A short history and applications of 3D Printing technologies in Turkey

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Abstract – After 1990, with the effect of government's new economic reforms, Turkish economy has greatly opened to global competition and this forced local manufacturers to do their own R&D work internally. In 1993 Arcelik, one of the Turkey's largest consumer products and white goods manufacturer installed Turkey's first 3D printer; 3D Systems' SLA 250. Within 10 years, Arcelik's RP Lab. become Turkey's largest and one of the largest labs in Europe.

After year 2000, more and more companies purchased their own 3D printers. After the adoption of 3D CAD software for jewelry design, large number of Solidscape wax printers are sold to jewelry industry for investment casting applications.

After 2003, medical applications started to grow rapidly and specialized companies were established for medical applications.

Although the progress is still slow, lately rapid manufacturing, tooling and direct metal fabrication application has also grown relatively faster than before...

Keywords –**3D printing, Turkey**

I. INTRODUCTION

Until the end of 1980's, Turkish companies from consumer products and automotive industry were mainly focused on mass production, assembling, marketing and sales. During these times most of the design, development work and tooling was outsourced from European and USA companies simply by licensing or importing related tooling and machinery.

After 1990, with the effect of government's new economic reforms, Turkish economy has greatly opened to global competition and this forced local manufacturers to do their own R&D work internally. This was the only way to become competitive globally. Rapid new product development and manufacturing requirements first forced companies start to use 2D and 3D CAD systems and CNC machines for tooling and machining. By the time, rapid prototyping requirements led companies to import and use 3D Printers.

In 1993 Arcelik, one of the Turkey's largest consumer products and white goods manufacturer installed Turkey's first 3D printer; 3D Systems' SLA 250. Within 10 years, with the support of Governments R&D funding, Arcelik installed larger SLA Systems and SLS systems (from DTM) and FDM systems from Stratasys. As a result Arcelik's RP lab become Turkey's largest and one of the largest in Europe.

Some of the other early adopters was ASELSAN (3D Systems SLA 5000, Stratasys FDM 1650) DOKTAS (Helisys LOM 2030H9, BASARI Elektronik (EOS STEREOS), Demirdokum (Stratasys FDM 1650).

Since the year 2.000, with the rapid growth of Turkish new product development applications and lower 3D printer system prices, more and more companies purchased their 3D own printers for in house design and development applications.

The table below shows the 3D printers used in Turkey and their distributors or reseller for Turkish market

Manufacturer/Brand	Representative / VAR
3D Systems	Cadem A.S., www.cadem.com.tr
Concept Laser	4C Ltd., www.4c.com.tr
Envisiontec / Perfactory	Piramit, www.piramtek.com
EOS GmbH	PROTEC, www.protec.com.tr
EOS GmbH (FORMIGA	3DDT Ltd. Turkey,
systems)	www.3ddt.com.tr
MCP-HEK / SLM	info(+)TRON A.S.,
	www.infotron.com.tr
Objet Geometries Ltd.	Plastosel, www.plastosel.com
Solido Ltd.	Yenasoft Ltd., www.yenasoft.com
SolidScape	4C Ltd., www.4c.com.tr
Stratasys	info(+)TRON A.S.,
	www.infotron.com.tr
Z Corp.	4C Ltd., www.4c.com.tr
	3DDT Ltd. Turkey,
	www.3ddt.com.tr

Based on the installed 3D Printer numbers, Turkish market mostly dominated by Solidscape, Stratasys, and Z Corp. systems. Currently, There are nearly 100 Stratasys FDM or Dimension machines installed and %20 of them used by Universities.

There are nearly 300 Solidscape systems and most of the used by Jewelry design and manufacturing companies.

There are about 30 Z Corp. 3D Printers and %30 of 3D Printers used by Universities. 10 of Z Corp. 3D Printers has color capability. These machines mostly used in

marketing, architectural, toys, footwear and GIS applications.

About 14 machines are installed from 3D Systems. 5 of them are used in Jewellery sector (1 SLA Viper, 3 Invision, 1 ProJet)

There are 22 3D printers from Objet. 3 of them are used in jewellery manufacturers.

There are about 5 EOSINT machines; 1 of them at Univ., 1 of them for jewellery manufacturer.

II. SERVICE BUREAUS

In Turkey, Some of the printer owner companies works also as a RP service bureau. There are little companies which is established solely as a RP service bureau. The below listed companies are leading ones that targets both local and European markets for various RP&M services.

RP Service Bureau	Offered 3D printing technologies
+90 www.plus90.com	Stratasys Vantage <i>se</i> + <i>SLA, SLS and</i> PolyJet
Defne Engineering www.defnee.com	Stratasys FDM
DesignEge www.designege.org	OBJET Eden 260
Troy Teknoloji Ltd. www.troyteknoloji.com	Z Corp. Zprinter Z310
Yuksel Model Ltd. www.yukselmodel.com	Z Corp. Spectrum Z510 System

These companies can also give 3D digitizing, reverse engineering and 3D CAD modeling, industrial design and engineering services.

Detailed list of service bureaus and most of the 3D Printer system users are given in reference [2]

III. EDUCATION and RESEARCH

Mostly with the support of Turkish Government or European Community Project funding, a lot of technical universities and some technical colleges brought and installed their own 3D printers. They are both used in education, research projects and RP&M services to industry.

Educational/research institution, City	Installed 3D Printer(s)
ABIGEM Teknopark, Kocaeli	OBJET Eden 260
Anadolu Univ., Eskisehir	Z Corp. Spectrum Z510
DesignEge, Izmir	OBJET Eden 260
Gaziantep Univ., Gaziantep	Z Corp. Z310

Istanbul Tech. Univ.	Objet Eden 500V Z Corp. Z310 Solidscape R66
IYTE, Izmir	3D Systems ThermoJet
Marmara Univ., Istanbul	Stratasys FDM 3000
Middle East Tech. Univ.,	2 x Stratasys Dimension
Ankara	EOS EOSINT P380
Sabanci Univ., Istanbul	Stratasys Dimension
Sakarya Univ., Sakarya	Z Corp. Z406
Sultanahmet End. Meslek Lisesi, Istanbul	Z Corp. Zprinter 310 Plus
TUBITAK Adana – USAM (Cukurova Univ.), Adana	Stratasys FDM Prodigy Plus
Yildiz Teknik Univ. Istanbul	3D Systems ThermoJet
Yeditepe Univ. ,Istanbul	Z Corp. Z310

Table: 3D printers installed at Turkish educational and research institutions $% \left({{\left[{{{\rm{T}}_{\rm{T}}} \right]}} \right)$

In Turkey, little basic research is done about 3D printing technologies, materials and software. However more work is done about 3D printing applications in Industry. Such as Ref [6]

For example, a PC controlled FDM type 3D printer is constructed at Gaziantep Univ. for educational purposes [5];



PC controlled 3D Printer (FDM)



The below project is made at Gebze Institute of Technology as an Government funded research project. [7]



Laser assisted direct metal part fabrication system (LADMPF) [7]



Samples fabricated via LADMPF experimental unit. [7]

At Middle East Technical Univ. Ankara, various research have been done on porous structures fabricated via SLS technology. [8], [9]



Ttrapped powder in 1 mm pores in a test part [8]

At Gazi Univ. Ankara, with the support of ASELSAN, a military electronics design and manufacturing company, some research have been done on copper coated stereolithographic EDM electrodes. [10]



Copper coated stereolithographic electrode before testing. [10]

IV. JEWELLERY APPLICATIONS

Turkey has Europe's one of the largest Jewelry design and manufacturing Industry. The first Solidscape systems are sold in 1998 for jewelry companies. Although it took a lot of effort and time (6 years) to adopt them jewelry 3D CAD software (mainly JewelCAD), after that many companies purchased their 3D Printers. Today, there are nearly 300 Solidscape systems are installed at jewelry manufacturers.

Although installed numbers are very low compared to Solidscape systems, other 3D Printer systems are also used by Turkish Jewelry companies such as, 3D Systems Viper, ThermoJet, Envisiontec / Perfactory and Meiko LC 510

Two of the Jewelry manufacturers GOLDAS and Favori leads Turkish Jewelry Industry with largest number of installed 3D Printers;

Company	Installed 3D Printers
Favori, Istanbul www.favori.com.tr	1 x Meiko LC 510
	3 x Solidscape ModelMaker II
	3 x Solidscape/ PatternMaster
	2 x Solidscape/ T66
	1 x 3D Systems ProJet
GOLDAS, Istanbul www.goldas.com www.molddsign.com	3D Systems SLA Viper
	3D Systems ThermoJet
	Solidscape/ PatternMaster
	EOS EOSINT M 250 Xtended

Below photos are belongs to GOLDAS and model made via their own 3D Systems Viper [4];



V. MEDICAL APPLICATIONS

In 2003, the first medical craniofacial implant design and manufacturing and surgery made with the cooperation of Cadem A.S. and Opr. Dr. Sacit Karademir from American Hospital [3]. Materialise MIMICS is used to handle CT data.



Sensable Freeform Haptic interfaced 3D modeling system was used to design the implant and 3D Systems' ThermoJet 3D Printer was used to manufacture wax models. After titanium investment casting, the implant successfully placed by Dr. Karademir.





Medical applications growing relatively fast in Turkey. Within last 2-3 years some companies are established especially for medical and dental applications of 3D printing technologies. They are listed in the below table;

Service bureaus for medical applications	3D printers
4C Medikal www.4cmedikal.com.tr	Z Corp.
Hofmann Turk	Concept Laser GmbH
www.hofmannturk.com	M1 Cusing
Ay Tasarim/Medical	Envisiontec
http://med.aytasarim.com	PERFACTORY
MedCAM www.medikalmodel.com	3D Systems SLA 250
ProMedART	3D Printers are
www.ProMedART.com	outsourced
Yuksel Model Ltd. www.yukselmodel.com	Z Corp. Spectrum Z510 System

Medical applications of 3D Printing and CAD/CAM technologies are advanced rapidly in Turkey within last 5-10 years. Currently -in many ways- they can easily compete with similar European or US companies. Some examples are given below;



Oral and Maxillofacial Surgery example by 4C Medikal and GATA [11]



Dental bridges via LaserCUSING from in house developed CoCr powder material, Hofmann Turk

stentCad[®] Klasik stentCad[®] Ötede



stentCad custom dental implant drilling guide from Ay Tasarim



Anatomic models for Orthognatic surgery by MedCAM





3D CT data, custom manufactured implant and photos before and after surgery – ProMedART [12]



CRANIAL IMPLANT PRO-MEL ProMedART uses Freeform haptic 3D modeling system for custom implant design

VI. ARCITECTURAL APLICATIONS

Mostly Zcorp 3D Printers are used for architectural modeling in Turkey. Below are some examples;



These models made by Yuksel Model, (www.yukselmodel.com)

The below models are desgined and manufactured by Erkan Kapucu (www.erkankapucu.com)





Finished model



Bank building model



Models via (Z-Corp) 3D printing by Erkan Kapucu

VII. DIRECT METAL FABRICATION

The first metal fabricator in Turkey was installed by Arcelik for rapid tooling applications. (DTM Sinterstation 2500). This system required post sintering and infiltration to get final tooling and it was not very usefull/practical for the company. Later this machine has left for glass filled PA sintering. Currently there are very few number 3D Printers in Turkey of direct metal sintering;

Company	Installed 3D Printers
e prototip	EOS EOSINT M270
www.e-prototip.com	
GOLDAS	
www.goldas.com	EOS EOSINT M 250 Xtended
www.molddsign.com	
Hofmann Turk	Concept Laser GmbH
www.hofmannturk.com	M1 Cusing

Hofmann Turk has opened its offices in at the end of 2008 and currently has the most advanced direct metal sintering capabilities in Turkey

VIII. FUTURE PROSPECTS

It is expected that 3D Printers and its applications will grow as Turkish industry grows and becomes globally more competitive.

Although TurkCADCAM yahoo e-mail group (<u>http://groups.yahoo.com/group/TurkCADCAM</u>) which has more than 5.000 members from Turkish CAD/CAM sector covers 3D Printer and RP&M related discussions and postings since its establishment in 2001 still there is no physical organization among the 3D Printer Users in Turkey.

It should be expected that in the near future a specific Rapid Prototyping or similar Association would be established (e.g. Turkish Rapid Prototyping and Manufacturing Association, TRPMA) and afterwards this association will be one of the members of GARPA (Global Alliance of Rapid Prototyping Associations).

It is hoped that this Workshop (RapidTech US-Turkey Workshop on Rapid Technologies 2009) and similar international events on Rapid prototyping and Manufacturing applications via 3D printers will be continued in the following years and this will speed up the process of establishing TRPMA.

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