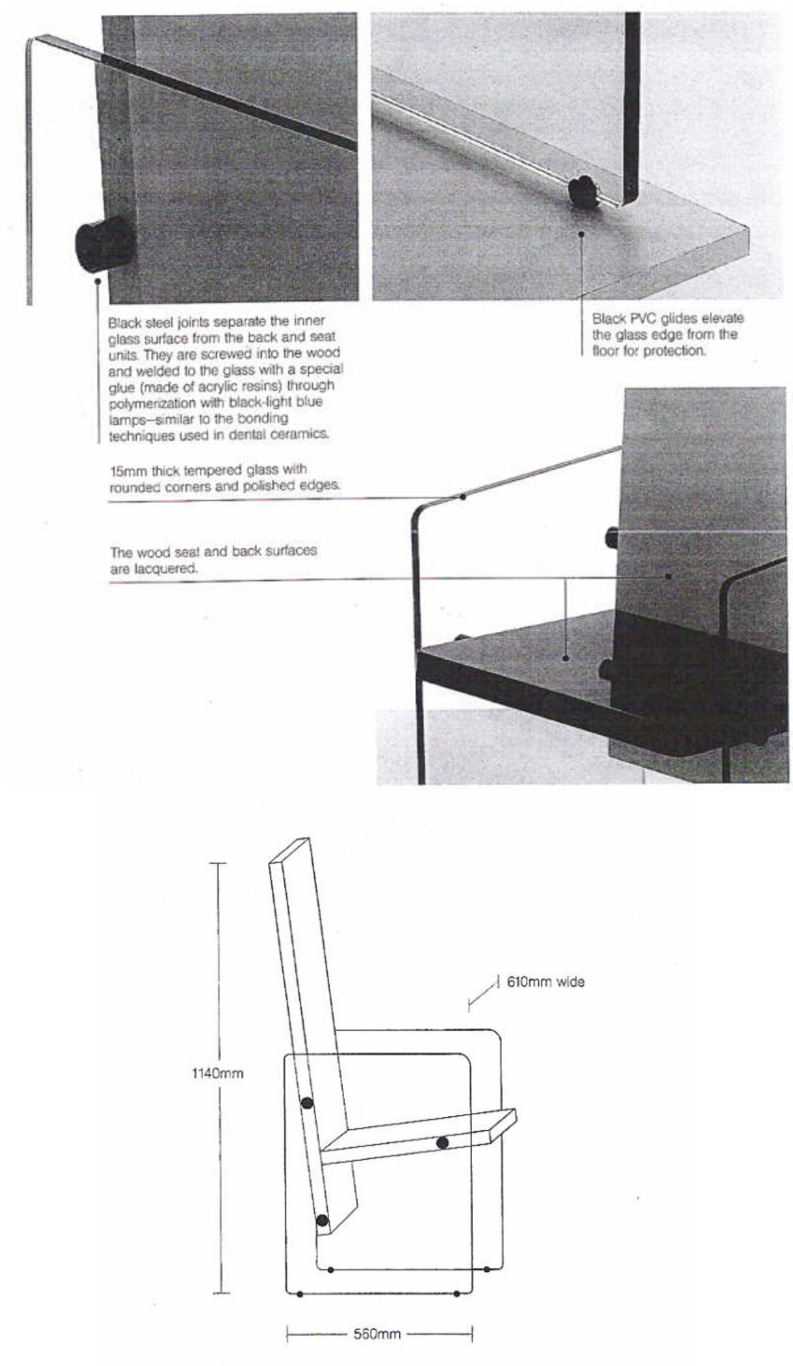


Figure 5.18. Colozzione Pak Armchair

(source: Byars 1997)

In this example, designer uses the tempred glass the vertical position which is the best for endurance hence seat place and dorsal side which were painted with lacquered are obtained to carry. The glass which has a shiny and transperant, image are supported by dry in an ovened lacquered. In addition when tempered glass and wood were combined coutchouc is softened their solid.

Figure 5.19. Coffee Table Glass Connection Details

Figure 5.20. Glass Coffee Table of Monitel

This example was produced by Monitel company, two krom glass which shape u and thickness is 1cm and four junction elements produced by indian rubber were combined besides krom legs were created with laser glue technique.

Figure 5.21. Monitel Coffee Table Glass Connection Details

In this coffee table two glass connection details were obtained the motion between up side glass and side glass. At the same time transparent coffee table which have crom legs with visual and pysical balance were obtained.

Figure 5.22. Bus stop

Glass and PMMA besides using in inner place furnishing are also used in city furnishing. Most designs which we see in our environment are products made of transparent plates. To prefer PMMA to glass in inner places because of its structural features continue also in city furnishing. Glass which has especially a fragile structure can be dangerous to use in places where people are in mass.

Figure 5.23. Junction detail

Call boxes, stops, billboards, car parks are places where this material is used the most. It is used horizontal and vertical in stops. The three sides of the stop are covered with PMMA panels which are used vertical. The main bearings are aluminium bases which are at the four corner of the stop. The PMMA plates with the support of apparatus placed on the bases are screwed and mounted tightening on it. PMMA plates are placed in prepared metal frames in billboards and panels where the names of the stops are written. Because the lightness of the plates which are prepared as sliding panels can easily mounted and dismounted.

Figure 5.24. Billboards

Figure 5.25. Call boxes

In call boxes we see again the combing of aluminium bases and PMMA plates. On the two bearing bases there is aluminium top and side panels mounted. These panels are made transparent by fragmentally dividing it with PMMA plates. The plates which are placed between the two aluminium parts are fastened with screwing method. In this way the call box has been made both sheltering and half-open.

Figure 5.26. Junction detail

A chair is designed fort he bride-bridegroom show organized in İzmir. This chair consist of PMMA sheet. PMMA sheets are cut at the dimensisons determinate by designer. After tahat on the horizontal components sticking method and on the vertical compenents screwing method are applied **(**Figure 5.27, Figure 5.28).

Figure 5.27. bride - bridegroom show’s chair

Figure 5.28. Junction details

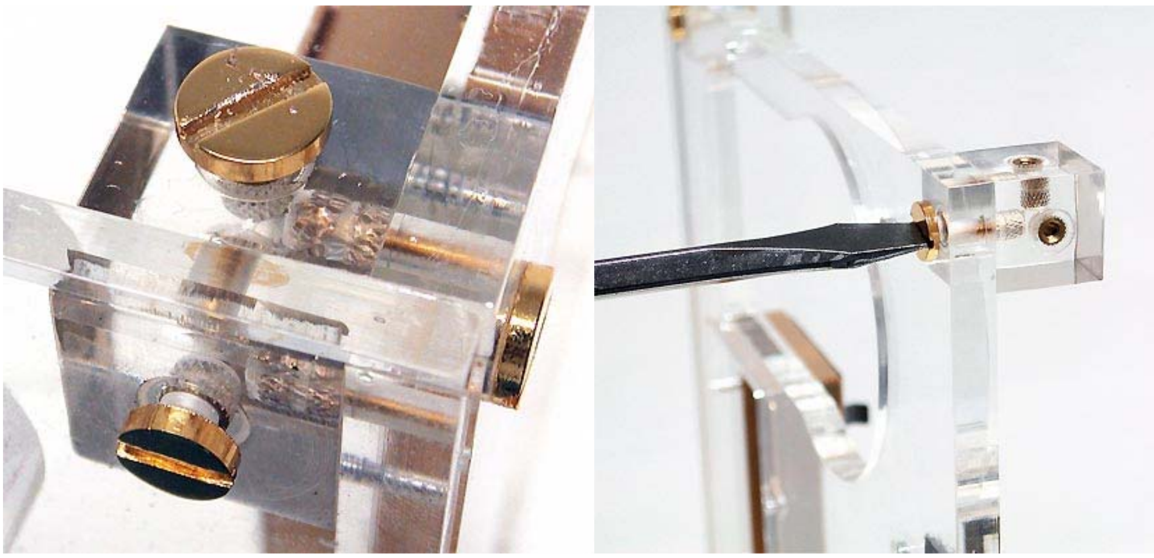


Figure 5.29. Junction details

5.2. A New Sheet As a Proposal Reinforced PMMA

When compared to metal materials, PMMA shows great differences of its own. PMMA materials are used on their own or with metal materials in furniture. Many accessories and junction details used in metal and wooden furniture are also used with PMMA furniture. The heat sensitivity of PMMA materials are much higher than metal materials. They react quicker and in higher quantities in both physical and chemical ways when exposed to heat.

PMMA reacts differently especially under heat. For this reason montage details should be given attention. To get better results in places where heat differs, the PMMA is mounted in a canal frame where it could freely expand and shrink. In the junction details to be formed of the panels with different materials, these expansions and shrinkages due to heat differences should be considered. Due to this reason, for example, in forming a table detail a PMMA platform should be connected to the metal footing of the table from one point or, these expansion and shrinkage quantities should be considered in the bolt hole calibres that will be opened up in junction points with more than one bolt. Besides this, there could be junction details such as shown on Figure 5.30. In this example, in the table-platform junction, bolting has been avoided and holes and gaps on the PMMA material have been created.

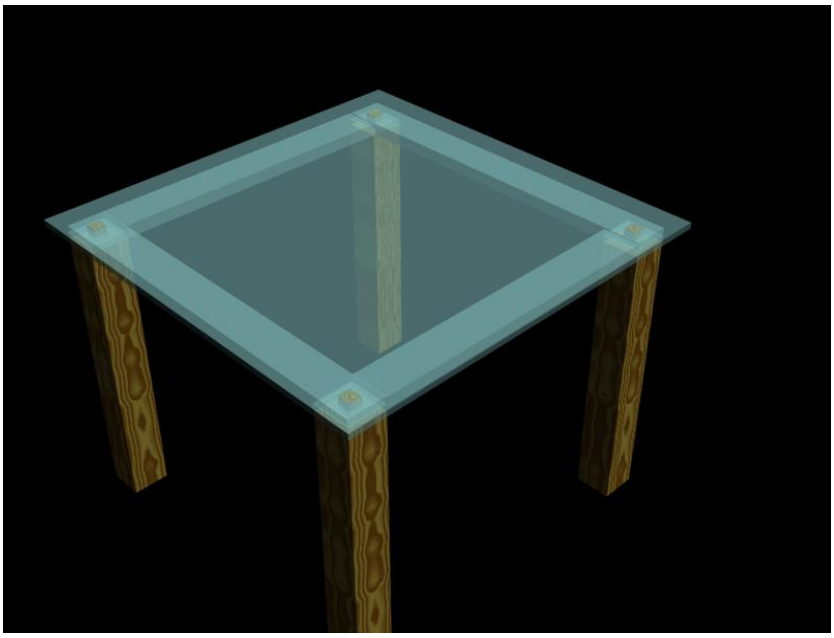


Figure 5.30. PMMA Table

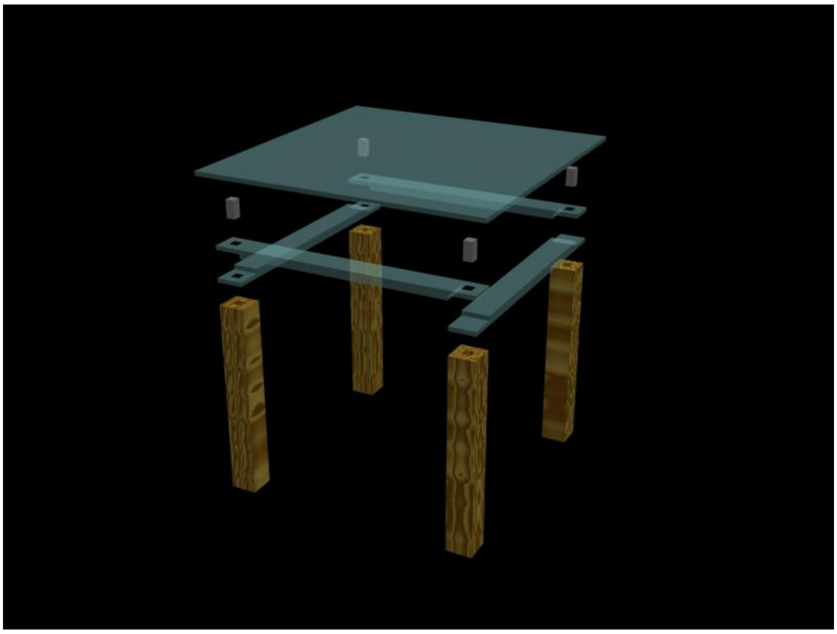


Figure 5.31. PMMA screw Table

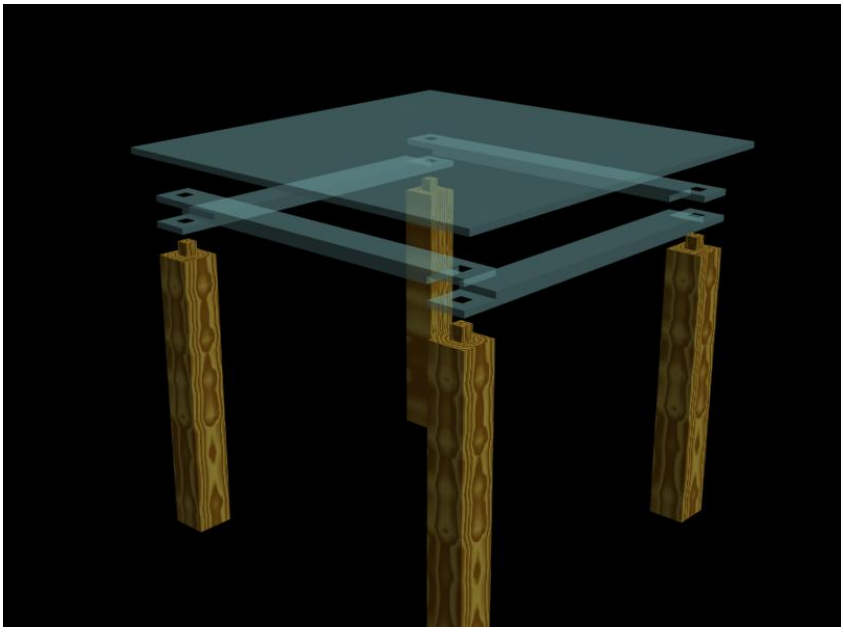


Figure 5.32. Junction details of without screw

In using the PMMA panels, it’s recommended to use wickerwork wire with these junction points which are used to improve endurance to gain stronger material. By placing a wickerwork wire panel between two PMMA panels a more stabilised material could be obtained Figure 5.33.

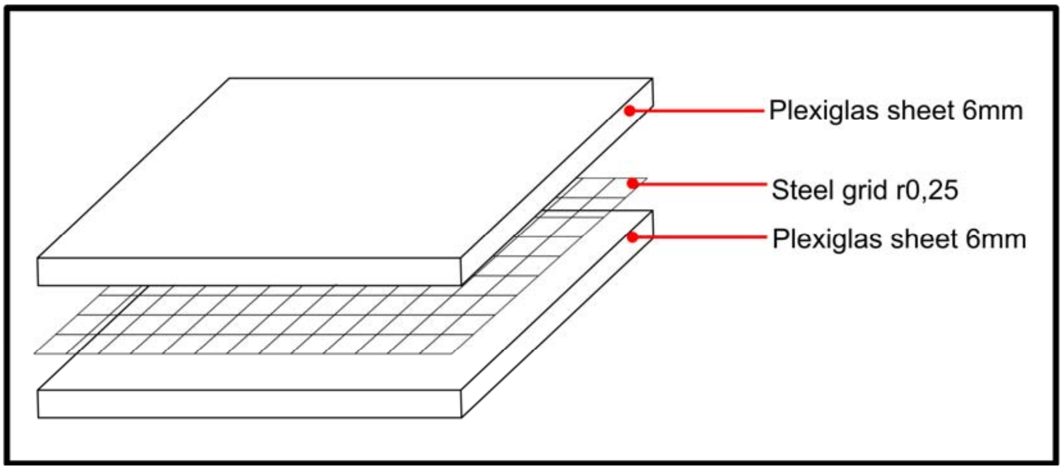


Figure 5.33. PMMA sheet with steel grid

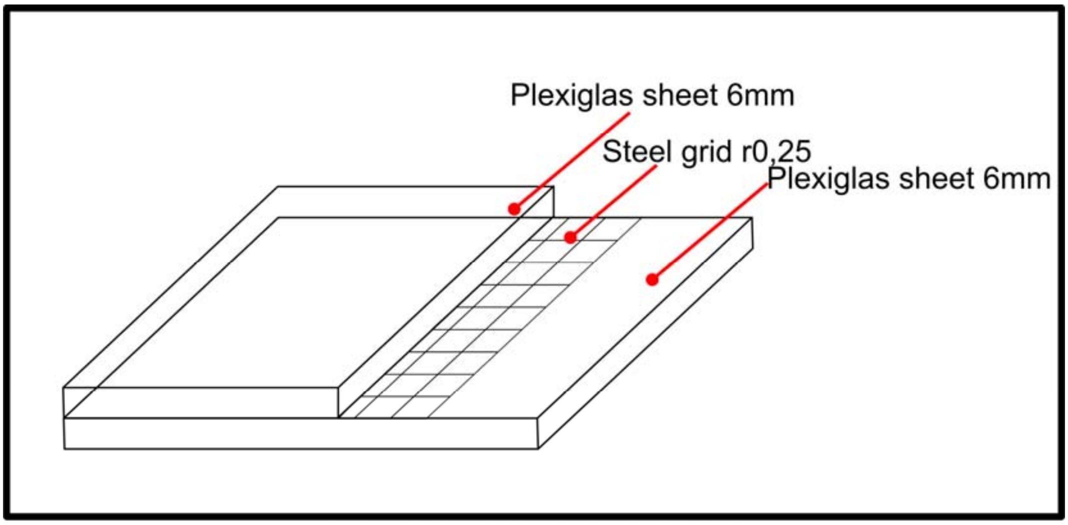


Figure 5.34. PMMA sheet with steel grid

Before the PMMA panel is processed after the production process, there has been placed a wickerwork made by galvanised wires, again prepared in the defined measures, between two PMMAs of the same dimensions. The wickerwork, made of galvanised wires, has been created by merging rustproof galvanised wires of 1mm to create a karolaj about 1cm * 1cm dimensions. The wickerwork placed between PMMAs that have been softened and prepared by heating is solidified by compressing the softened PMMAs. And afterwards it’s left to cool for some time. After cooling is over, the PMMA that has lost its shine a little during heating is polished again and turned into one panel over smooth surface. The last process is finalised by smoothing away the crusts and excesses on the sides of the panel.

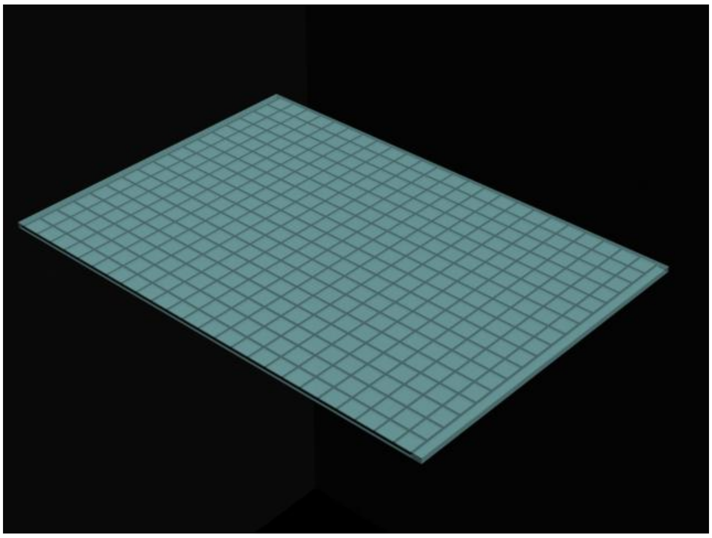


Figure 5.35. PMMA sheets model

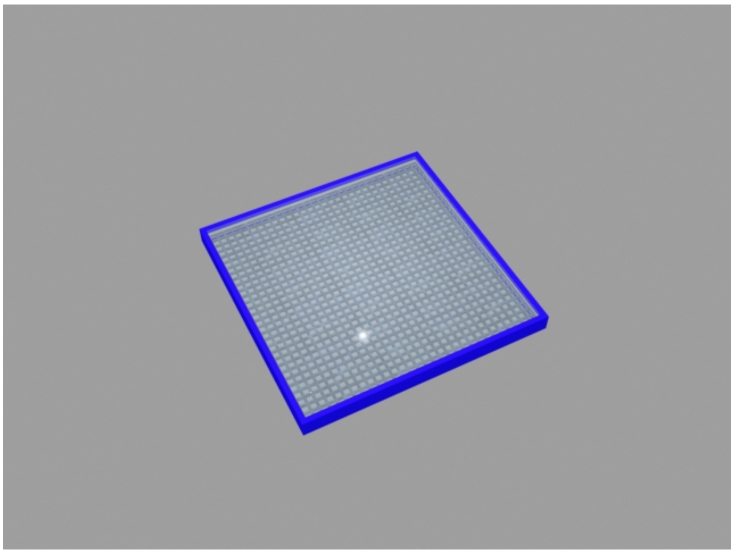


Figure 5.36. PMMA table sheets model

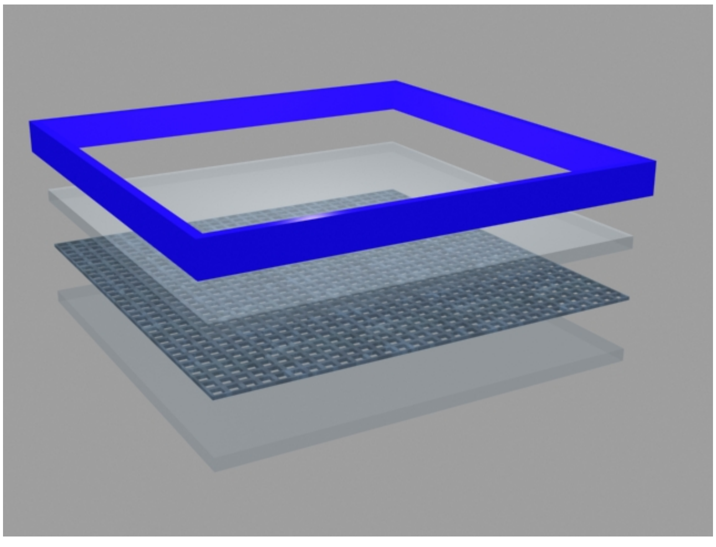


Figure 5.37. PMMA table sheets model detail

This process has increased both pressure and the hauling endurance of the PMMA material. Besides these pluses, this texture formed within the transparent PMMA provides the material with a different sight and aesthetic. The aesthetical concerns of the design will define the desired colour and dimension differences in the material. Variety could be gained since the galvanised wickerwork placed in the material differs in thickness and pattern. But, for the material and the wickerwork inside not to deform in heat, the gaps within the wickerwork should not be too big and for the PMMA material not to deform, the wickerwork wires should not be too thick. The metal wickerwork within the material could be used as matte or semi-matte as well as different textures and shapes. Juncture could be done by opening up the wickerwork wire gaps and placing it on the male-female chip on the footing. Figure 5.35.

This panel could be used in many different designs. The colour and transparency attribute existing in PMMA itself provides variety in aforementioned material since it could also be protected in producing new material. Besides this, being easily processed, easily pierced from the junction details with various materials and itself, and being lighter compared to other corresponding materials are other attributes that makes it preferable. It's also an important attribute that this material is stronger than glass in endurance. With these attributes it could be defined as a material that allows the designer freedom in his work.

Due to the furniture designed using this product have strong endurance to external influences, it will also be applicable to use outdoors as well as indoors. But, while using these outdoors, it should be seen to that the exposure of the galvanised wickerwork to the external influences is prevented or there should be wickerwork chromium or rustproof materials between the PMMA panels. Thus, with this equipment it will be possible to create designs to use both indoors and outdoors.

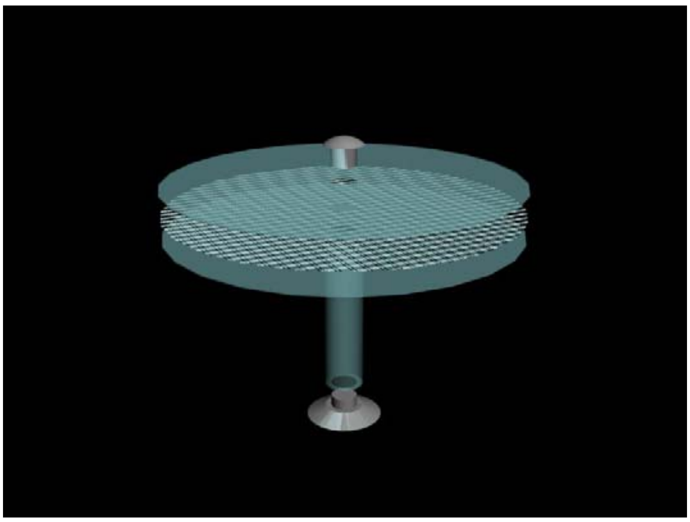


Figure 5.38. Chrome base

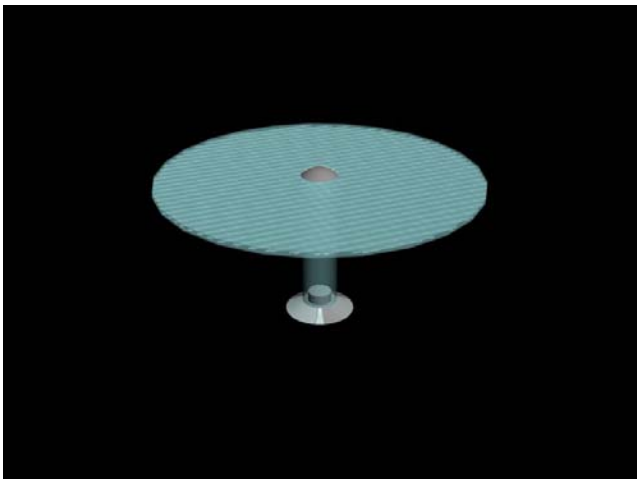


Figure 5.39. PMMA round table

5.3. A New Junction Detail Proposal

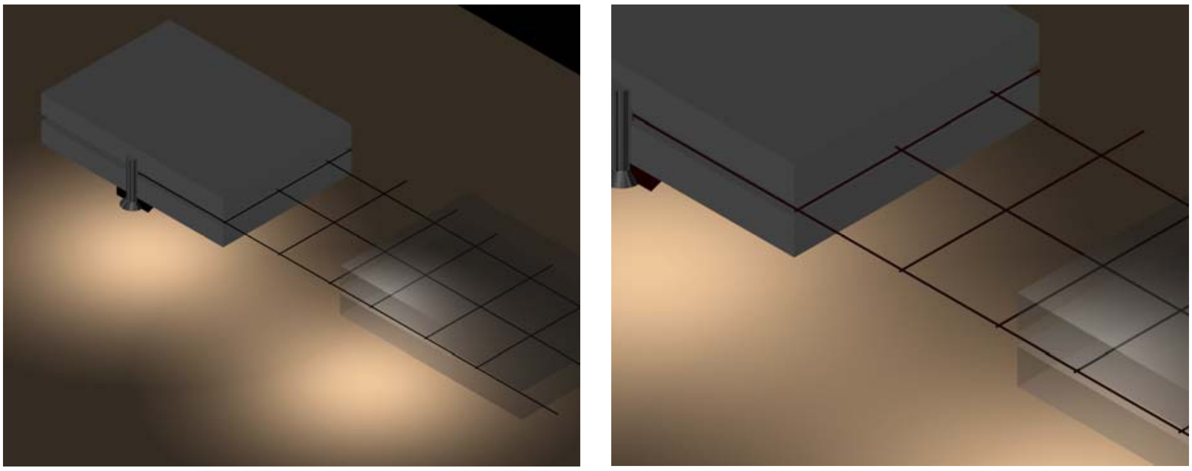


Figure 5.40.New junction detail proposal-1

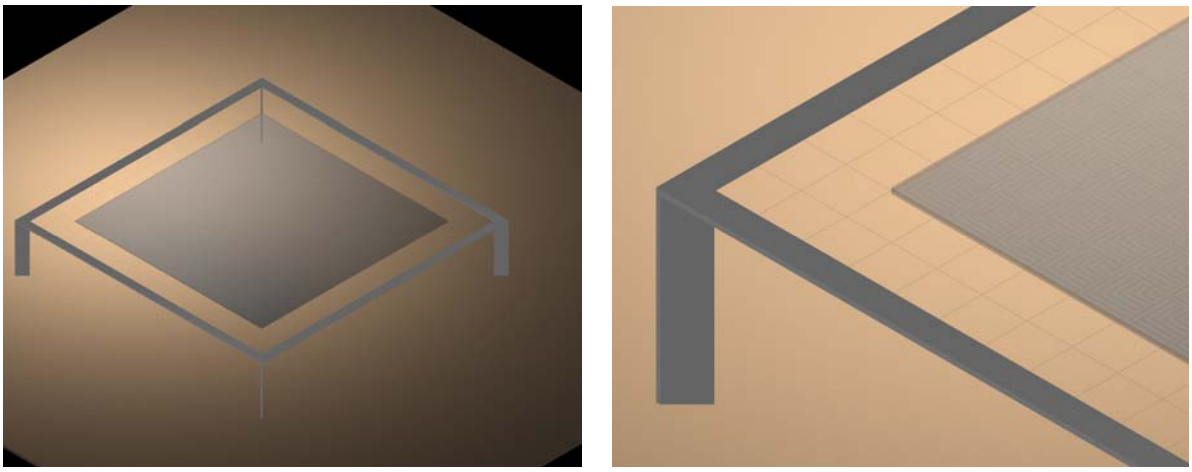


Figure 5.41. New junction detail proposal-2

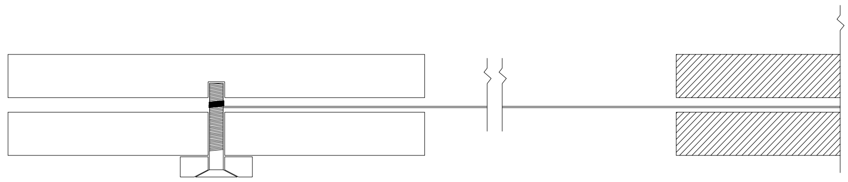


Figure 5.42. New junction detail proposal-3

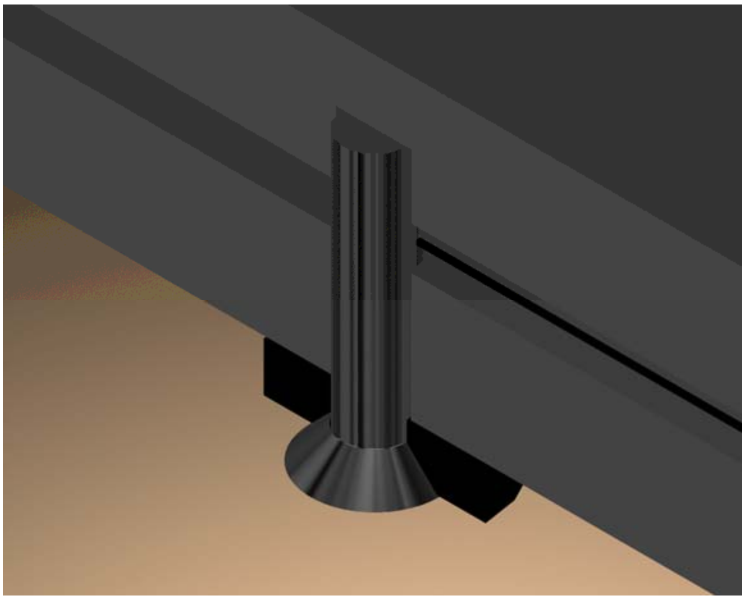


Figure 5.43. New junction detail proposal-4

CHAPTER 6

CONCLUSION

While humans' arrangements of their residence according to the request and functions forms the furnishing concept. Another fact like aesthetics has been added besides function to this concept in the modern age. Aesthetics concern has leaded the designer and user to different materials. The used different materials must also offer some standards of the present life style. The glass and PMMA which are one of the different materials and which are used in this thesis study has been proved to be suitable for our present life and the usage has been increased in the course of the time.

The flexibility caused by the fabric of both materials has also been reflected to the imagination of the designer and has provided to force the limits of producibility. While solutions has been found for the fragility of the glass which is the first meaning of transparent in architecture, PMMA which carry transparency and flexibility constitution opens up new vistas to the designers. Despite the glass is formed from natural materials and though PMMA is artificial it is also a positive approach to the environment pollution which is the most important problems of nowadays because it is a recycling material.

PMMA and glass which are used alone are also used together with other materials. Combining them with to or more different materials stronger and more functional products are derived. In this study combining details are researched and different suggestions are submitted. PMMA and glass, aside from their standalone uses, have been used with other materials as well. More functional and higher endurance products have been obtained by merging two or more different materials. In this study the junction details have been examined and different proposals have been given.

Aiming to gain a different view from both PMMA's endurance increasing and from the designer view; the iron wickerwork used between double panel thicknesses can be illustrated with this different material junction. The produced material, while not having the PMMA lose the lightness and transparency attributes it's renown for, has removed, both virtually and physically, the fragility and endurance inadequacy that exist as a result of the lightness and transparency with the aid of a material with high hauling endurance such as iron. The obtained product, while allowing PMMA materials to pass through wider gaps, gives the customer and designer a more dependable image with both the outlook and physical attributes. With all these attributes, this material is applicable in internal and external space furniture, stand and advertisement jobs, as well as lightning and accessory.

In today's furniture design, the latest customers tending towards different outlooks, attributes and functions has made designers vie towards materials unused in this field before or completely new materials. In this manner, it's a sought and desired attribute for the products to be functional, aesthetical and new and made of materials unused beforehan.

The reinforced PMMA plate which is adviced on working process, was compared to the basic PMMA plate which was not applied to any working process. The results of the test was shown as figures and graphs.

The PMMA plate which has thickness of 3 mm, was cut in 18*4 cm pieces according to the determined test standard. The straw wires are placed on the 1*1 cm gap between the pieces which were put on the fireproof teflon.

Figure 6.1. PMMA plate and the Galvanised wires

The prepared component was heated up in the oven whose temperature is reached to 185°C therefore the PMMA plate was softened.The PMMA which was passed the soften process, was combined with the straw galvanize wires that are put between PMMA.

Figure 6.2. The PMMA pieces that are put in the oven

Figure 6.3. Hot press

The pieces which are well combined into eachother, are placed into the hot press to boil up.The product was placed fastly into the hot press whose temperature is fixed 185°C for not to be shock cooled.

15 tons force was applied on the product that was pressed approximately 5-6 minutes.After that, weight was put on the product taken from the press for providing to stay smooth while cooling.After 10 minutes, the product became ready for the test.

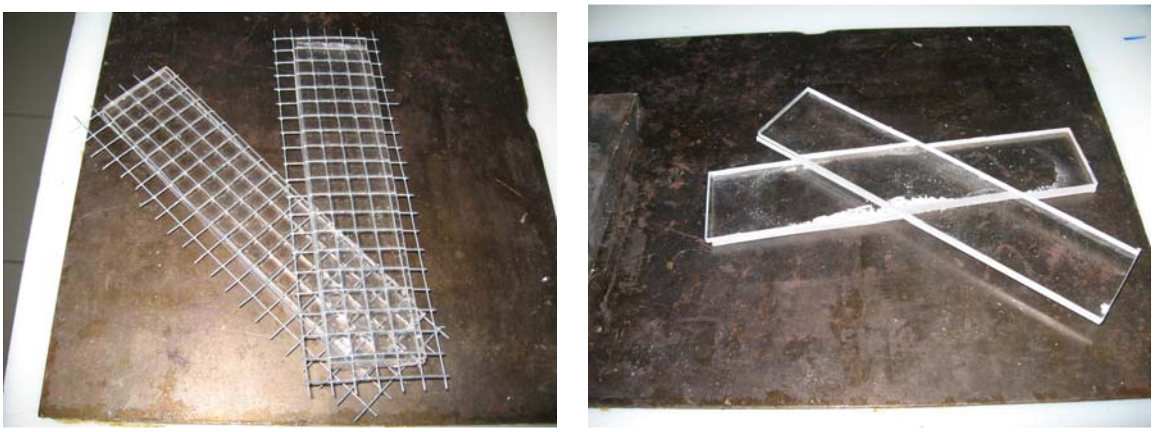


Figure 6.4. Products taken from the pres

Figure 6.5. Schimodzu AG universal test machine

On the other hand, this product is compared to the PMMA plate which was prepared by cutting in 18cm* 4cm dimensions and 6mm thickness.The bending test was applied to the compared products in the Schimodzu AG universal test machine.

First the PMMA plate is placed on the prepared stage.At the same time, Schimodzu AG Universal test machine is connected to the computer for drawing graph of applied force

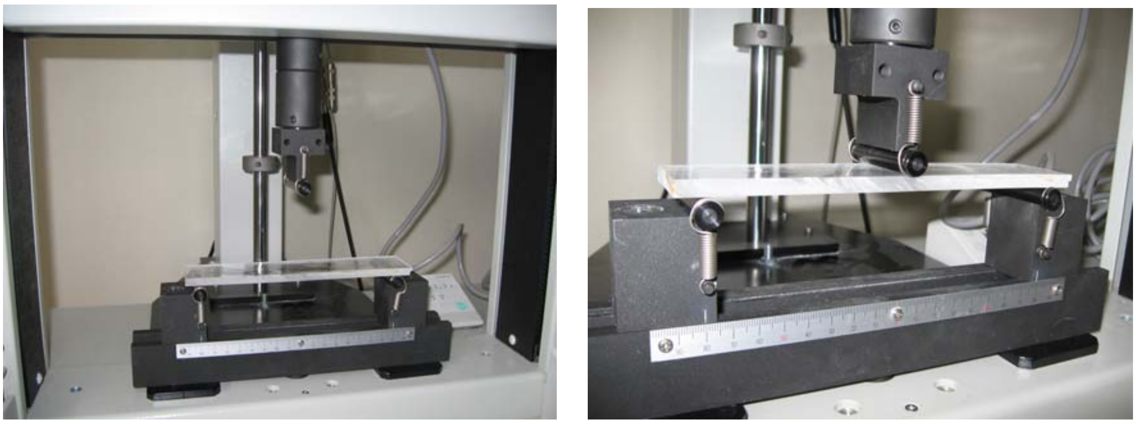


Figure 6.6. The bending test is applied to the PMMA plate

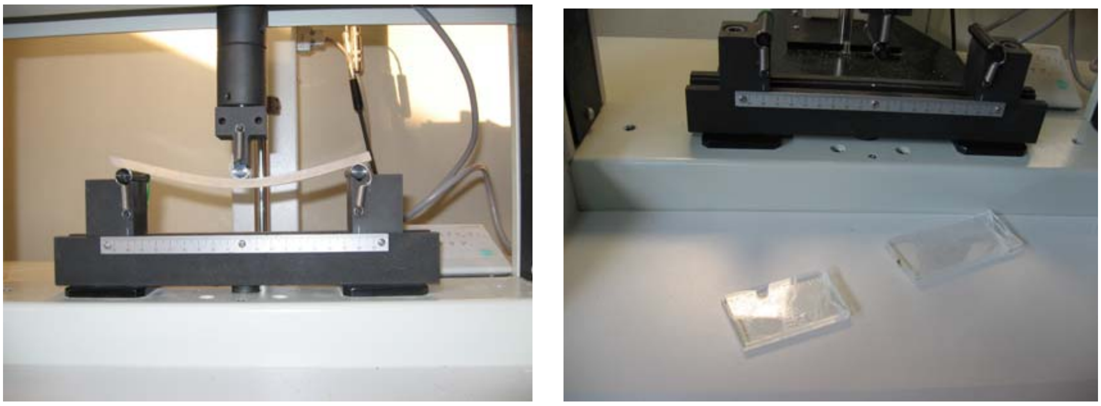


Figure 6.7. After the applied bending test, PMMA plate breaks down

Facing the rapidly increased force, the PMMA plate started to bend and when the applied force reached 500N, the break down of the plate was observed.

After all, the reinforced PMMA plate was applied by the same test.It was observed that the reinforced PMMA plate made the same bending moves against the force too.However, it is established that it can stand the force up to 585 N.

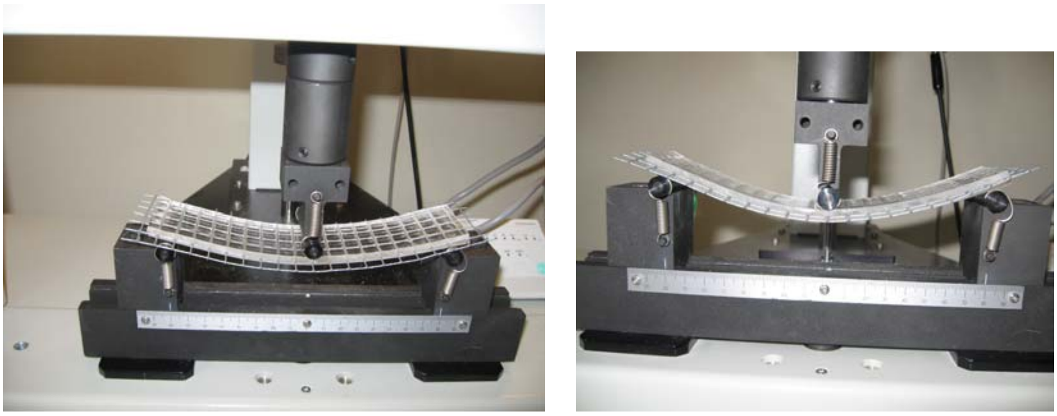


Figure 6.8. The bending test is applied to the reinforced PMMA plate

Figure 6.9. After the applied bending test, the reinforced PMMA plate breaks down

The resistant force of the reinforced plate is more than the regular plate that is proved by the test.In the first two graphs, the bending ratios of the plates against the different forces is showed.In the last graph the breaking diagram that shows the durability of the two products is put on top of each other to provide the necessary comparison.

Table 6.1. PMMA test

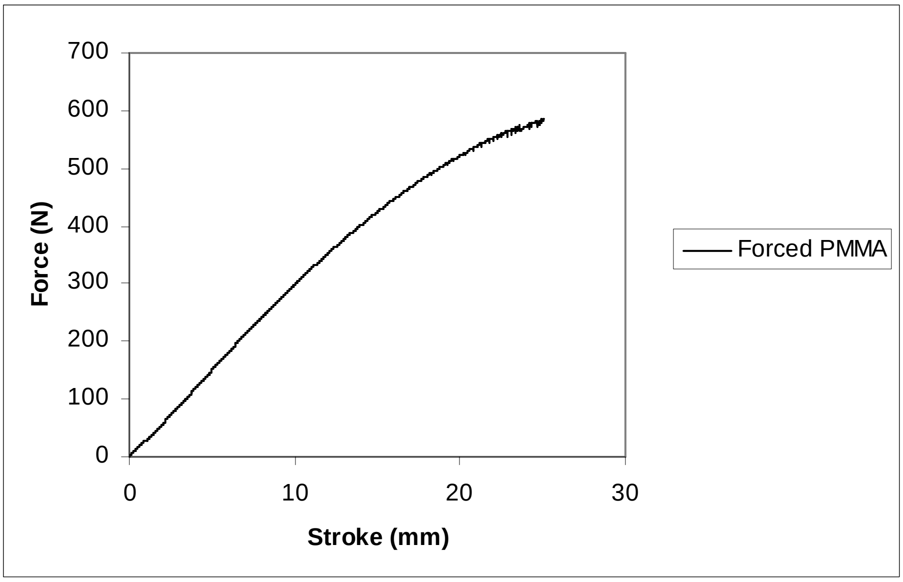


Table 6.2. Reinforced PMMA sheet test

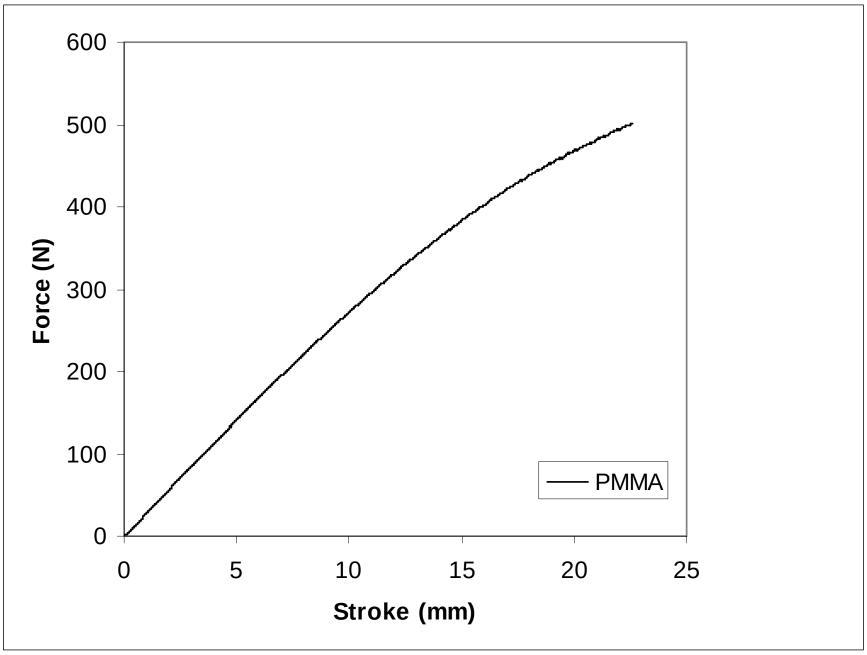
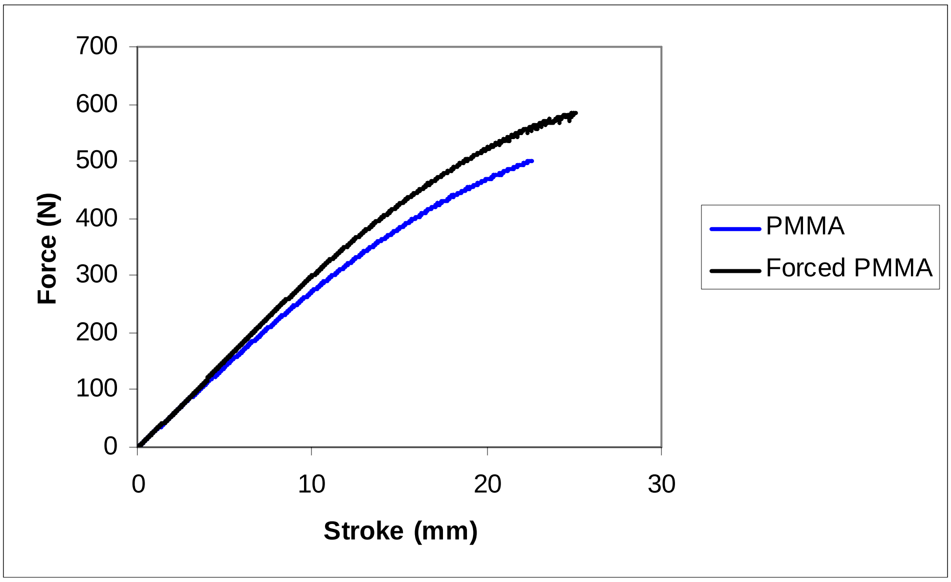


Table 6.3. Reinforced PMMA sheet test –PMMA test



PMMA metarial has features which is flexibility, weightless and strength these qualities provide to designers freedom in their designs. But same metarial structural qualities create some ristrictions in production side. Thanks to these metarial solution to aim to PMMA's cross section thickness,increase the transportation in wide surface and decraese the tension at vertical side. Studies which are given down side of the page if PMMA metarial use corrcectly, you can profit from design and production advantages (Figure 6.10.- 6.20).

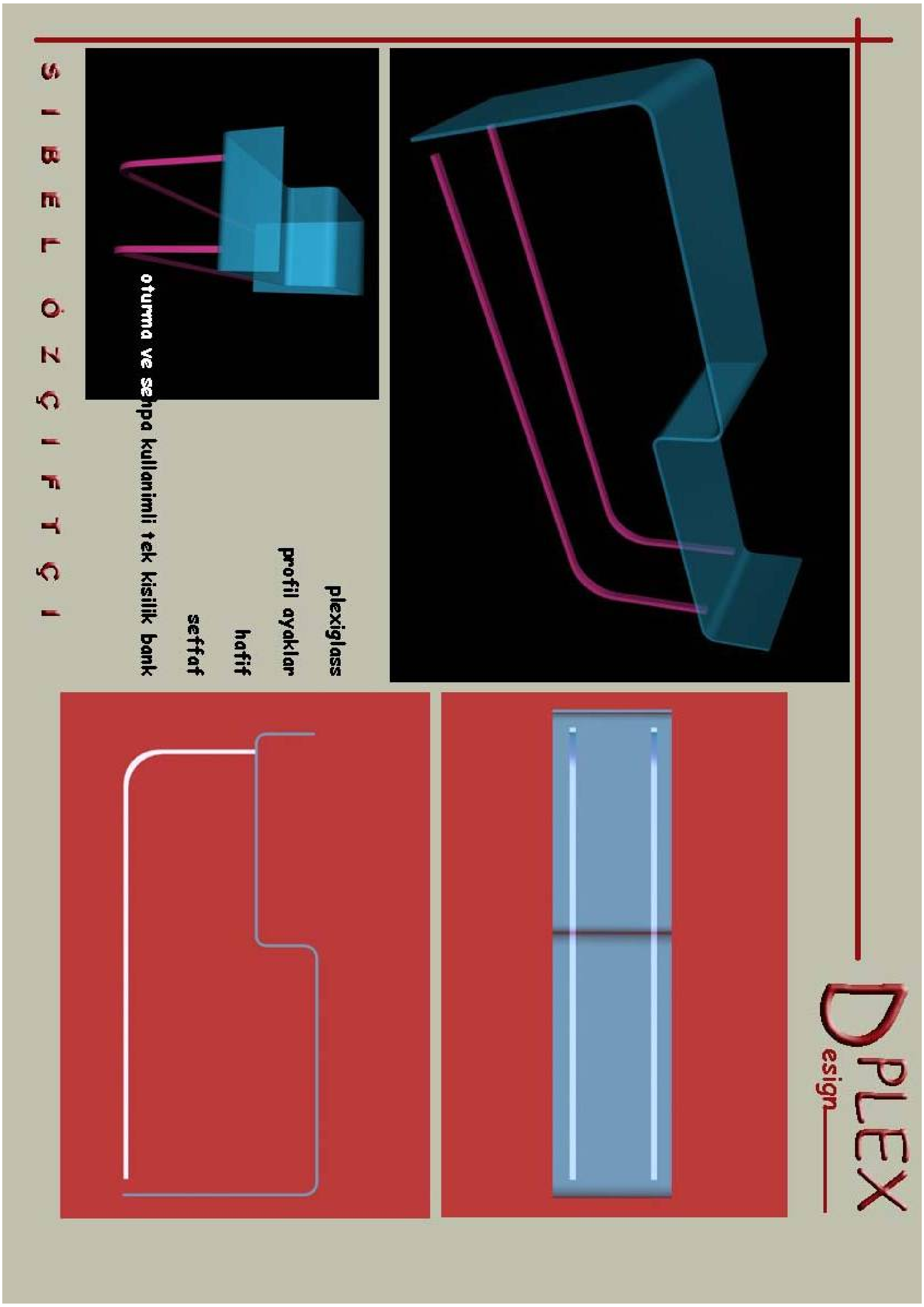


Figure 6.10. PMMA Furniture design – bench
designed by Sibel Özçiftçi

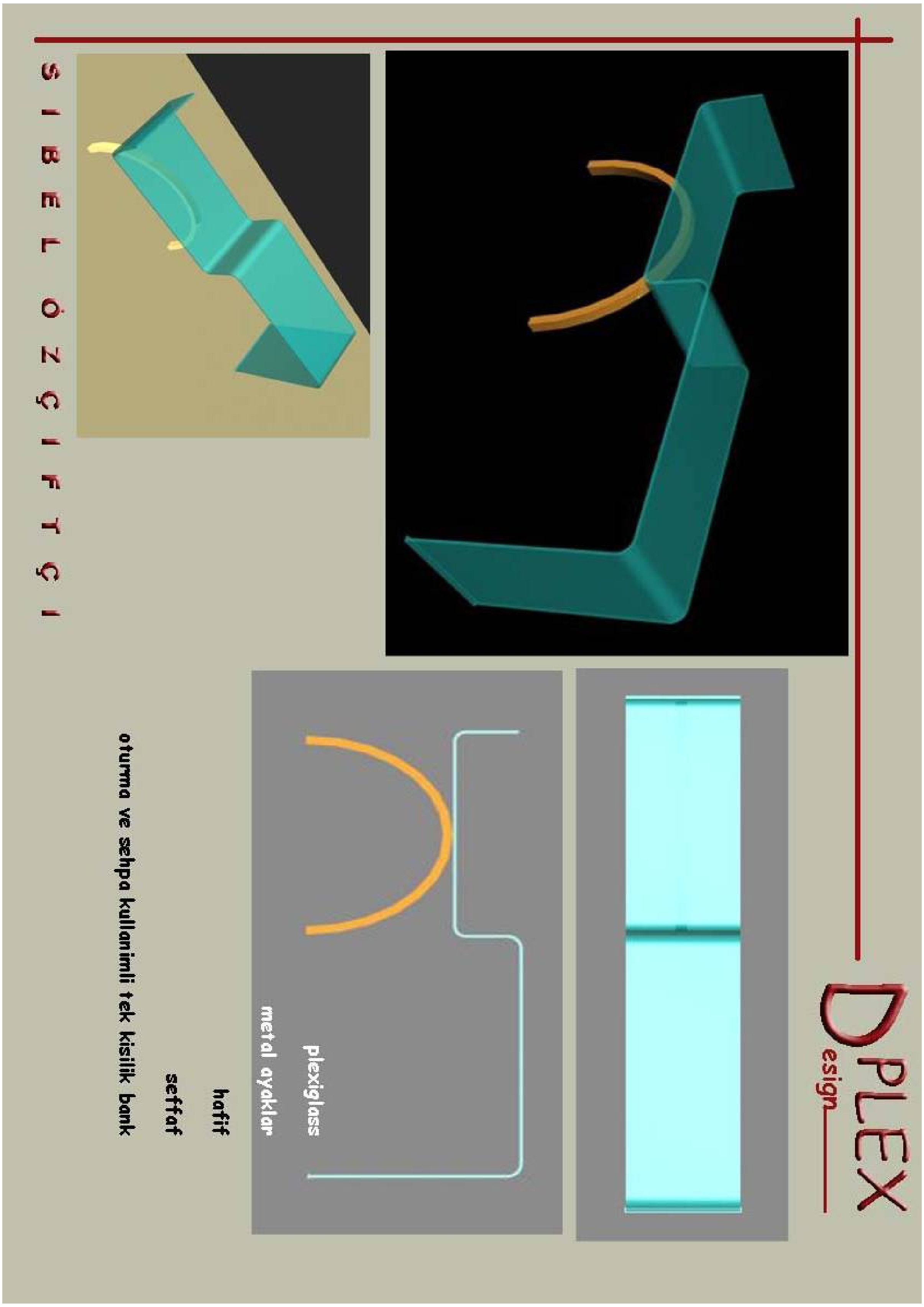


Figure 6.11. PMMA Furniture design – bench
designed by Sibel Özçiftçi

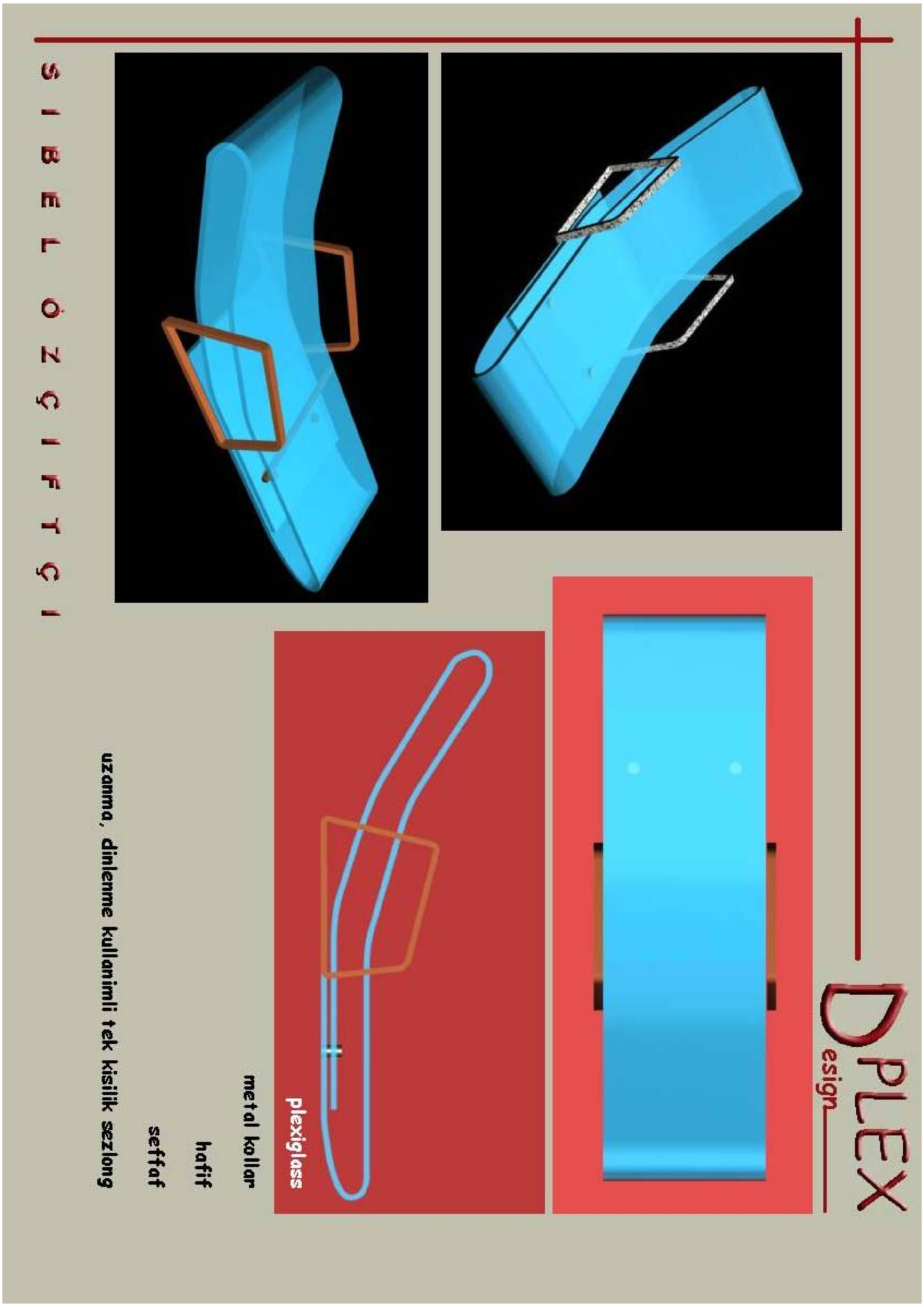


Figure 6.12. PMMA Furniture design – day bed
designed by Sibel Özçiftçi

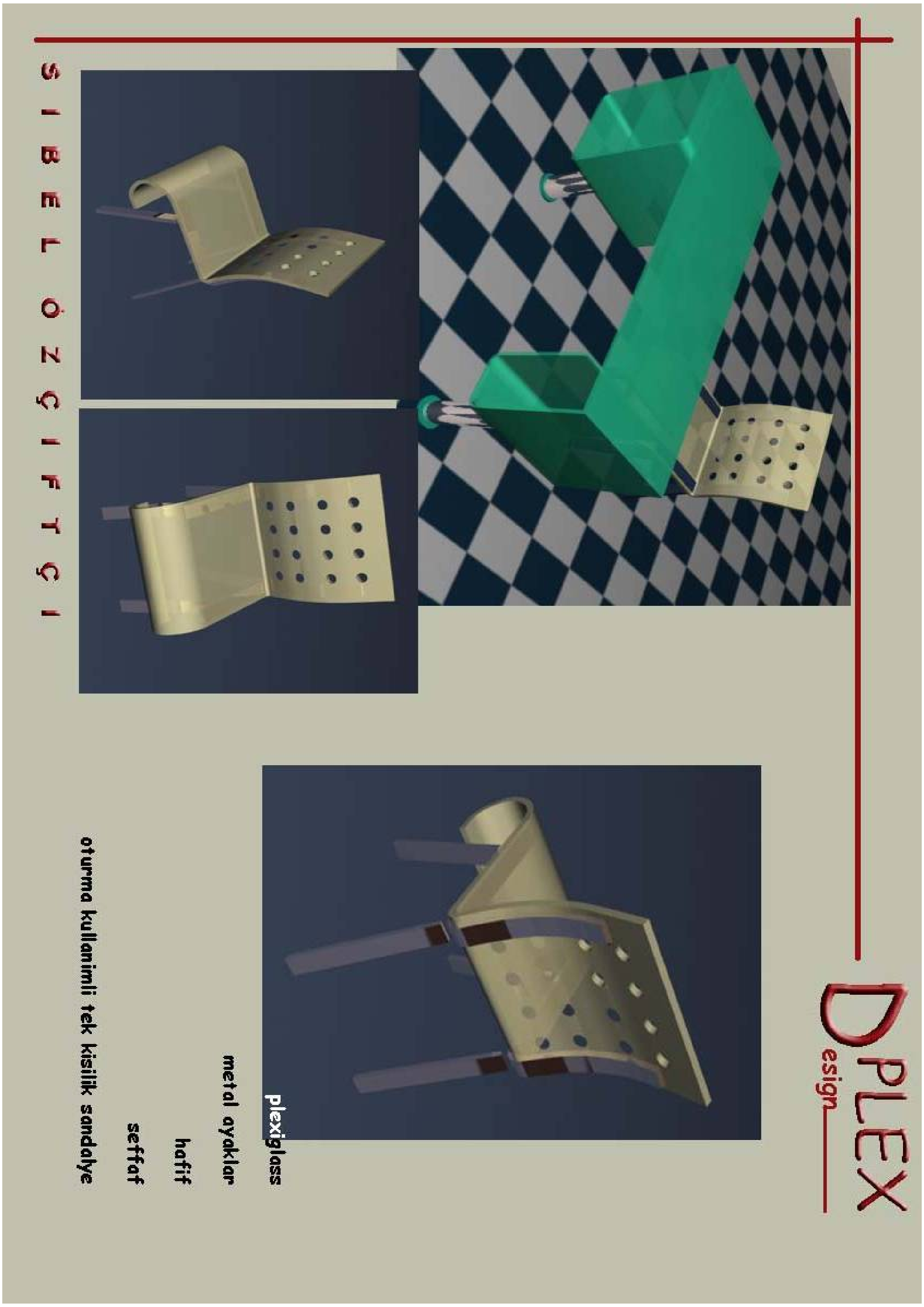


Figure 6.13. PMMA Furniture design – chair
designed by Sibel Özçiftçi

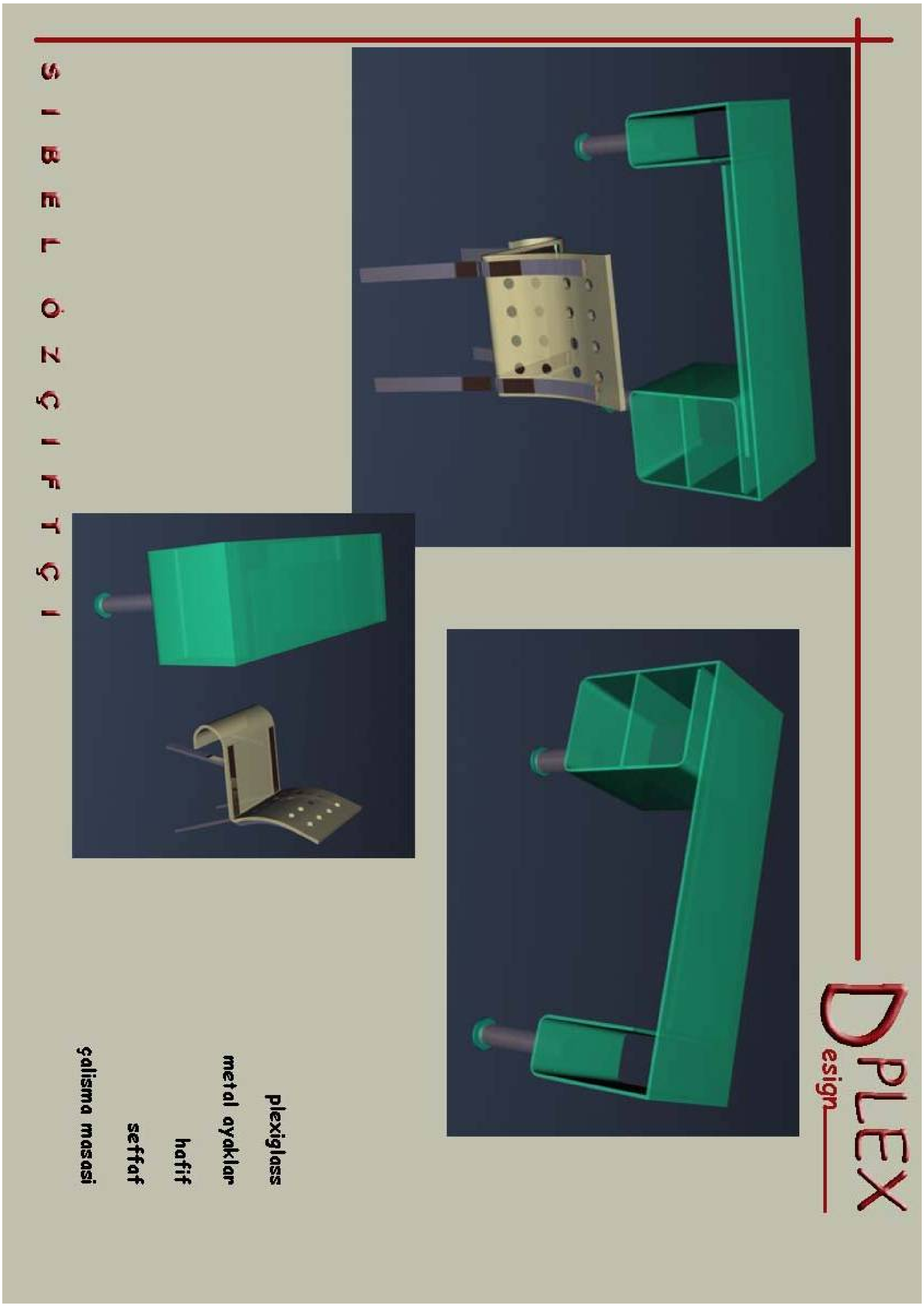


Figure 6.14. PMMA Furniture design – Office table
designed by Sibel Özçiftçi

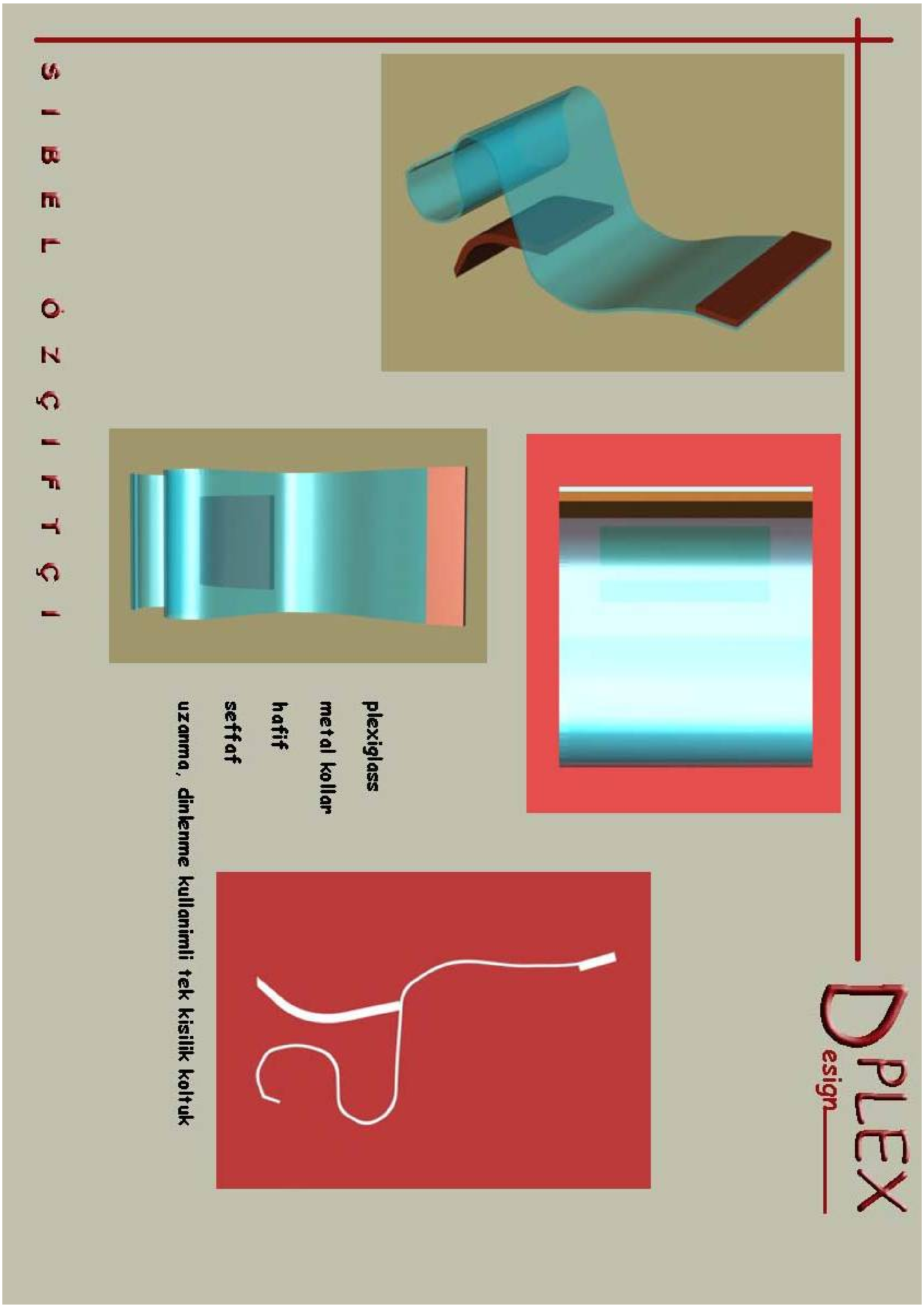


Figure 6.15. PMMA Furniture design – arm chair
designed by Sibel Özçiftçi

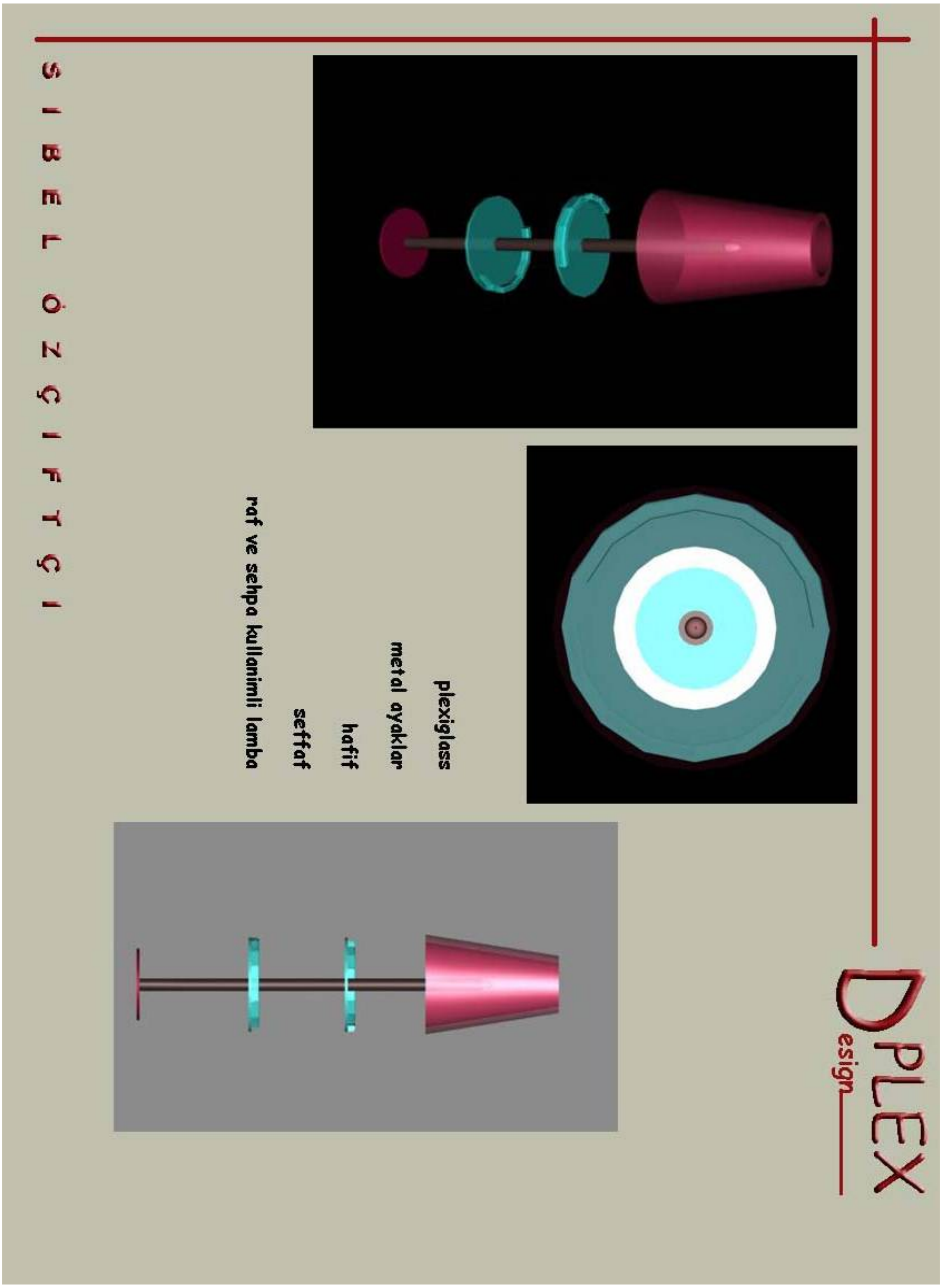


Figure 6.16. PMMA Furniture design – lamp
designed by Sibel Özçiftçi

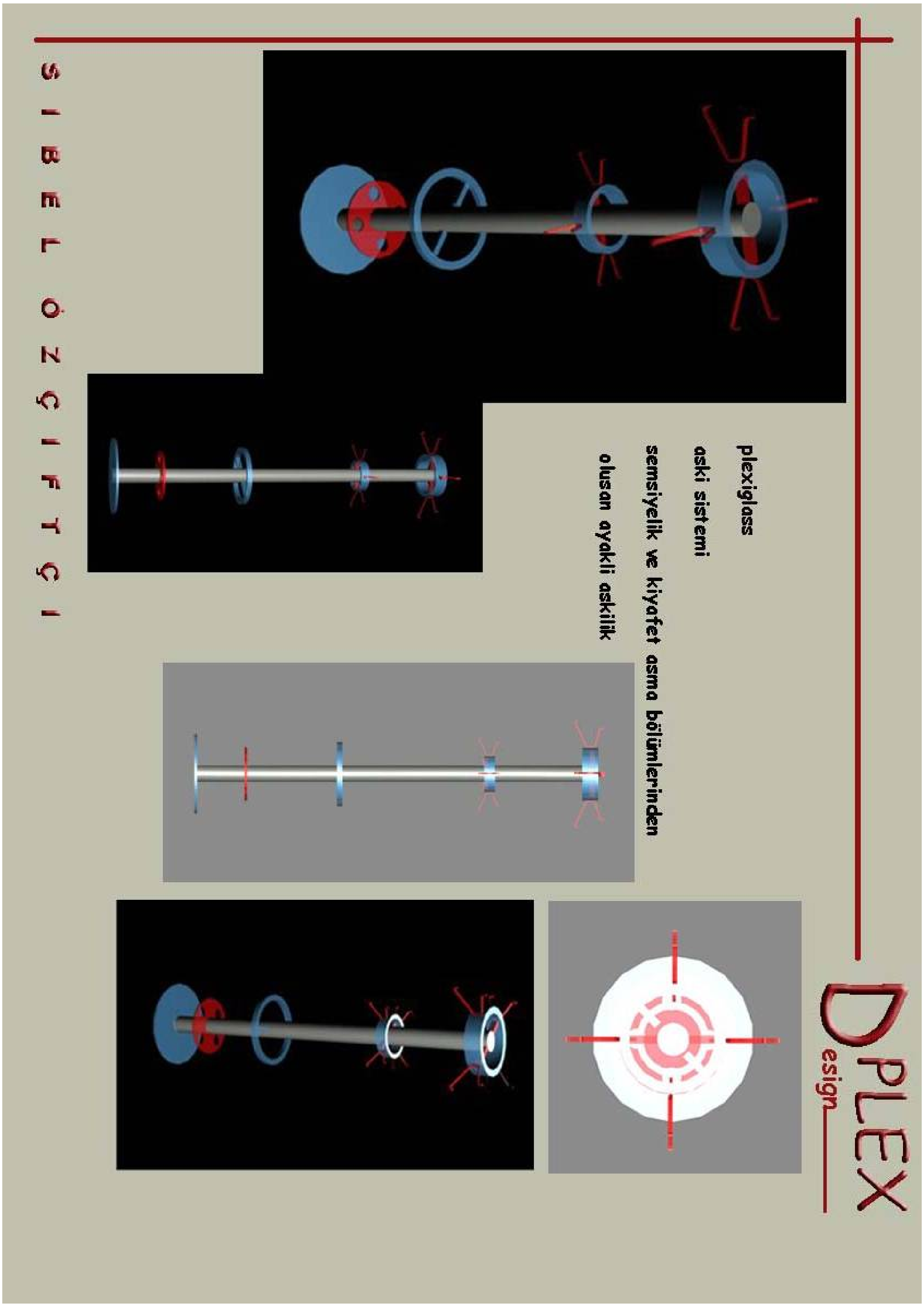


Figure 6.17. PMMA Furniture design –hanger
designed by Sibel Özçiftçi

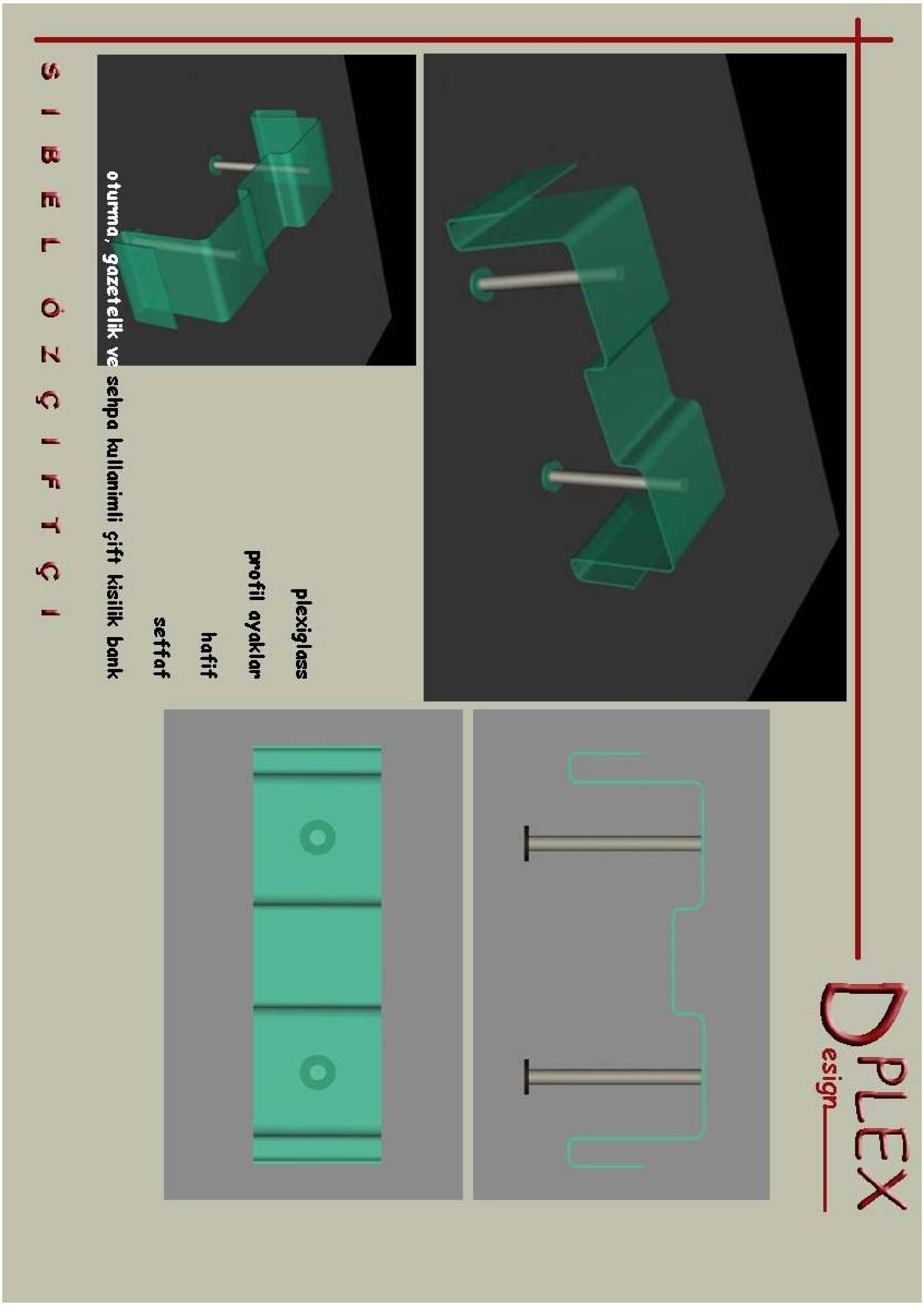


Figure 6.18. PMMA Furniture design – multifunctional bench designed by Sibel Özçiftçi

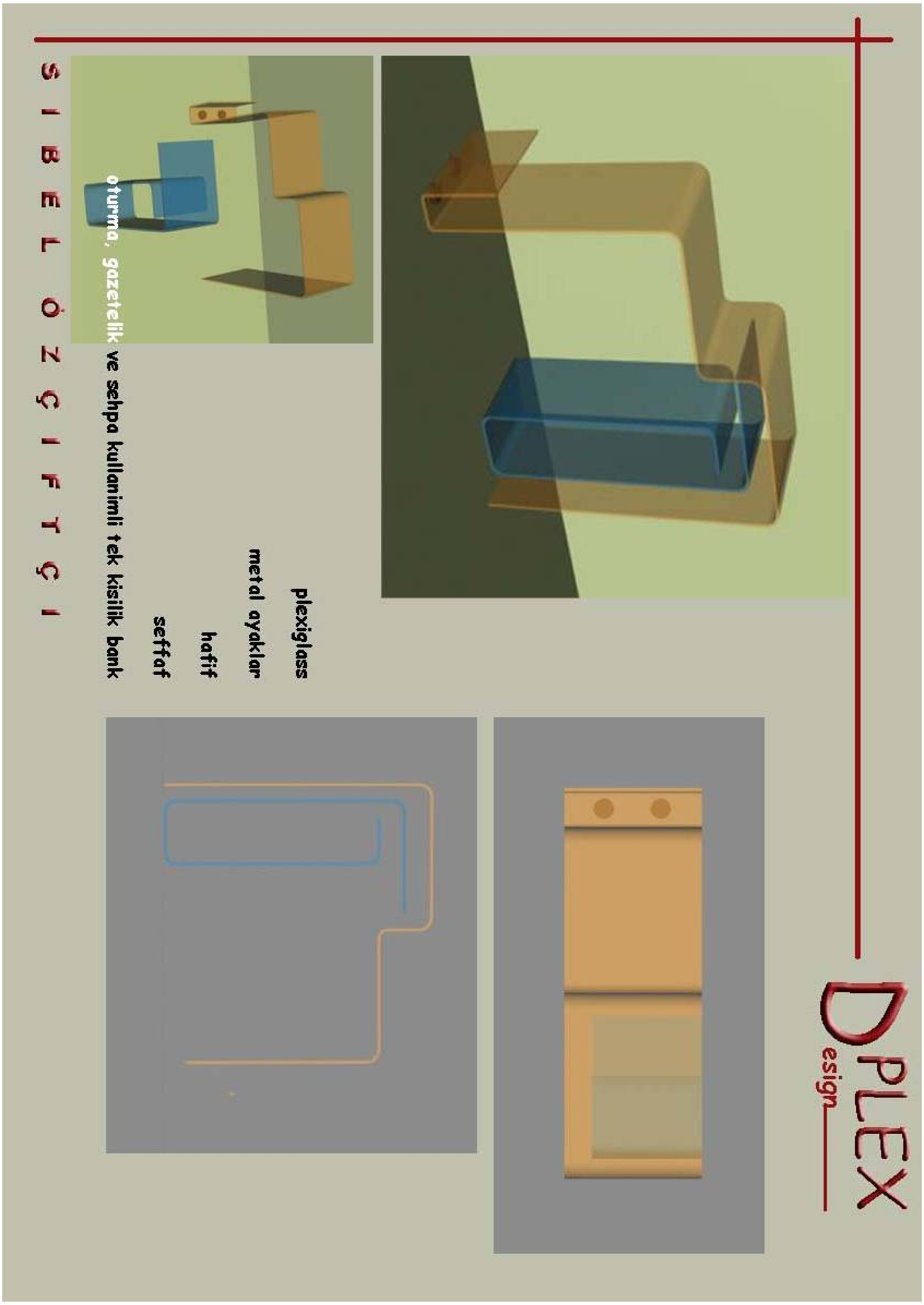


Figure 6.19. PMMA Furniture design – multifunctional bench designed by Sibel Özçiftçi

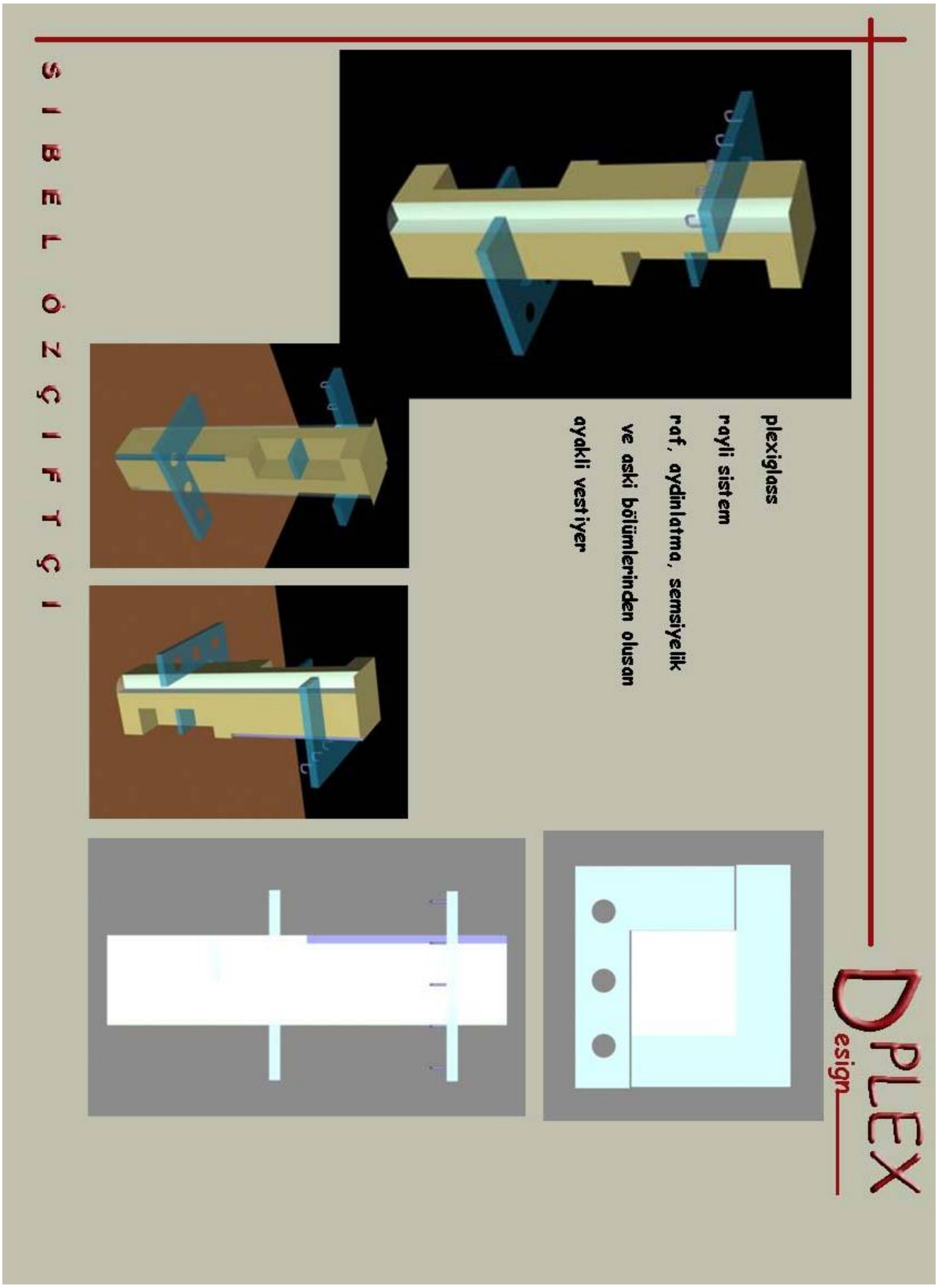


Figure 6.20. PMMA Furniture design – vestiary
designed by Sibel Özçiftçi

The PMMA panels strengthened and changed in appearance by metal wickerwork shall be used in different architectural areas as well as furniture design. It's especially liable to being developed on obtaining a material that could be an alternative to the glass usage in buildings. New methods and materials in building "covering" is served to the will of architects. One of them is "Double Skin".

In the system called "Double Skin" the outermost side of the building is covered with a shell which is made of two glass panel that presses air between them. The air that is pressed between causes heat, voice and air isolation and in this system can be used for natural air conditioning of high buildings. With additional solar cells, solar energy can be benefitted and the air that circulates in the air conditioning which is heated can also be used for energy production "(Web_28, 2006)".

Figure 6.21. Double Skin System
(source: Web_29, 2006)

The new panel that has been crafted can be used on many different designs. The natural specification of PMMA as being colored and transparent provides new created material to have miscalleneous types on creation and protection. Also easy processiblity and easy combinability with itself and other materials, easy piercableness and being lighter then same type of materials causes it to be prefered to other same type materials. At the same time PMMA to be more strengthfull then glass is another important qualification. With all these specifications PMMA gives desşgners freedom on their designs. Finally this material is used in "Double Skin" systems for being transparent and carrying, can be used as glass that we talked about before.

İn this study, transparent sheets, glass and PMMA which are used furniture production were studied. As a designer approach different examples and combine details are given. Combine details which are used furniture production were researched and PMMA panel's strength, variety and flexibility were suggested as an beneficial metarial

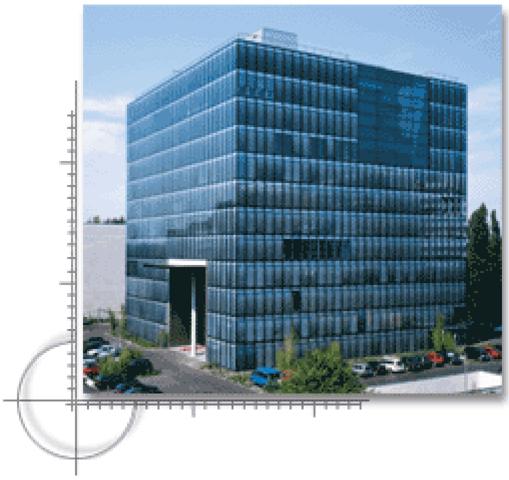


Figure 6.22. Cubus and Inn Side Residence-Hotel, Dusseldorf

(source: Web_30, 2006)

. Second suggestion in outer covering systems,using metarial which is ready to improve. İn outer covering system, its two dimensions are greater than its thickness, doing transporting and covering same time, it resists against to out forces with its tangent outer covering middle point with axis forces, odd or even curving volume transporting systyems are understood “(Türkçü 2003)”.

Figure 6.23. Paul Klee Centre, Renzo Pıano

(source: Web_31, 2006)

Metarials for outer covering systems must be homogenous and rigit.First important thing is reinforced concrete. Concrete is poured out in molds which you want and it resist to pressure. Attraction force occurs in some areas,concrete steel and steel rush mat are used in this areas. İn plastic metarials react like concrete for that reason to increase attraction force galvanization rush mat wire are used with PMMA. Compare to reinforced concrete Light permeability, lightness and easily transportation are advantages to PMMA.

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