

Faculty of Engineering

Introduction to Computer Aided Manufacturing

MECH 433

FALL 2014

Term Project:

Chess Set



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Executive Summary:

M.E. Chess is a unique start-up company that offers an exclusive self-customized chess set that is inspired from Mechanical Engineering tools. It provides chess lovers from different ages the opportunity to have a chess that is designed by them. The company has been founded by a group of Female Mechanical Engineering students in UAE University. M.E. Chess will be profitable by the end of the third year.

M.E. chess is at the start offering a black and transparent chess set that is inspired from Mechanical Engineering tools. It is made from high quality plastic by the hands of Engineers to ensure you the quality that you cannot find anywhere else. The customer will have the opportunity to change the color or add his/her own touch to add uniqueness to the set.

M.E. Chess has identified three keys to success. Number one is developing creative and unique chess set. The second key is to introduce a high quality chess set. The last key to success is the good listen to customer for product improvement.

M.E. Chess has acknowledged three customer groups that it will go after. The first group is children who are willing to become an engineer to improve their mental skills and in the same time know more about Engineering tools. The second market segment is chess player who like to collect unique chess set or like to have their self-customized chess set. The third group is special needs people who needs certain language to be printed on the pieces (Braille language).

The possibility of success of M.E. Chess is ensured by its obligated management team, directed by 4 Mechanical Engineering Students from the best University in the country (UAEU). In addition to the help from Specialized Doctors in the field of Manufacturing. These experiences, in addition to the high standard education will help the company to gain market penetration based on the quality of the product.

Business Description:

M.E. Chess is a company created by Mechanical Engineering Students to manufacture special chess set inspired from Mechanical Engineering tools e.g. nuts, screw, etc. The set is made of high quality plastic with black and transparent colors. What makes our set special is its unique idea and because it offers the customers the opportunity to customize his/her own chess set and add his/her own touch. Our company offers the customers the chance to choose the materials from our list, the colors, and the size and even choose a specific shape or add a text. This is done by just contacting our representative to explain your ideas. Adopting this technique (single item manufacturing technique) will help us to adapt to markets change. Our mission is to offer a high quality, on time and error free chess set. The more children that engage to chess and engineering in general, the more successful we are. Our customers are chess lovers from different ages starting from children who love chess to chess-masters who want to own unique sets. In addition to special need people.

Location:

The company will be located in UAE because all of the team members are located there. In addition, the UAE has one of the most open and dynamic economies in the world and other advantages which include:

- No restrictions on profit transfer or repatriation of capital
- No corporate or income taxes
- A currency, the Dirham, that is stable, secure and pegged to the US dollar
- Very low, or non-existent, import duties
- Competitive labor costs

Main Objectives:

The company objectives are:

- To be a top chess set supplier in the regional market.
- To develop innovative, unique and high quality chess set.
- To keep the company in full production capacity until the company become profitable
- To attract the attention of more design professionals to work in the company.
- To become a part of improving UAE in the manufacturing field

Management team:

M.E. Chess has committed management team with good knowledge in engineering and industry, good manufacturing experience and superior administrative abilities. The team includes a president, vice president, financial officer, marketing officer, directors of operation, designers and representative.

Key advantages:

The most important keys advantages for M.E. Chess are:

- Unique and high quality chess set manufactured by Engineers.
- Communication with the customers to listen to their requirements, modifications and complains.
- Reliable team with good knowledge, experience and managing skills.

Strategic Positioning:

Our company has a bright future because amateur chess always search for unique pieces of their own. We will provide the customers to choose the style and colure of the chess with high quality and acceptable price. Also in the future we will employ creative people to stay in the head of our competitors and we will open many Branches around the world to be on global level.

Vision of the future:

Our vision is to be the first and the best company worldwide and especially in UAE and the Middle East for manufacturing chess sets. With the goal of implementing Sheikh Mohammed Bin Rashid UAE Vice President, Prime Minister and Ruler of Dubai goal who insists to be always in the 'first place'.

Funds Required:

We will only apply to Khalifa fund which provides financial support to local and unique projects. They have different funding program, as well as the loan amount, depends on the type of the project such as:

- Micro: supports small projects to create new source of incomes. Its maximum loan is 100,000 AED
- Zaarie: to support Emirati farmers with maximum limit of 1 Million AED
- AlHasela: to support Emirati fisherman who have fishing license. The loan of this program is up to 250,000 AED
- Tasneea: We will apply for this program because it encourages manufacturing ideas that supports the economy of Abu Dhabi. The loan can be up to a maximum limit of 10 Million. The maximum grace period is 36 months and maximum repayment period is 60 months with interest rate of approximately 5%¹.

Therefore, we will ask for a loan of 9.5 Million AED and 60 months (5 years) for repayment.

Development:

Location Determination:

In UAE, we chose Al- Ain city. This location was chosen because renting in Al- Ain is less expensive comparing to other cities like Abu Dhabi and Dubai. In addition to that our material supplier is located in Al- Ain so it will be easy to get the material needed without any delay. If any help is needed from our qualified University Doctors, we can contact them easily. Also, starting business in Al-Ain will support the establishment of a sustainable manufacturing industry in the Emirate with a vision to become a global benchmark in manufacturing field.

¹ Khalifa Fund, (2014), retrieved on 10 January 2015 from <http://www.khalifafund.ae/SitePages/Home.aspx>

Development process

The process of developing the business will be advised by asking Dr. Basel Al Sayyed, assistant professor in UAEU, or Eng. Rajesh, expert in CNC machines working in UAEU labs, in the main points that we need to consider about manufacturing using CNC machines. While in the business field we will ask for advices from Dr. Osama, professor in UAEU, or Eng. Jwan, instructor of Engineering Economy course, about the main point we need to consider for opening any business.

Project plan:

It has been communicated with different institutions in order to confirm some information about starting a business. For instance, it has been communicated with the Higher Corporation for Specialized Economic Zones in Abu Dhabi in order to rent an available land with 5000 m² area in Al Sanaiya in Al Ain. Also we got some information about the license from the same institution. For building the company, it has been communicated with Bin Maktoom company for constructions to get an estimation of the cost of such area.

Development team:

The team will cooperate in such business should have different characteristics. First they all should be aware about how much they are responsible of their job, specially the ones who will work on the machines. Also they should have experience on the field they work in, have unique administrative skills. Our team consists of 8 members. The main four members will be our group (M.T.N.A) who made this project since they took CAM course in UAEU, therefore they have the knowledge of using the main components in making the business which are DMG and Cincinnati machines. We will be divided as follows:

- **President:**

She is the one who hold the whole company and make the final decision about any idea or concern related to the business expertise in the Internet and development of strategic business. She will make general superposition of the sections in the company and managing the business in the right way. The safety of the workers and their insurances is also her task.

- **Director of Operations:**

She holds the whole production and manufacturing process since she is expert in using DMG and Cincinnati machines. She is the only one who will work in the Cincinnati machine while she has two operators will assist her in using DMG machines. She can also work as a vice president if needed.

- **Chief Financial Officer:**

She is expert in the financial and information technology business. She also serves as a staff accountant and computer programmer with other firms. Marketing and advertisement is also one of her task.

- **Director of Product development:**

She is expert in using CATIA software to design the part since she took a course for learning this program. She makes sure to satisfy the customers by making different designs of the products.

The other four members are the labors working in different jobs:

- **Two Operators:**

They have minimum work experience of 5 years in how to use DMG machines. Each one of them have salary of 2000 AED.

- **Painter:**

He is expert in painting the chessmen without trace of any defects. His salary is 1000 AED

- **Driver:**

- He will distribute the products to the costumers and bookshops by a Pickup car. His salary is 1000 AED.

Sales estimates

Analysis Current Product Mix:

Our company provides one main product, which is a complete customized chess set. The set will be sold with the price of 100AED. The choice of getting separate pieces is provided, in case the customer misplaced or broke a piece, with each piece by the price of 15AED.

Making a five year financial plan, and assuming that 45000 sets would be sold in the first year, profit will start in the third year.

Marketing Goals and Strategies:

- *Marketing goals*

Our marketing goal is to reach to a wide range of customers, and provide them with the best. We hope to get profit by the second or third year into the business.

- *Marketing strategies*

To guarantee our spot in the market, we need to bring something new and focus on our uniqueness when marketing our product. We provide something that isn't currently available in the region, which is providing people with a unique, one of a kind and high quality chess set. The exclusivity for the customer comes from the ability of choosing any colour for the set and writing whatever they please. This is what would be focused on when advertising the product.

Competitive research:

In our research online, we found many suppliers of chess sets in the UAE, but no manufacturers in the country, which is an advantage for us.

But some of the best chess manufacturing companies around



the world are Rechapados Ferrer, Italfama, Jaques of London and Manopoulos.²

Looking at the strengths and weaknesses of one of these companies, we'll focus on the company Manopoulos. Started in 1970 by Constantinos Manopoulos, this company manufactures sets out of wood



Figure 1 Chess set by Manopoulos

² Top chess manufacturing companies, Chesswala: <http://www.chesswala.com/top-chess-manufacturing-companies/>

and metal, inspired by sculptures of Greek history and mythology.³

Strengths: This company has been in the market from a long time and already has a reputation to be one of the best chess manufacturers. Also, the design of the chess sets is unique and luxurious.

Weakness: Though the designs are nice, they are limited and don't give a lot of choice for the customer in terms of color and customization. Looking at competitors inspires us to work harder and be better, by copying their strong points and avoiding their weak points.

Pricing Policy:

The price for the product is chosen so that it satisfies the customer and be worthy to the hard work and long hours that is put into it. On different shopping websites (like eBay and amazon), the market was checked to decide on a number at first, 100AED, which is reasonable compared to what can be found in the market. With the help of Excel, the five year financial plan was made, and assuming that 45000 pieces will be sold in the first year with that price, profit will be made in the third year, which is acceptable. Then with a survey, people were asked if they would pay that much for a customized chess set, and 70% of them thought it was a fair price for what they'll get. So, the chess set was decided to be sold at the price of 100AED.

Advertising and Promotion:

In our project we will depend on the social-media because it is the most popular way these days. As a start we will announce about our product in Instagram , Twitter, You-Tube, BBM and WhatsApp. Also we will make some shows about our product for the first customers, for example, less price , extra free Chess and will provide the costumers with brochures and our business card.

³ Manopoulos, retrieved on Jan 2014 from <http://www.manopoulos.com/>

Operations (CAPP and Production Planning)

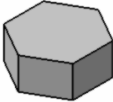
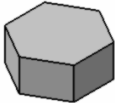
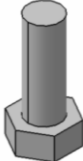
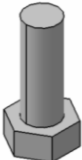
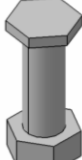
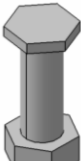

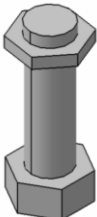
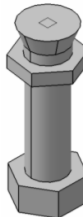
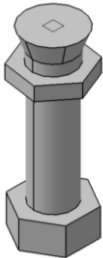
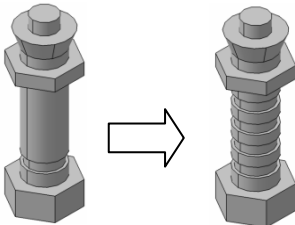
Our product contains 32 pieces and plastic plate. The material used (plastic rod) will be provided from the Technical-parts-shop in Al Sanaiya and each product will consume rod of 2 meters long and 30 mm diameter and plastic plate of 30*30mm.

To make the production planning easier, we start to make our pieces on CATIA software, to create a CAD-model to help us to put the dimensions in the DMG machine. This section will contain the following for each part:


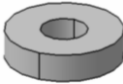


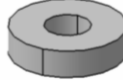



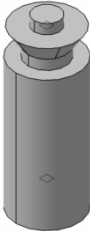

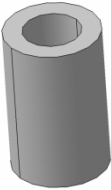


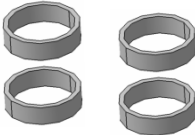

- Geometric features and sequences of each part
- Machining features and sequences of each part
- CAD model for each part
- Simple description about DMG program of each part
- Working on the final look of the product

1- King

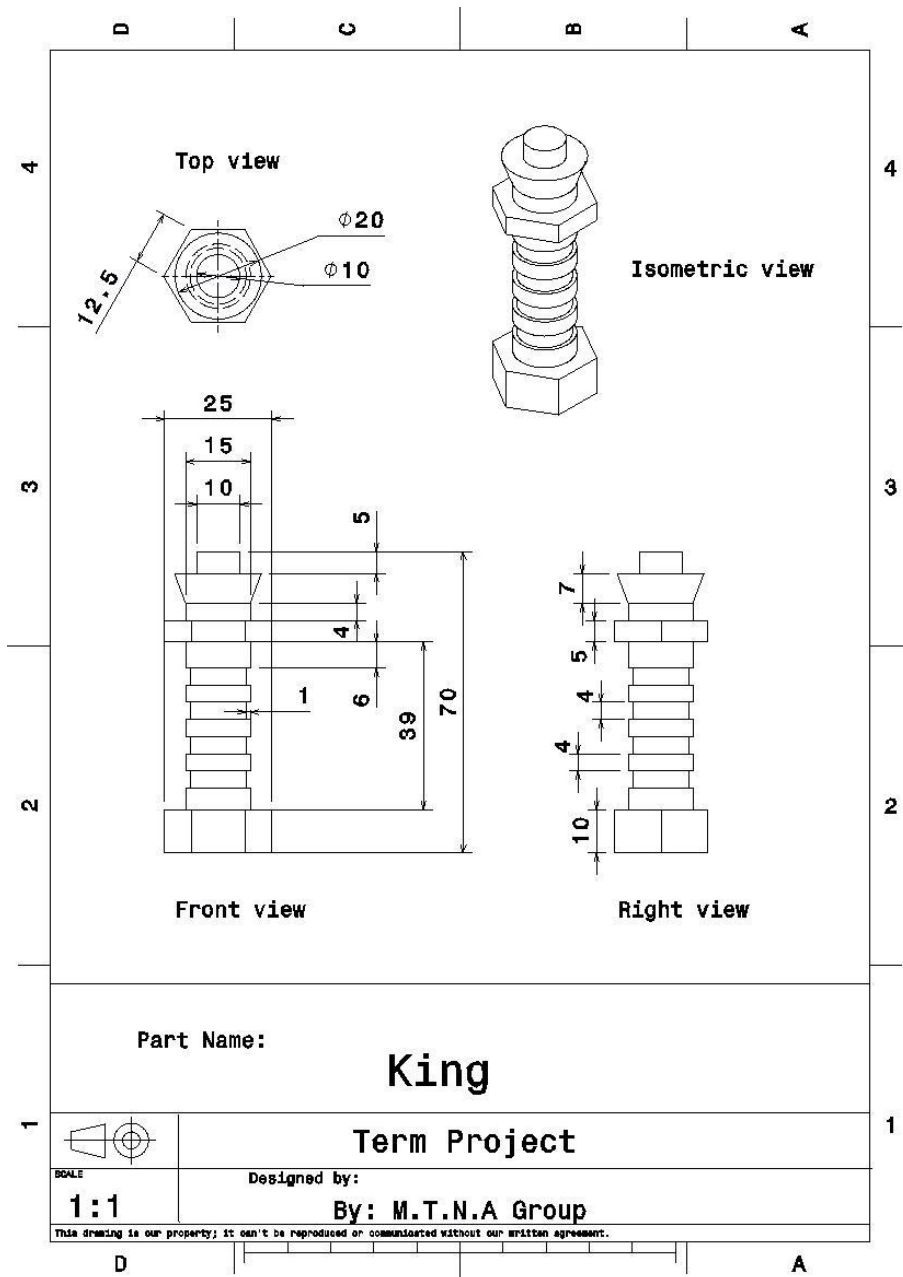
a- Geometric features and sequences of the King

Seq#	Before	Geometric Feature	After
1		<ul style="list-style-type: none"> - Hexagonal of diameter 25 mm - Pad to height of 10 mm 	
2		<ul style="list-style-type: none"> - circle of diameter 15 mm - Pad to height of 39 mm 	
3		<ul style="list-style-type: none"> - Another hexagonal of diameter 25 mm. - Pad to 5 mm 	
4		<ul style="list-style-type: none"> - Circle of diameter 15 mm - Pad to 4 mm 	
5		<ul style="list-style-type: none"> - Taper shape (lower circle has D=15 mm, upper circle has D= 20 mm) - Multi-section solid command 	
6		<ul style="list-style-type: none"> - A ring of inner diameter= 13 mm and outer diameter= 15 mm - Pocket to height of 4 mm - Pattern of 4 instances with 4 mm spacing directed upward. 	

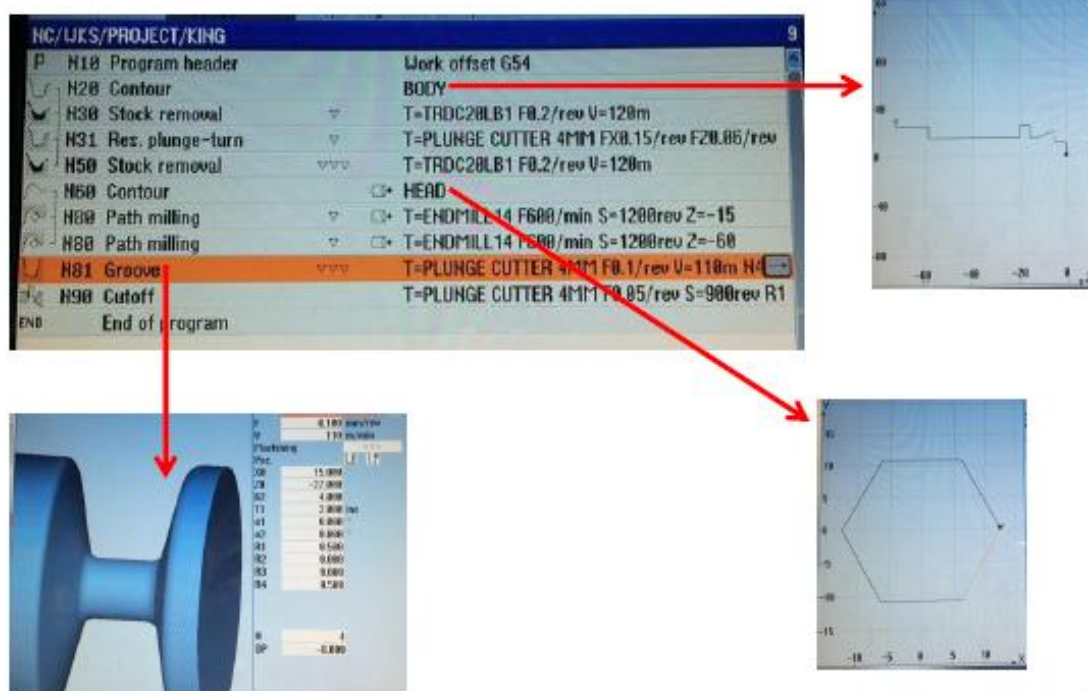
B. Machining features and sequences of the King

Seq#	Before	Machining Feature	After	Operation
1				Turning
2				Turning
3				Turning
4				Turning
5				Turning

C. CAD Model of the King



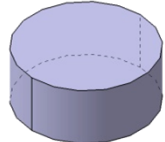
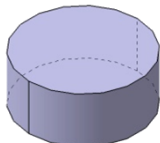
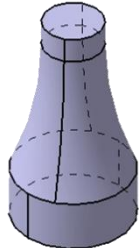
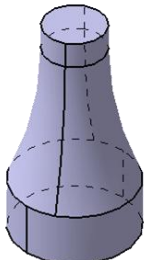
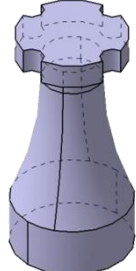
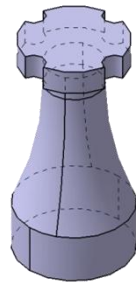
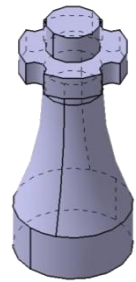
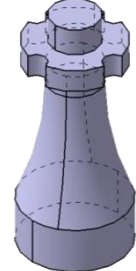
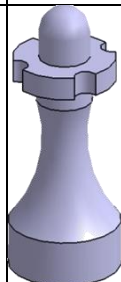
D. Simple description about DMG program of the King







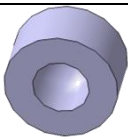


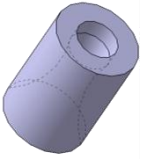


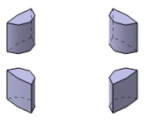
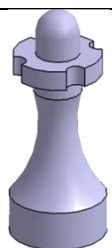
This part has been manufactured by the DMG machine. To create it we start to draw the body contour as shown in the above picture. Then we draw the hexagonal base contour and use the groove option all of that depend on the dimensions listed on the CAD-model of the king. The manufacturing of the king in the DMG machine took 11:52 minutes and that was the longest part among all other parts .

2- Queen

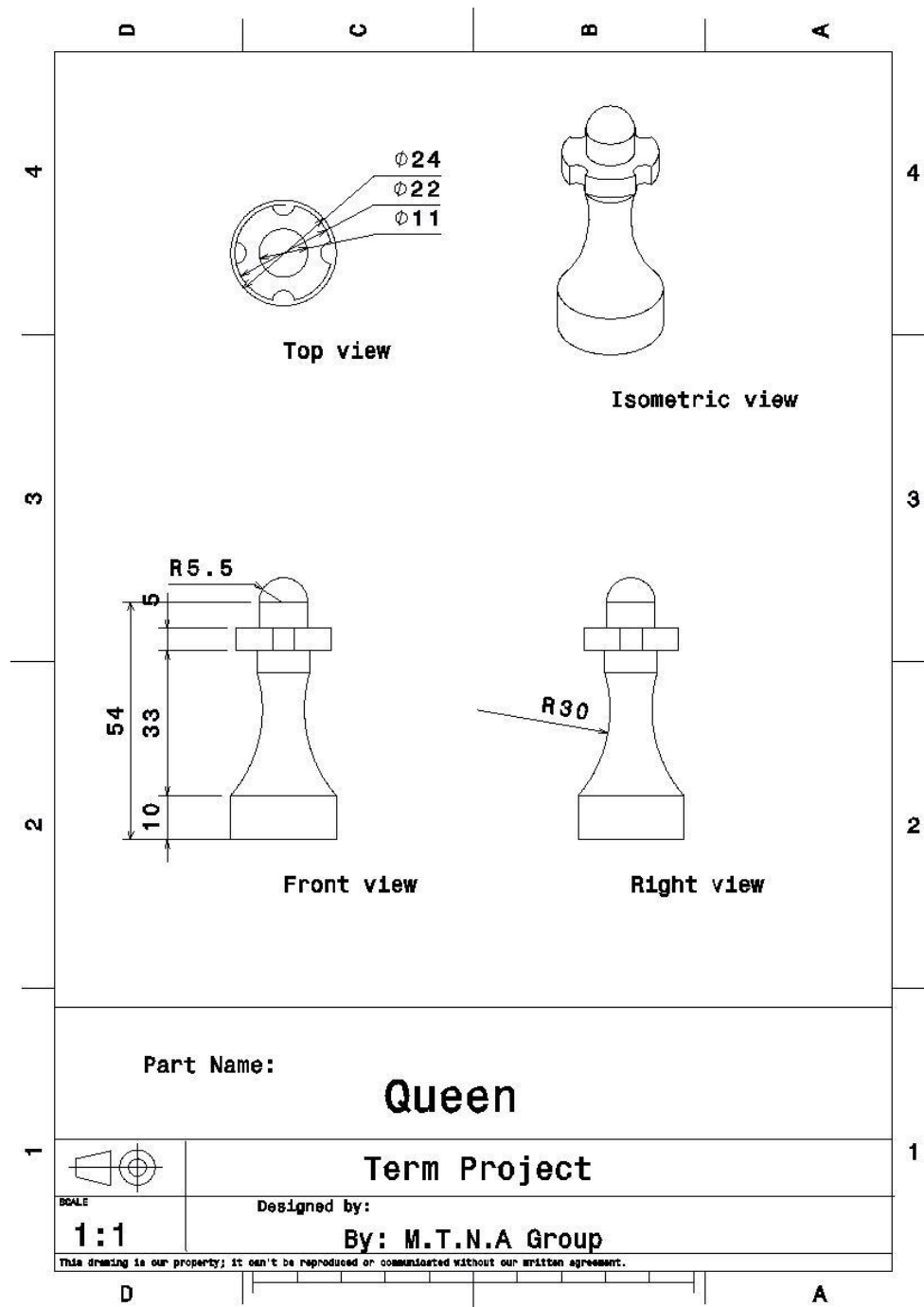
A. Geometric features and sequences of the Queen

#	Before	Geometric Feature	After
1		Pad a 24mm diameter cylinder with height of 10mm.	
2		Pad a radially tapered cylinder with diameters of 24mm and 12mm, tapered with radius of 30mm.	
3		Pad a 22mm diameter cylinder with height of 5mm, with 4 cutouts of 5mm diameter cylinders.	
4		Pad an 11mm diameter cylinder with height of 6mm.	
5		Pad half a sphere with diameter of 11mm.	

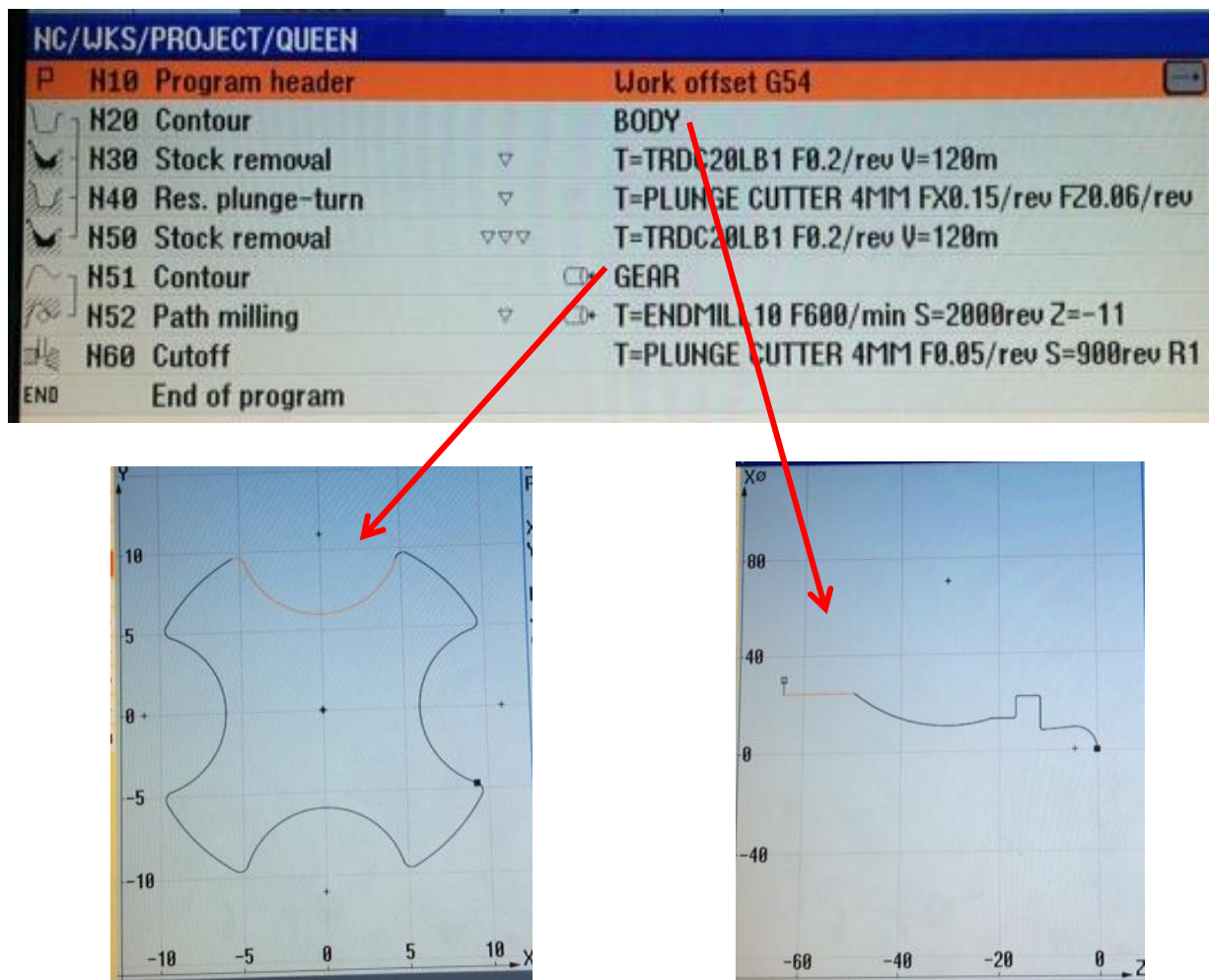
B. Machining features and sequences of the King

#	Before	Machining Feature	After	Operation
1		 holed cylinder with inner diameter= 22mm and height= 24 mm		Turning
2		 Cylinder with outer diameter 22mm and height of 11.5mm, inside, half a sphere of radius 5.5mm on top of a 5.5mm in radius, 6mm in height cylinder.		Turning
3		 Cylinder with outer diameter 24mm, with a radially tapered cylinder in the insider, with diameters 24mm and 12mm, tapered with radius of 30mm.		Grooving
4		 Four quarters of cylinders with diameter of 5mm and height of 5mm.		Face milling

C. CAD Model of the Queen



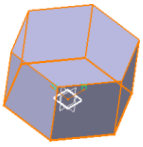
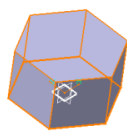
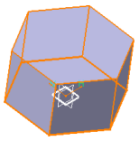

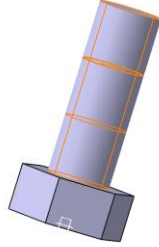
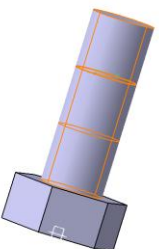
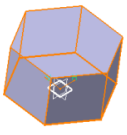
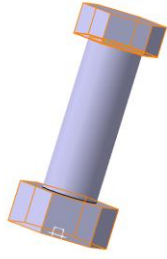
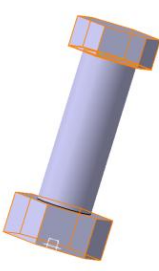

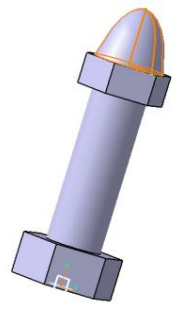
D. Simple description about DMG program of the Queen




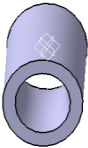


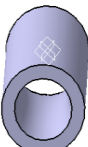
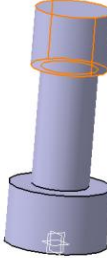
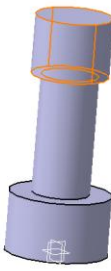
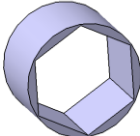
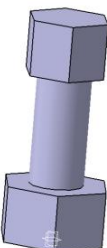
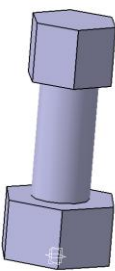

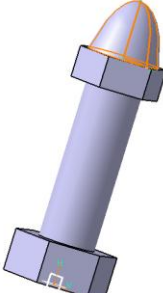
This part has been manufactured by the DMG machine. We started to draw the body contour as shown in the above picture. Then we draw the gear head contour all of that depend on the dimensions listed on the CAD-model of the Queen. The manufacturing of the Queen on the DMG machine consumed 6:13 minutes and that was the shorter time between all pieces.

3- Bishop

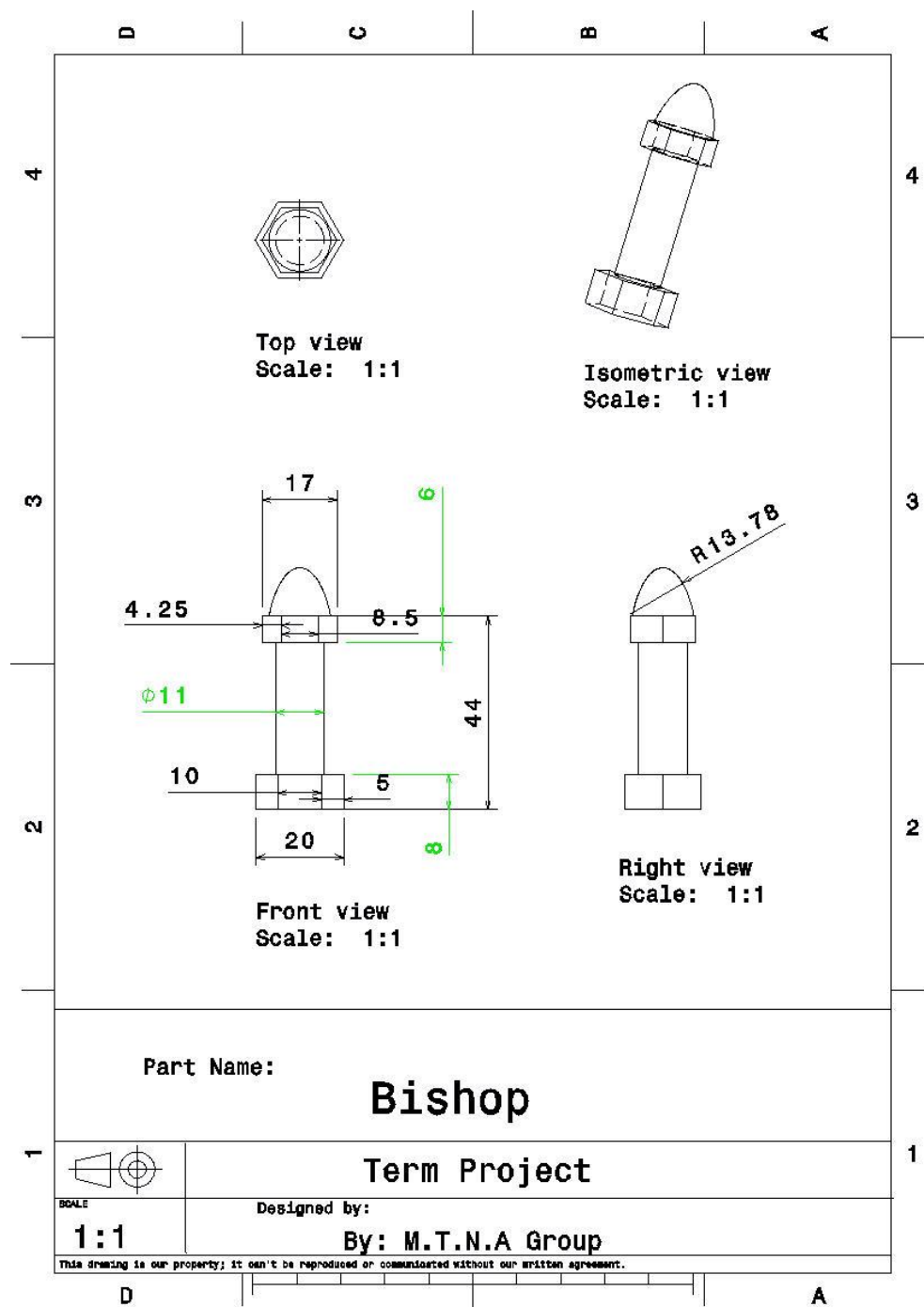
A. Geometric features and sequences of the Bishop

Before	Geometric feature	After
1. Scratch	 <p>Draw a hexagon (5*10) mm and pad it to height of 8 mm</p>	
 <p>2.</p>	 <p>Draw a circle (Diameter 11 mm) and pad it to height 30 mm (shaft)</p>	
 <p>3.</p>	 <p>Draw a hexagon (6.5*4.25) mm and pad it to height of 6 mm</p>	
 <p>4.</p>	 <p>Draw quarter ellipse (minor diameter 17 mm, major diameter 20 mm) and use shaft (180) to have half an ellipse</p>	

B. Machining features and sequences of the Bishop

Before	Machining feature	After	Operation
1. 	 From the blank (Diameter = 20 mm, remove a ring (height 39 mm) to reduce the diameter to 17 mm to have an open slot		Turning
2. 	 Remove a ring to reduce the diameter to 11 mm from the middle to have a groove		Turning
3. 	 Remove a ring that has hexagonal shape from inside from the top and bottom side to have chamfered edges		Path milling
4. 	 Remove a hexagonal that has a half ellipse from inside		Turning

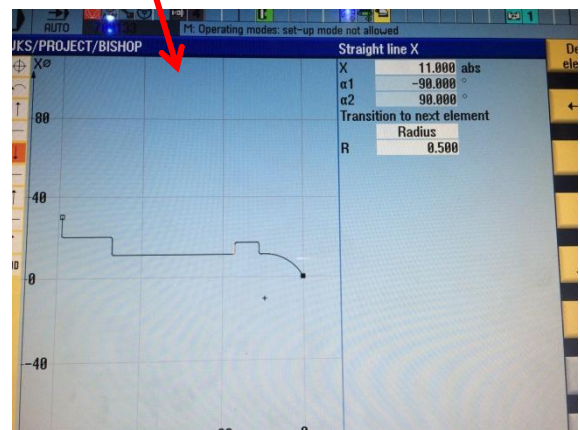
C. CAD Model of the Bishop



D. Simple description about DMG program of the Bishop

NC/LKS/PROJECT/BISHOP		
P	N10	Program header
	N20	Contour
	N30	Stock removal
	N31	Res. plunge-turn
	N32	Stock removal
	N70	Contour
	N80	Path milling
	N90	Contour
	N100	Path milling
	N21	Cutoff
END		End of program

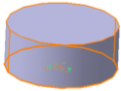
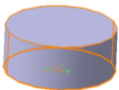
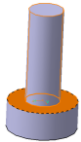
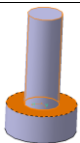
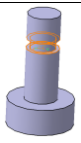
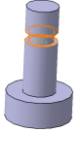
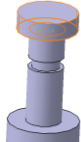
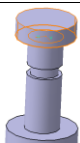
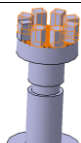
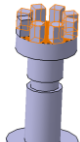
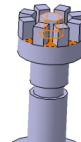
Work offset G54
BODY
T=CNMG20LB5 F0.2/rev V=120m
T=PLUNGE CUTTER 4MM F0.15/rev F20.06/rev
T=TRDC20LB1 F0.2/rev V=120m
TOP
T=ENDMILL14 F600/min S=2000rev Z=-11
BASE
T=ENDMILL14 F600/min S=2000rev Z=-47
T=PLUNGE CUTTER 4MM F0.05/rev S=900rev




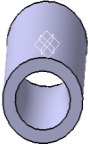


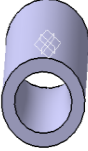
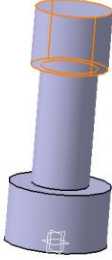
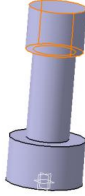

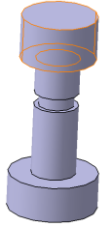
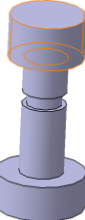

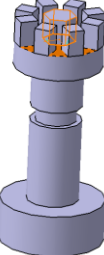
This part has been manufactured by the DMG machine. To create it we start to draw the body contour as shown in the above picture. Then we draw the hexagonal base contour all of that depend on the dimensions listed on the CAD-model of the Bishop. The manufacturing of the Bishop on the DMG machine consumed 8.04minutes.

4- Brook

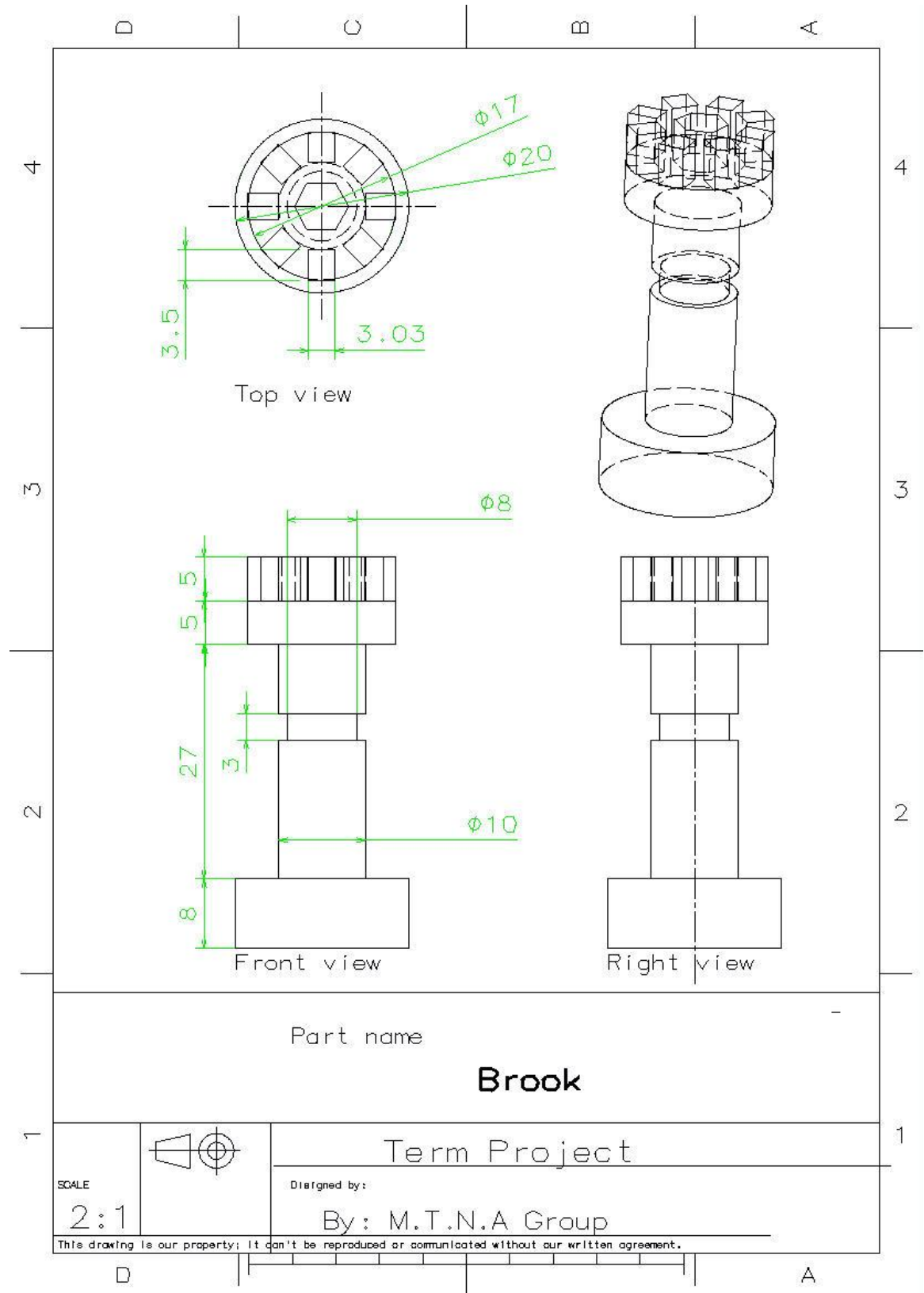
A. Geometric features and sequences of the Brook

Before	Geometric Features	After
1- Scratch	<ul style="list-style-type: none"> - Pad a 20 mm cylinder with height of 8mm 	
2- 	<ul style="list-style-type: none"> - Circle with diameter = 10 mm - Pad to height=27 mm 	
3- 	<ul style="list-style-type: none"> - Groove of 1mm depth 	
4- 	<ul style="list-style-type: none"> - Circle with diameter = 17mm - Pad to height=5 mm 	
5- 	<ul style="list-style-type: none"> - 5mm Pad of 3.03*3.5mm rectangle Then circular pattern 	
6- 	<ul style="list-style-type: none"> - Draw a hexagon and pad it to height of 5 mm 	

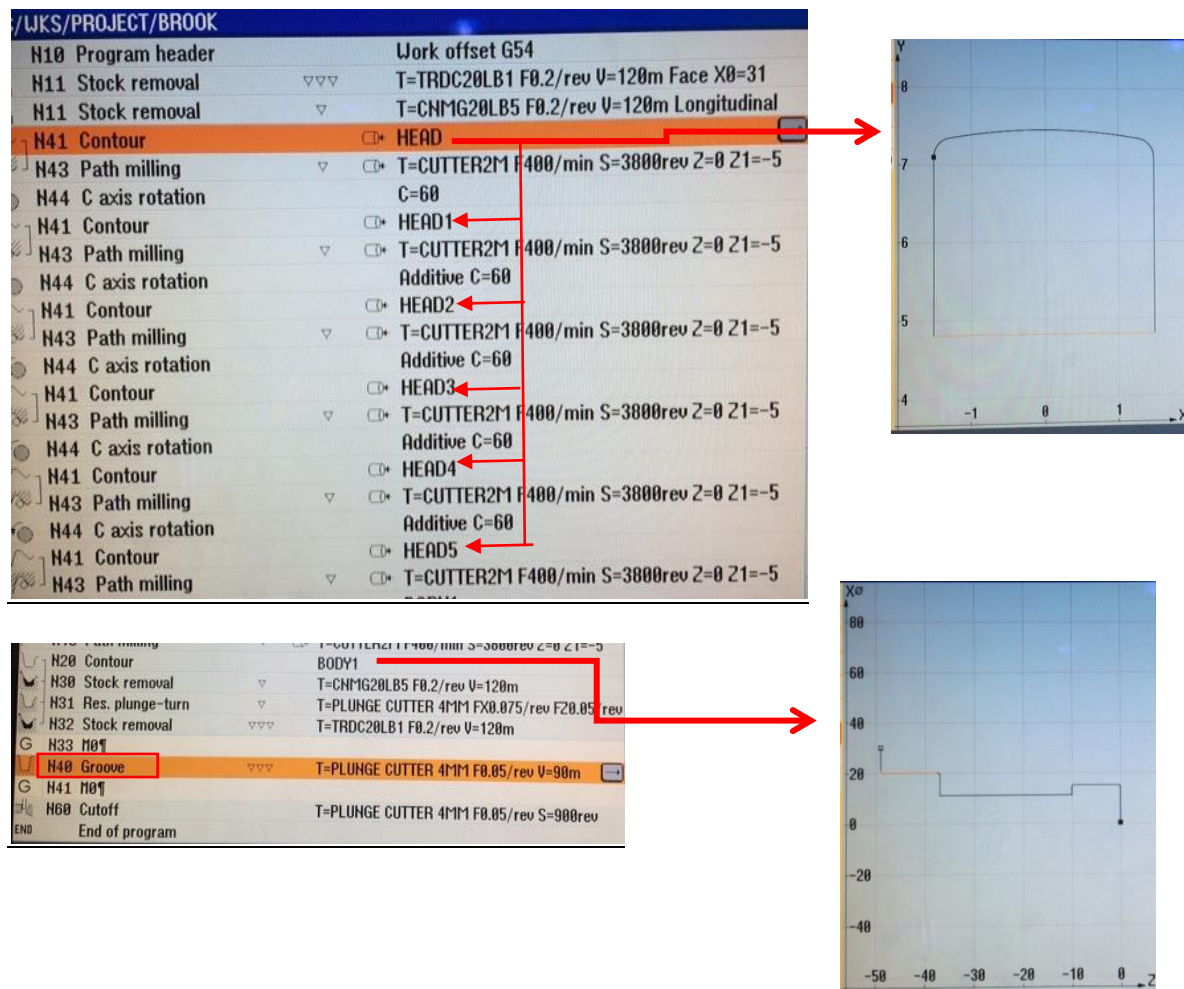
B. Machining features and sequences of the Brook

Before	Machining feature	After	Operation
5. 	 From the blank (Diameter = 20 mm, remove a ring (height 37 mm) to reduce the diameter to 17 mm to have an open slot		Turning
6. 	 Remove a ring to reduce the diameter to 10 mm from the middle to have a groove		Turning
7. 	 Remove a ring from inside from the middle		Turning
8. 	 Remove 6 of this shape from the head		Path milling

C. CAD Model of the Brook



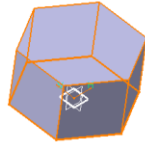
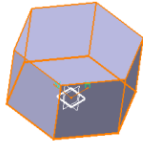
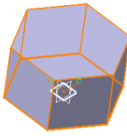
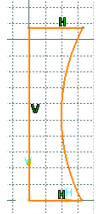

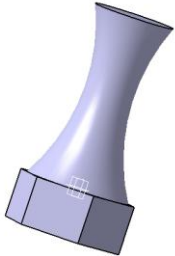
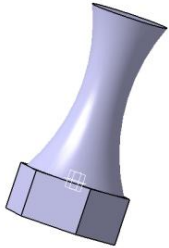
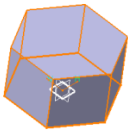
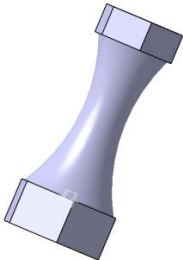
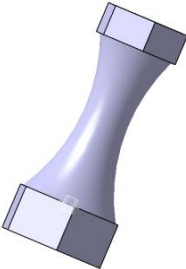
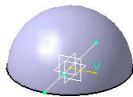
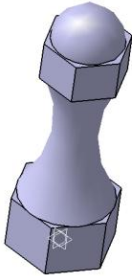
D. Simple description about DMG program of Brook







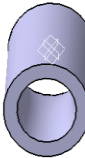
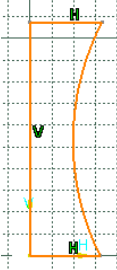


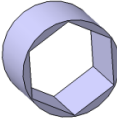
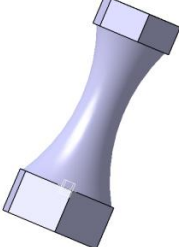
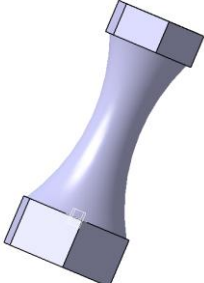
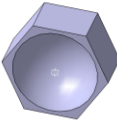

This part has been manufactured by the DMG machine. To create it we start to draw 6 rectangles contours to be removed from the head –as you can see from the first picture-. Then we draw the body contour as in the second picture. Finally, by using the groove option, the middle groove has been created, all of that depend on the dimensions listed on the CAD-model of the Brook. The manufacturing of the Brook on the DMG machine consumed about 7:20minutes.

5- Pawn:

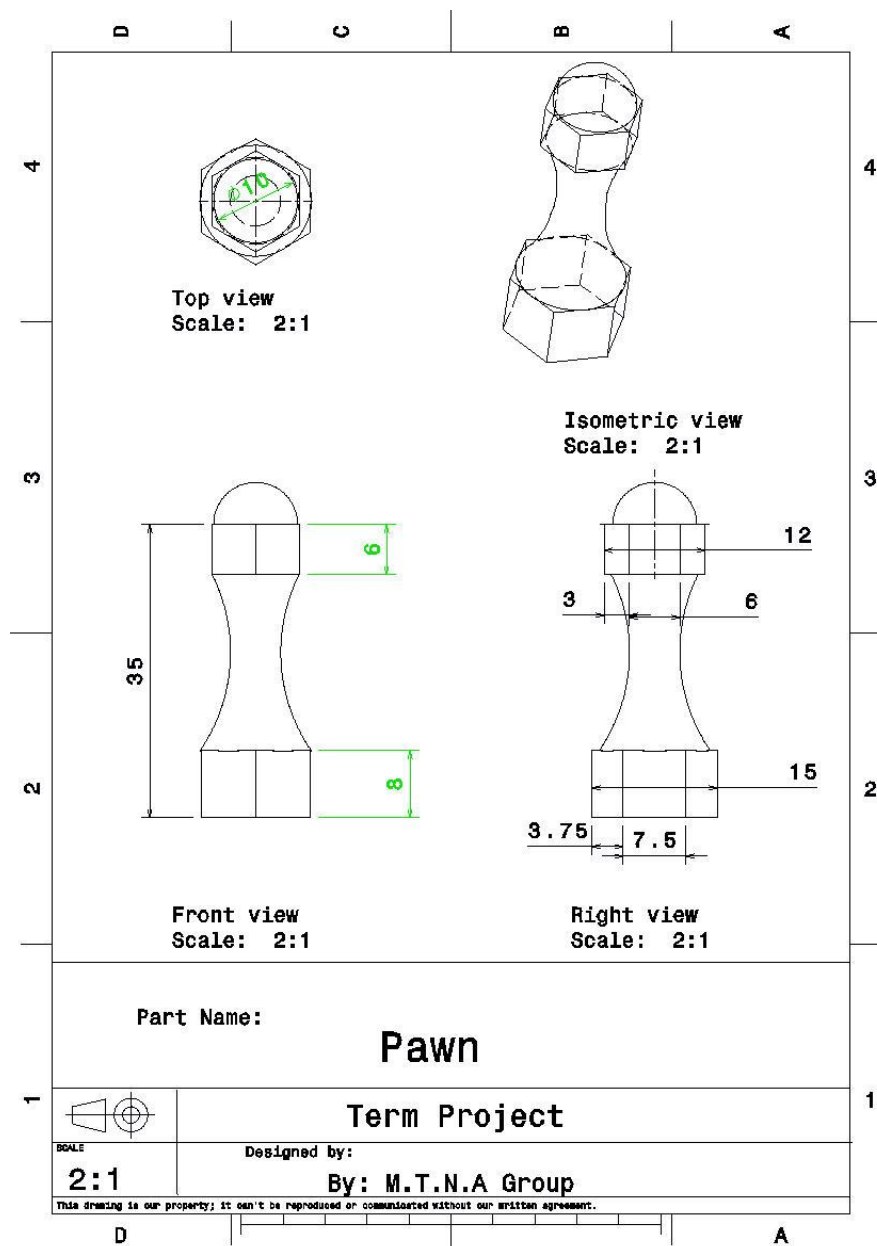
A. Geometric features and sequences of the Pawn

Before	Geometric feature	After
1. Scratch	 <p>Draw a hexagon (7.5*3.75) mm and pad it to height of 8 mm</p>	
2. 	<p>Draw this shape (Base= 7.5 mm, Top = 6 mm, Height = 21 mm). Use shaft to have a slot with specific curve</p>  	
3. 	 <p>Draw a hexagon (6*3) mm and pad it to height of 6 mm</p>	
4. 	<p>Draw quarter a circle (Diameter = 10 mm) and use shaft (180) to have half a sphere (Curve)</p> 	

B. Machining features and sequences of the Pawn

Before	Machining feature	After	Operation
1. 	 <p>From the blank (Diameter = 15 mm), remove a ring from the upper side with inner diameter = 12 mm and outer diameter = 15 mm</p>		Turning
2. 	 <p>Remove a cylinder that has this shape</p>  <p>from inside</p>		Turning (Plunging)
3. 	 <p>Remove a cylinder that has hexagon shape (same dimension mentioned before) from inside from the top and bottom side</p>		Path milling
4. 	 <p>Remove a hexagon that has a half sphere from inside from the top side (Diameter = 10 mm)</p>		Turning

C. CAD Model of the Pawn



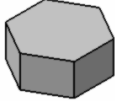
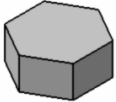
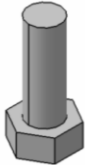
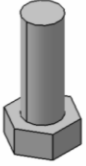

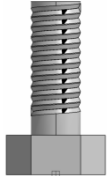
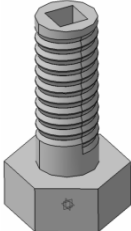
D. Simple description about DMG program of the Pawn

This part has been manufactured by the DMG machine. To create it we start - as the Bishop- to draw the body contour. Then we draw the hexagonal base contour, all of that depend on the dimensions listed on the CAD-model of the Pawn. The manufacturing of the Pawn on the DMG machine consumed about 6:24minutes.



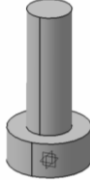
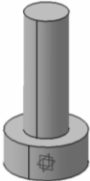
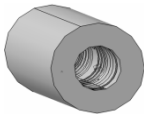
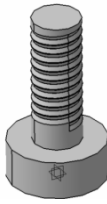
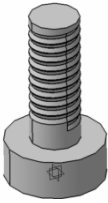
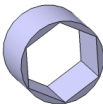
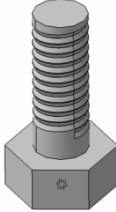
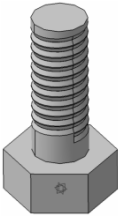
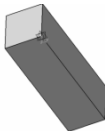
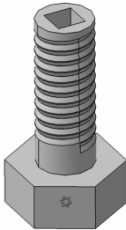
6- Knight

Knight-Body

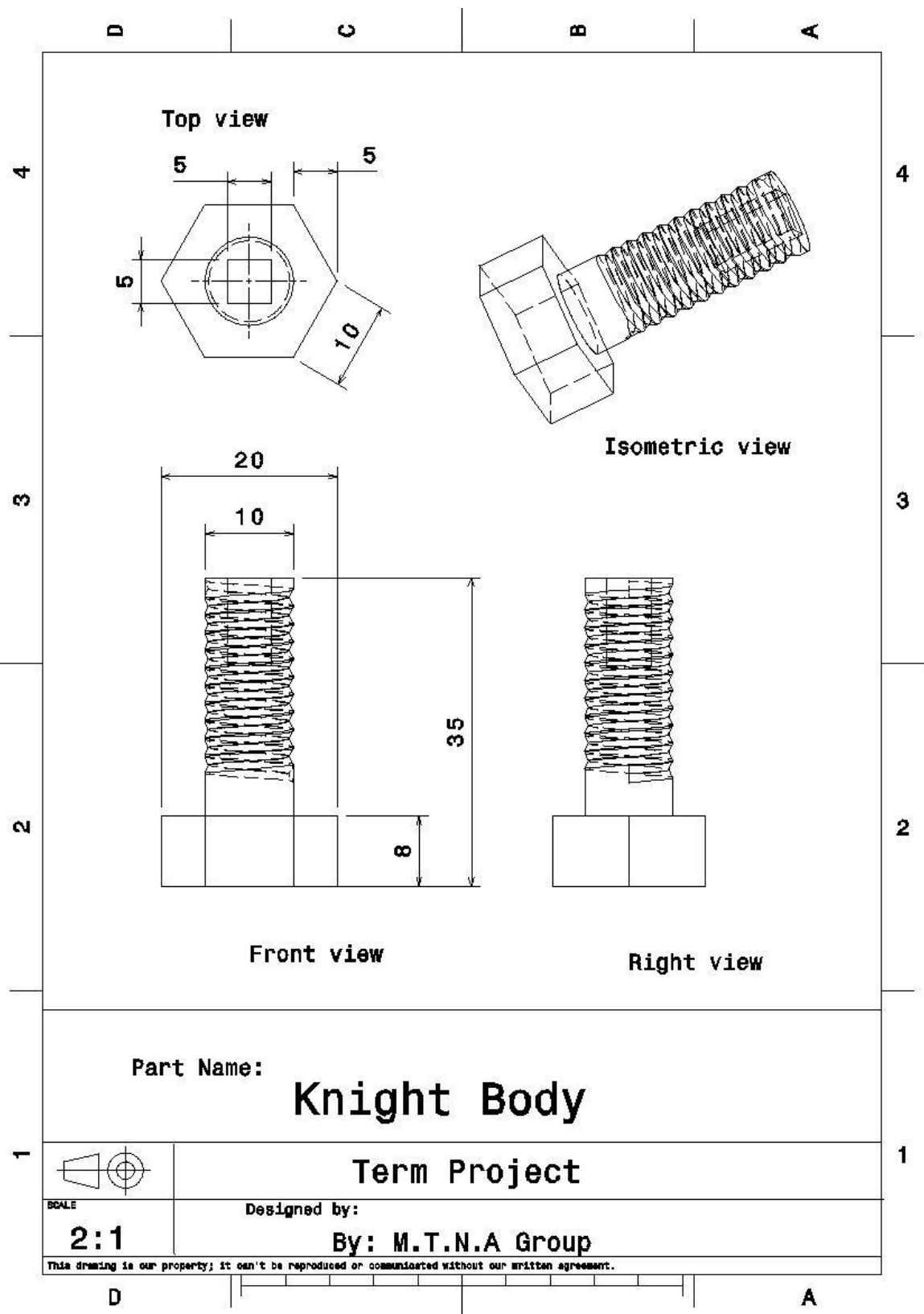
A. Geometric features and sequences of the Kight-Body

#Seq	Before	Geometric Features	After
1	Scratch	<ul style="list-style-type: none"> - Hexagonal with diameter = 20 mm - Pad to height = 8mm 	
2		<ul style="list-style-type: none"> - Circle with diameter = 10 mm - Pad to height=27 mm 	
3		<ul style="list-style-type: none"> - Helix with pitch of 2 mm and height = 21 mm - slot 	
4		<ul style="list-style-type: none"> - square with length of 5 mm - Pocket to 10 mm depth 	

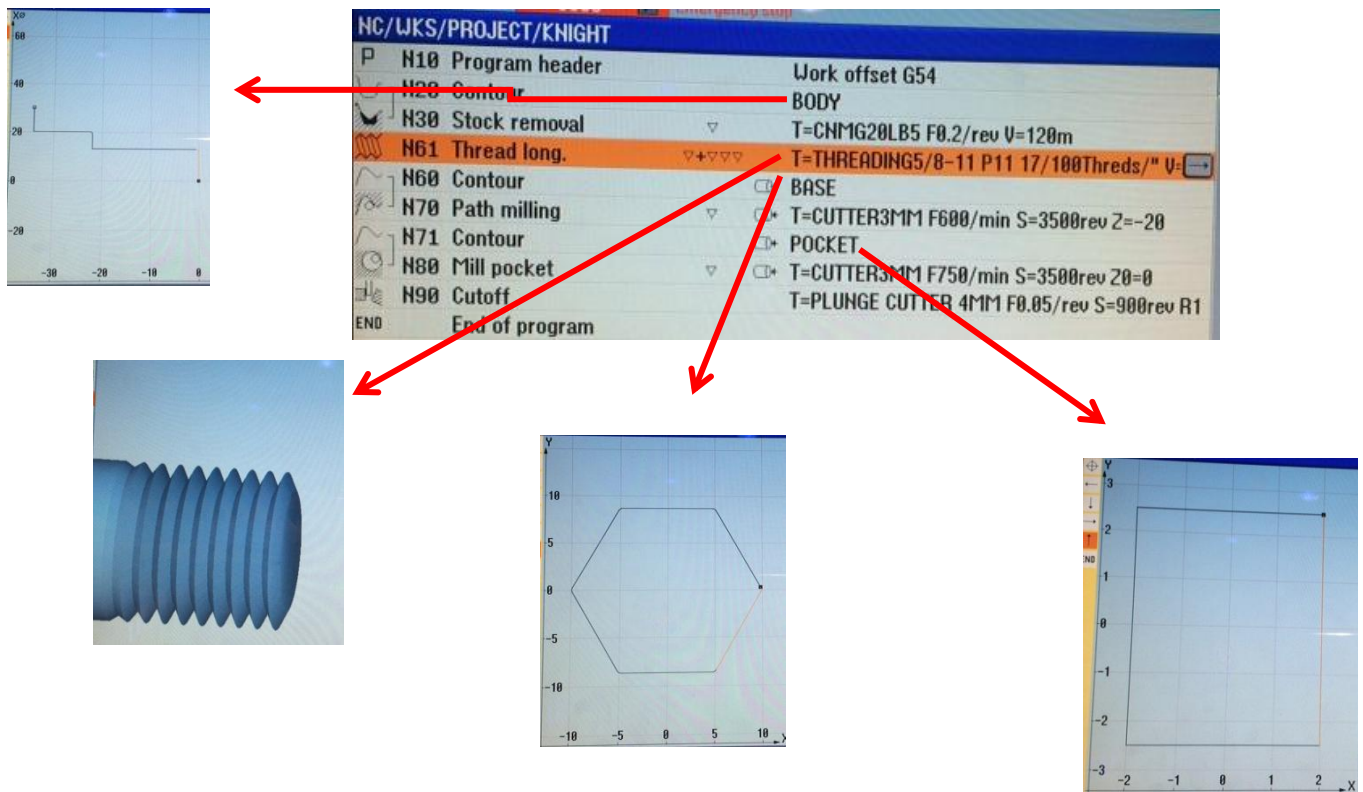
B. Machining features and sequences of the Knight Body

#seq	Before	Machining Feature	After	Operation
1				Turning
2				Turing
3				Milling
4				Milling

C. CAD Model of the Knight Body



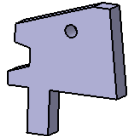
D. Simple description about DMG program of the Knight-Body



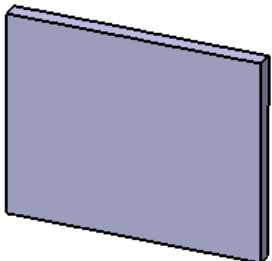
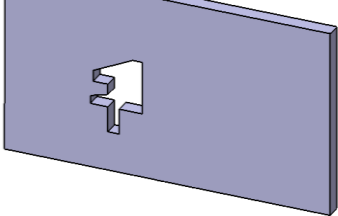
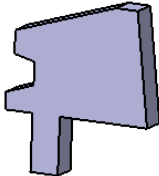
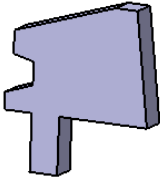

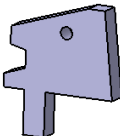
This part has been manufactured by the DMG machine. To create it we start to draw the body contour –as you can see from the above picture-. Then by using the thread option, 8 threads has been created. After that we draw the hexagonal base contour ,all of that depend on the dimensions listed on the CAD-model of the Knight-Body. The manufacturing of the Knight body on the DMG machine consumed about 6:29 minutes approximately the same time of the Pawn.

Knight-Head

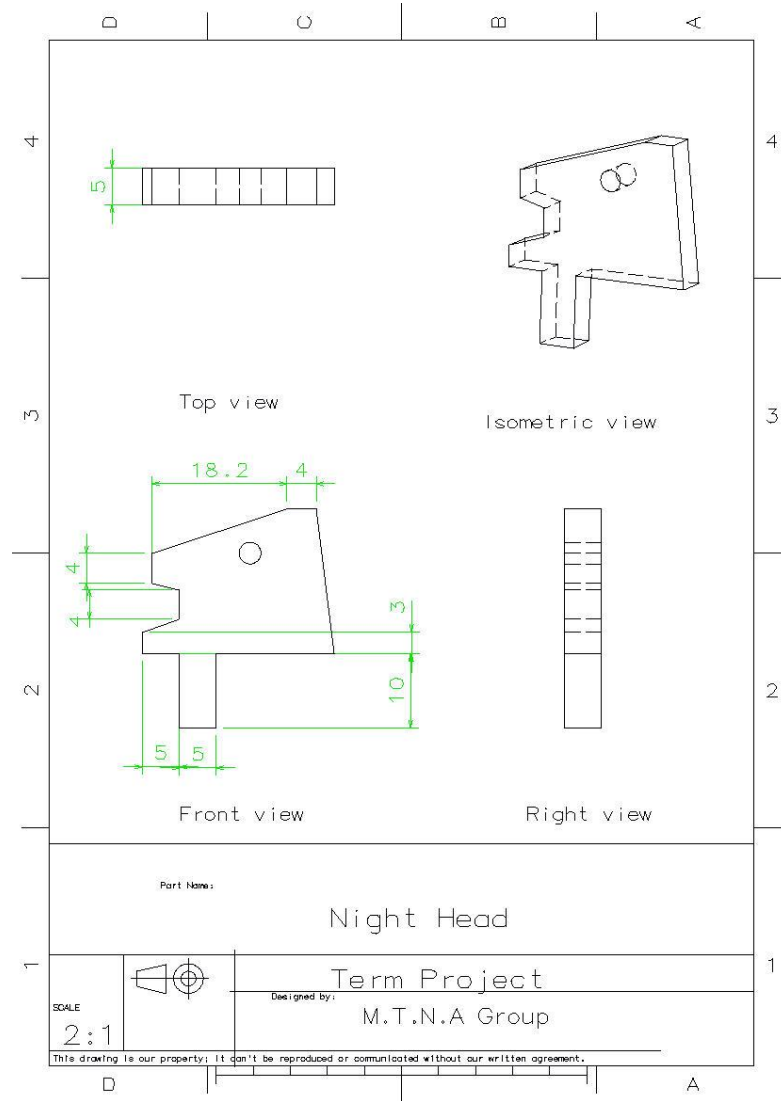
A. Geometric features and sequences of the Knight-Head

#Seq	Before	Geometric Features	After
1	Scratch	- 5mm Pad for the profile of Knight head shape	

B. Machining features and sequences of the Knight Body

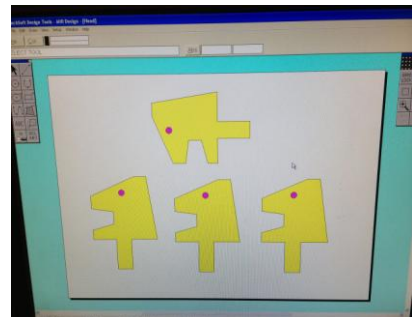
#seq	Before	Machining Feature	After	Operation
1				Milling
2				Drilling

C. CAD Model of the Knight Head



D. Simple description about Boxford program of the Knight-Head

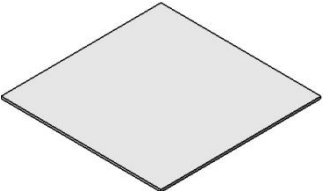
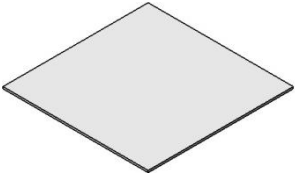
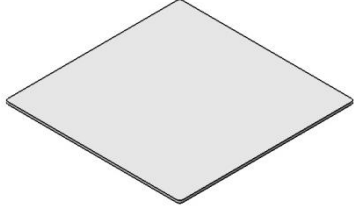
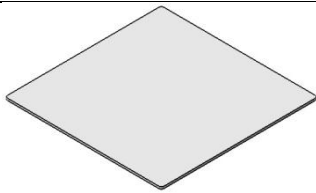
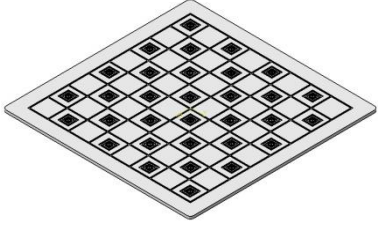
For this part Boxford milling machine has been used. This machine contains a very easy software (Boxford V10 software) , we just draw the needed profile, clamp the work-piece and then start manufacturing.



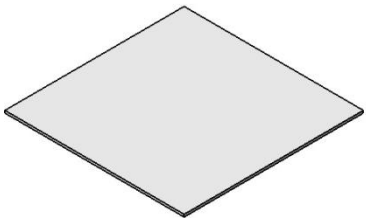

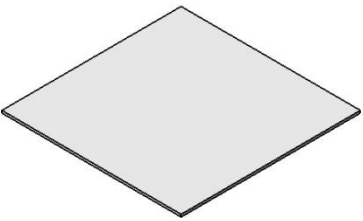
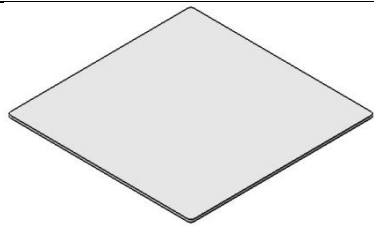
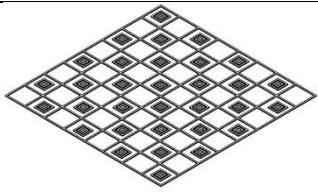
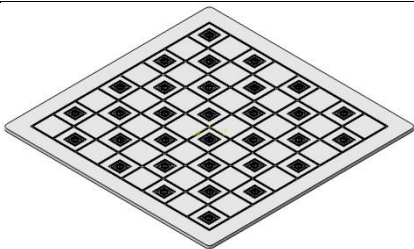
Knight head in the software

7- Chess board

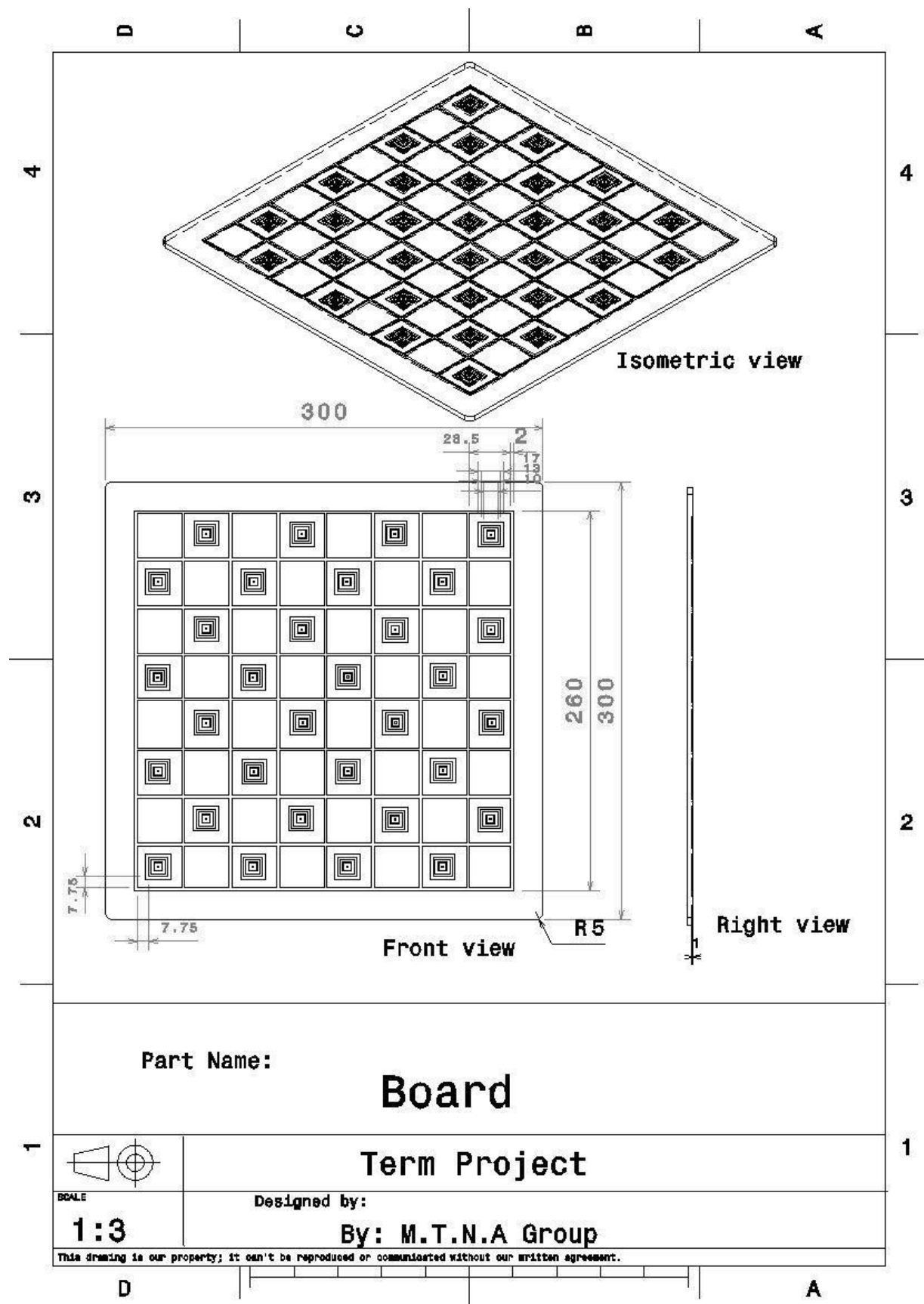
A. Geometric features and sequences of the board

Seq#	Before	Geometric Feature	After
1	Scratch	Pad a rectangle 300mm*300mm, 4 mm in height.	
2		Fillet the corners with radius of 5mm.	
3		Draw the lines with the following dimensions, use pocket command with thickness of 2mm: 260mm*260mm square divided equally with 8 horizontal and vertical lines, inside it 3 concentric squares with sides of 17mm, 10mm and 5mm.	

B. Machining features and sequences of the Board

#	Before	Machining Feature	After	Operation
1		 4 rectangles with side of 5mm and height of 4mm, missing quarter of a cylinder with radius of 5mm.		Milling
2		 lines of thickness 2mm, 1mm deep: 260mm*260mm square divided equally with 8 horizontal and vertical lines, inside it 3 concentric squares with sides of 17mm, 10mm and 5mm.		Milling

C. CAD Model of the Board



This part has been manufactured by the Cincinnati milling machine. The production of it was created from plastic plat of 30*30mm. In fact this part was the easiest; first we draw the needed shapes on the board by CATIA; then put the CATIA file in the software connected with the machine; after that clamp the board inside the machine in a safe way; finally start manufacturing.



Safe and strong clamping way

Working on the final look of the product

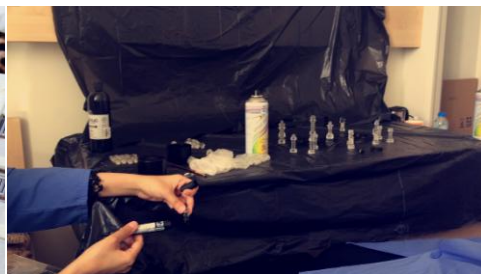
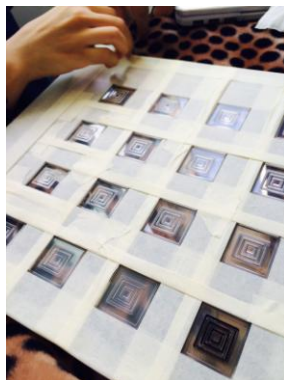


Before



After

The Last step in the production planning was the painting. This step is very technical and important for the final look and the costumer will decide to buy the product or not depending on the final look. We choose the spray painting because it is inexpensive and have a nice shining.



Painting mechanism

Risk Management

Mitigation Plan:

Here are two main problems that we may face while managing the business:

- Damage in a machine by mistake while working. This is a significant issue because any damage may cost more than 50,000 AED. However we may ask our university (UAEU) to work in their machine while fixing the one has been damaged. Also we need to teach the workers how to use the machine very properly and when to use the emergency button. We also should monitor their work and see how do they use the machine to prevent such problem. We may also add cameras to monitor the workers and to let them know that our eyes on them all the time.
- A new competitor may establish in UAE: To keep our popularity we need to ask people and take their opinions about the preferred shape and what do they like in chessmen by making surveys from one period to another because in general people like changes each period and they may like different styles of chessmen from one period to another. Also we may offer sale promotions to our customers

Contingency Plan:

If we didn't get any orders or we lost in this business we have other alternatives such as:

- Making another small business as additional extra source of income. For instance, buying small condominium then rent its departments.
- Manufacturing other products like chains. We can use the same shape of chessmen but adding a chain. It can also be different interesting shapes people may buy.



Figure : examples of key chains

- Change the business of chess set to another project such as accessories (earrings and rings) using the same material and machines of the previous business. It can be colored and painted. Mostly this product will appeal to teenagers who like to wear unique and strange things.



Figure : examples accessories

- Last alternative is to sell the building, machines and material if none of the above businesses gives profit. Or we can rent the place to another company.

Financial Plan

The return on investment:

The return on investment (ROI) is a profitability measure that evaluates the performance of a business. There are several methods to determine (ROI). One way is to divide the net profit of the project by its the total assets⁴. In the fifth year, the total assets is 1,563,700 AED and the net profit is 1,406,170 AED. As result, the return on investment calculated to be:


$$ROI = \frac{1406170}{1563700} * 100 = 89.9 \%$$

This high value means the investment gains compare favorably to the total asset. This value is higher than the internal rate of return (IRR= 65%).

Financial Projections:

(Check Appendices for the financial excel sheets)

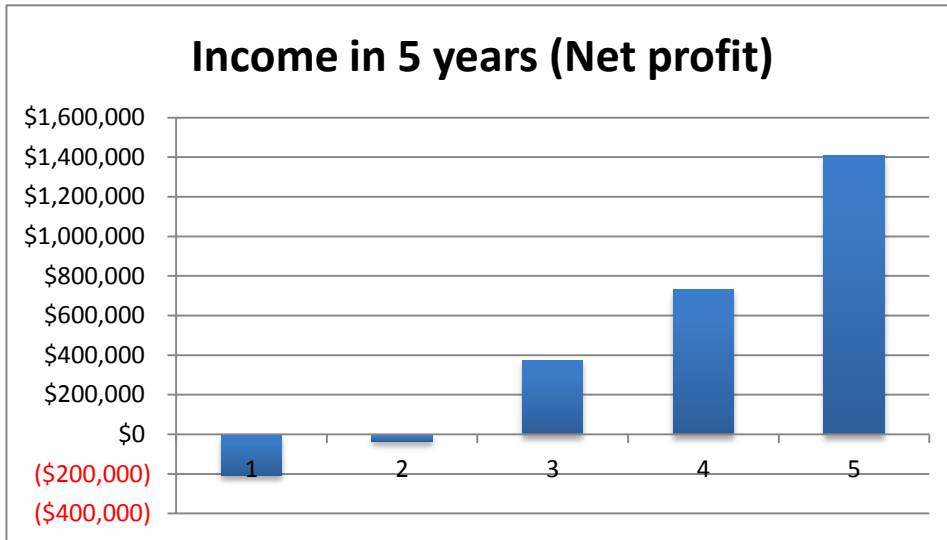
○ **Total Cost:**

	Description	Total Cost
Pickup Car 	Used to distribute orders of our products to costumers and bookshops	50,000 AED (source: http://cars.mitula.ae/mitsubishi-fuso-dubai)
Machines	4 DMG each cost 305120 AED (source: http://ecoline.dmgmori.com/) 1 Cincinnati cost 67953 AED (source: http://www.ebay.com/)	Total = 1,288,433 AED
Phone	Will be used to answer customer calls for doubts or orders , also For using WhatsApp to receive orders by massages. And for using Instagram	1400 AED (source: souq.com)
Computer	Will be used to update social media accounts and receive customer feedback and for advertisement. Moreover , will used in accounting by excel.	2000 AED (source: souq.com)

⁴ Return on Investment (ROI), (2014) retrieved on 10 January 2015 from <http://www.entrepreneur.com/encyclopedia/return-on-investment-roi>

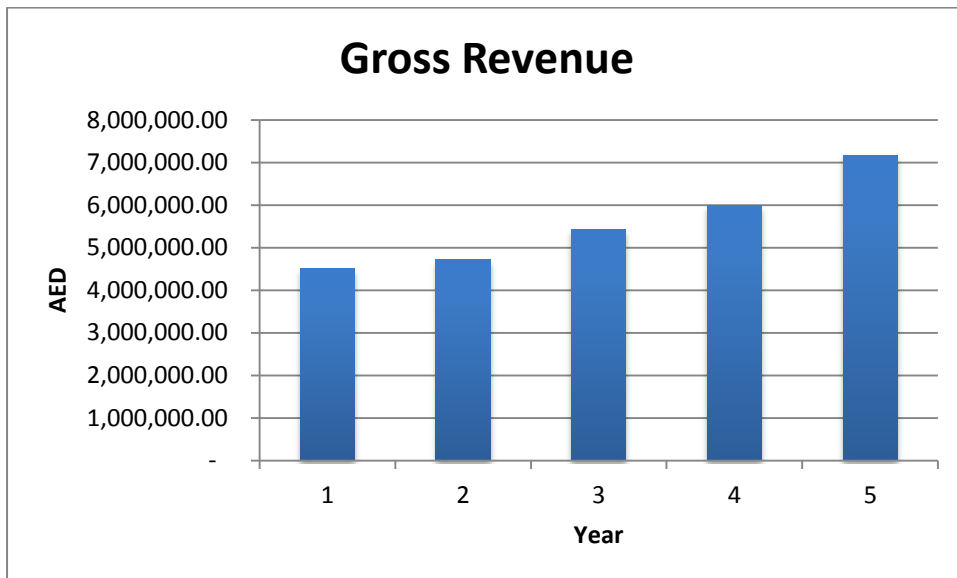
Internet service	Will be used to update social media accounts 165 AED / month 200 AED for connecting router (source: Etisalat)	total: 2180 AED/year
Marketing	Broachers = 5000 AED/yr Posters= 5000 AED/year	Total = 10,000 AED
Construct Building	1500 AED per m ² (source: Bin Maktoom Construction company) land area = 5000 m ² (source: Higher Corporation for Specialized Economic Zones in Abu Dhabi)	total cost= 7,500,000 AED
Rent of the land	15.5 AED/m ² Land area= 5000 m ² (source: Higher Corporation for Specialized Economic Zones in Abu Dhabi)	Total cost = 77500 AED/year
License	-	5000 AED (source: Higher Corporation for Specialized Economic Zones in Abu Dhabi)
Insurance	We have four workers each has a medical insurance of 3000 AED	Total= 12,000 AED
Utilities	Electricity and water	Estimated to be 30,000 AED
Salaries	-	Painter: 1000 AED Driver: 1000 AED 2 Machine operators: each has 2000 AED total salaries= 72,000 AED
Investment Cost		9,050,513 AED

- **Net Profit:**



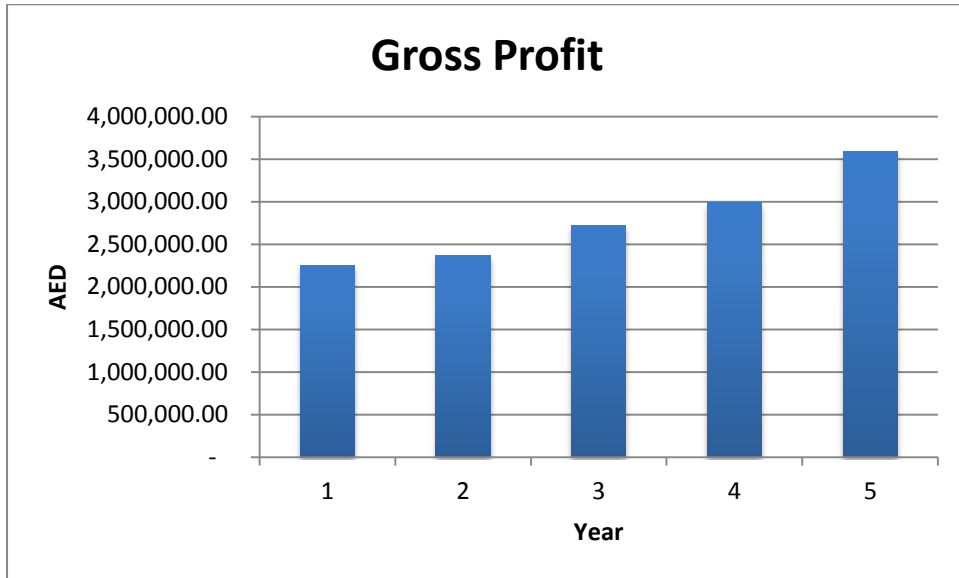
- **Revenue:**

*Revenue = Unit Price * number of units*

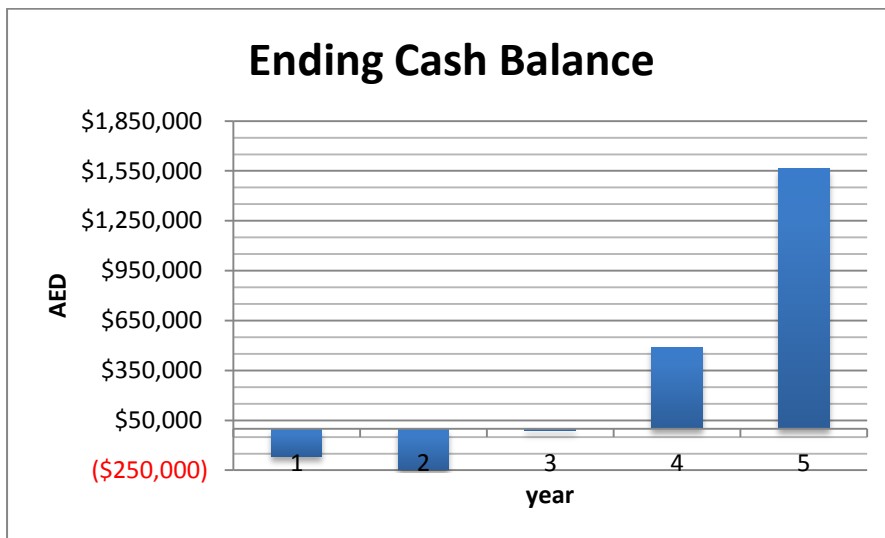


- **Gross Profit:**

Gross Profit = Revenue – Manufacturing cost



- **Cash Flow**



Conclusion:

After hard working and team correlation this project is done with which was very interesting and useful for us as the future mechanical engineers. This project didn't focus on the Computer Aided Design field only; in fact it was in educating us how to start a new business with creative ideas.

In this project we discussed many important issues as: business description, strategic position, vision of the future, Development of the project, sales estimates operations we followed and our financial plan. All of our discussions in this report depend on people's desires, because we search about this issue and ask the people through a survey and social media.

Finally, we would like to thank D. Basel and Eng. Rajish for their help and for answering the question we faced. The difficulty we faced in this project started at the beginning of using the DMG machine but after 2 parts it became easy and fun to work with. Actually without overstatement, now we become professional on this machine. At the end we hope that our project gets your appreciation.

References:

- 1- Khalifa Fund, (2014), retrieved on 10 January 2015 from <http://www.khalifafund.ae/SitePages/Home.aspx>
- 2- Top chess manufacturing companies, Chesswala: <http://www.chesswala.com/top-chess-manufacturing-companies/>
- 3- Manopoulos, retrieved on Jan 2014 from <http://www.manopoulos.com/>
- 4- Return on Investment (ROI), (2014) retrieved on 10 January 2015 from <http://www.entrepreneur.com/encyclopedia/return-on-investment-roi>

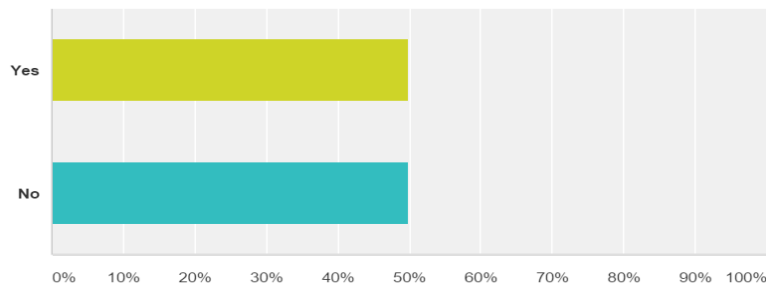
Appendices

Survey

An online survey was conducted, with 54 participants from different backgrounds, the answers were as following:

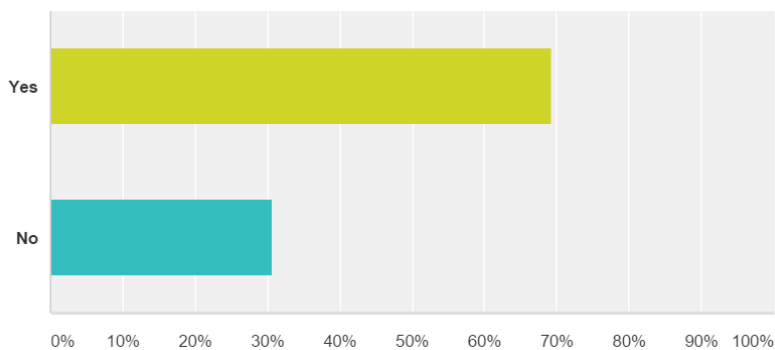
1. Do you know how to play chess?

- ☐ Yes
- ☐ No



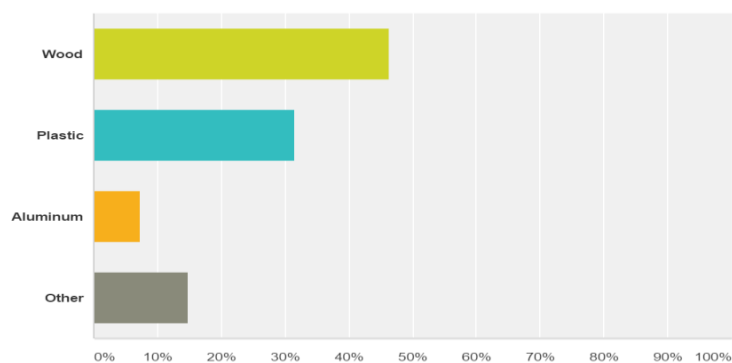
2. Would you want a customized chess set? (With your choice of color and ability to write your initials.)

- ☐ Yes
- ☐ No



3. What material do you prefer a chess set to be made out of?

- ☐ Wood
- ☐ Plastic
- ☐ Aluminum
- ☐ Other



4. What colors do you prefer your chess set to be? (Write two colors.)

(Sample of the answers)

Black and white

white and pink

Dark blue and

Brown and black

Black and purple

Golden and white

Red and blue

red and black

gold and black

Green and white

Silver and pink

white and purple

Financial Excel Sheets:

- Model Inputs:

Year 1 model inputs				
Use this area to capture key components of the Profit and Loss Statement and the Balance Sheet for the first year only.				
1. Year-one revenue expectancy				
	<Product 1>	<Product 2>	<Product 3>	<Product 4>
Number of units sold annually	45,000			0
Average sales price per unit	\$100.00			\$0.00
Annual revenue per product	\$4,500,000	\$0	\$0	\$0
Total year 1 revenue	\$4,500,000			
2. Year 1 cost of goods sold				
	<Product 1>	<Product 2>	<Product 3>	<Product 4>
Expected gross margin per product	50.00%	0.00%	0.00%	0.00%
Annual cost of goods sold per product (manufacturing cost)	\$2,250,000	\$0	\$0	\$0
Total year 1 cost of goods sold	\$2,250,000			
3. Annual maintenance, repair, and overhaul				
Factor (%) on capital equipment	5%			
4. Number of years for straight-line depreciation				
	5			
5. Annual tax rate				
	0%			
6. If long-term debt is being used to finance operations, enter the total loan value.				
	\$9,500,000			

- Profit and Loss:

Year-by-year profit and loss assumptions					
	Year 1	Year 2	Year 3	Year 4	Year 5
Annual cumulative price (revenue) increase	-	5.00%	15.00%	10.00%	20.00%
Annual cumulative inflation (expense) increase	-	10.00%	15.00%	5.00%	8.00%
Interest rate on ending cash balance	0.00%	0.00%	0.00%	0.00%	0.00%

	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue					
Gross revenue	4,500,000.00	4,725,000.00	5,433,750.00	5,977,125.00	7,172,550.00
Cost of goods sold (manufacturing cost)	2,250,000	2,362,500	2,716,875	2,988,563	3,586,275
Gross margin (Gross profit)	2,250,000.00	2,362,500.00	2,716,875.00	2,988,562.50	3,586,275.00
Other revenue [source]	\$0	\$0	\$0	\$0	\$0
Interest income	\$0	\$0	\$0	\$0	\$0
Gross profit	\$2,250,000	\$2,362,500	\$2,716,875	\$2,988,563	\$3,586,275
Operating expenses					
Sales and marketing	\$10,000	\$11,000	\$12,650	\$13,283	\$14,345
Payroll and payroll taxes (salaries)	72,000	\$79,200	\$91,080	\$95,634	\$103,285
Depreciation	1,758,367	1,758,367	1,758,367	1,758,367	1,758,367
Insurance	12,000	\$13,200	\$15,180	\$15,939	\$17,214
Maintenance, repair, and overhaul	64,592	71,051	74,280	67,821	69,759
Utilities (water and electricity)	30,000	\$33,000	\$37,950	\$39,848	\$43,035
Property taxes	0	\$0	\$0	\$0	\$0
Administrative fees	5,000	\$5,500	\$6,325	\$6,641	\$7,173
space rental	77,500	\$85,250	\$98,038	\$102,939	\$111,175
Total operating expenses	\$2,029,458	\$2,056,567	\$2,093,869	\$2,100,471	\$2,124,352
Operating income	\$220,542	\$305,933	\$623,006	\$888,091	\$1,461,923
Interest expense on long-term debt	426,265	340,302	250,041	155,266	55,753
Operating income before other items	(\$205,723)	(\$34,369)	\$372,965	\$732,825	\$1,406,170
Loss (gain) on sale of assets	0	0	1,000	0	0
Other unusual expenses (income)	0	0	0	0	0
Earnings before taxes	(\$205,723)	(\$34,369)	\$373,965	\$732,825	\$1,406,170
Taxes on income	0%	0	0	0	0
Net income (loss) (net profit)	(\$205,723)	(\$34,369)	\$373,965	\$732,825	\$1,406,170
profit %	-5%	-1%	7%	12%	20%

○ Balance Sheet:

Assets	Initial balance	Year 1	Year 2	Year 3	Year 4	Year 5
Cash and short-term investments	\$0	(\$166,617)	(\$247,843)	(\$11,997)	\$488,936	\$1,563,700
Accounts receivable (Sales not yet paid)	0	0	0	0	0	0
Total current assets	\$0	(\$166,617)	(\$247,843)	(\$11,997)	\$488,936	\$1,563,700
Buildings	\$7,500,000	\$7,500,000	\$7,500,000	\$7,500,000	\$7,500,000	\$7,500,000
Land	0	0	0	0	0	0
Capital improvements	0	0	0	0	0	0
Machinery and equipment	1,291,833	1,291,833	1,291,833	1,291,833	1,291,833	1,291,833
Less: Accumulated depreciation expense	0	1,758,367	3,516,733	5,275,100	7,033,466	8,791,833
Net property/equipment	\$8,791,833	\$7,033,466	\$5,275,100	\$3,516,733	\$1,758,367	\$0
Goodwill	\$0	\$0	\$0	\$0	\$0	\$0
Deferred income tax	0	0	0	0	0	0
Long-term investments	0	0	0	0	0	0
Deposits	0	0	0	0	0	0
Other long-term assets	0	0	0	0	0	0
Total assets	\$8,791,833	\$6,866,849	\$5,027,257	\$3,504,737	\$2,247,302	\$1,563,700
Liabilities	Initial balance	Year 1	Year 2	Year 3	Year 4	Year 5
Accounts payable (Payment to suppliers)	\$0	\$0	\$0	\$0	\$0	\$0
Accrued expenses	0	0	0	0	0	0
Notes payable/short-term debt	0	0	0	0	0	0
Capital leases	0	0	0	0	0	0
Other current liabilities	0	0	0	0	0	0
Total current liabilities	\$0	\$0	\$0	\$0	\$0	\$0
Long-term debt from loan payment calculator	\$9,500,000	\$7,780,739	\$5,975,516	\$4,080,031	\$2,089,772	(\$0)
Other long-term debt	\$0	\$0	\$0	\$0	\$0	\$0
Total debt	\$9,500,000	\$7,780,739	\$5,975,516	\$4,080,031	\$2,089,772	(\$0)
Equity	Initial balance	Year 1	Year 2	Year 3	Year 4	Year 5
Owner's equity (common stocks)	\$0	\$0	\$0	\$0	\$0	\$0
Paid-in capital	0	0	0	0	0	0
Preferred equity	0	0	0	0	0	0
Retained earnings	0	(205,723)	(240,092)	133,873	866,697	2,272,867
Total equity	\$0	(\$205,723)	(\$240,092)	\$133,873	\$866,697	\$2,272,867
Total liabilities and equity	\$9,500,000	\$7,575,016	\$5,735,424	\$4,213,904	\$2,956,469	\$2,272,867

Total Assets	\$7,780,739	\$5,027,257	\$3,504,737	\$2,247,302	\$1,563,700
Profit	-205,723	-34,369	373,965	732,825	1,406,170
ROI	-2.6	-0.7	10.7	32.6	89.9

○ Cash Flow:

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Operating activities						
Net income	(\$205,723)	(\$34,369)	\$373,965	\$732,825	\$1,406,170	\$2,272,867
Depreciation	1,758,367	1,758,367	1,758,367	1,758,367	1,758,367	8,791,833
Accounts receivable	0	0	0	0	0	0
Inventories	0	0	0	0	0	0
Accounts payable	0	0	0	0	0	0
Amortization	0	0	0	0	0	0
Other liabilities	0	0	0	0	0	0
Other operating cash flow items	0	0	0	0	0	0
Total operating activities	\$1,552,644	\$1,723,997	\$2,132,331	\$2,491,191	\$3,164,536	\$11,064,700
Investing activities						
Capital expenditures	\$0	\$0	\$0	\$0	\$0	\$0
Acquisition of business	0	0	0	0	0	0
Sale of fixed assets	\$0	\$0	(\$1,000)	\$0	\$0	(1,000)
Other investing cash flow items	0	0	0	0	0	0
Total investing activities	\$0	\$0	(\$1,000)	\$0	\$0	(\$1,000)
Financing activities						
Long-term debt/financing	(\$1,719,261)	(\$1,805,224)	(\$1,895,485)	(\$1,990,259)	(\$2,089,772)	(\$9,500,000)
Preferred stock	0	0	0	0	0	0
Total cash dividends paid	0	0	0	0	0	0
Common stock	0	0	0	0	0	0
Other financing cash flow items	0	0	0	0	0	0
Total financing activities	(\$1,719,261)	(\$1,805,224)	(\$1,895,485)	(\$1,990,259)	(\$2,089,772)	(\$9,500,000)
Cumulative cash flow	(\$166,617)	(\$81,226)	\$235,847	\$500,932	\$1,074,764	\$1,563,700
Beginning cash balance	\$0	(\$166,617)	(\$247,843)	(\$11,997)	\$488,936	
Ending cash balance	(\$166,617)	(\$247,843)	(\$11,997)	\$488,936	\$1,563,700	

○ Loan Payment Calculator:

5-Year Financial Plan—Manufacturing
Loan payment calculator

Annual interest rate	5.0%
Monthly rate	0.41%
Loan amount	\$9,500,000
Term of loan (months)	60
Payment	(\$178,793.78)

Note: This calculator can generate principal and interest payments for a period of up to 30 years (360 months).

Month	Principal balance	Principal payment	Interest	Payment
1	\$9,500,000	(\$140,090)	(\$38,704)	(\$178,794)
2	9,359,910	(140,660)	(38,133)	(\$178,794)
3	9,219,250	(141,233)	(37,560)	(\$178,794)
4	9,078,017	(141,809)	(36,985)	(\$178,794)
5	8,936,208	(142,387)	(36,407)	(\$178,794)
6	8,793,821	(142,967)	(35,827)	(\$178,794)
7	8,650,855	(143,549)	(35,245)	(\$178,794)
8	8,507,305	(144,134)	(34,660)	(\$178,794)
9	8,363,171	(144,721)	(34,073)	(\$178,794)
10	8,218,450	(145,311)	(33,483)	(\$178,794)
11	8,073,139	(145,903)	(32,891)	(\$178,794)
12	7,927,237	(146,497)	(32,297)	(\$178,794)
13	7,780,739	(147,094)	(31,700)	(\$178,794)
14	7,633,645	(147,693)	(31,100)	(\$178,794)
15	7,485,952	(148,295)	(30,499)	(\$178,794)
16	7,337,657	(148,899)	(29,895)	(\$178,794)
17	7,188,758	(149,506)	(29,288)	(\$178,794)
18	7,039,252	(150,115)	(28,679)	(\$178,794)
19	6,889,137	(150,727)	(28,067)	(\$178,794)
20	6,738,410	(151,341)	(27,453)	(\$178,794)
21	6,587,069	(151,957)	(26,837)	(\$178,794)
22	6,435,112	(152,576)	(26,217)	(\$178,794)
23	6,282,536	(153,198)	(25,596)	(\$178,794)
24	6,129,338	(153,822)	(24,972)	(\$178,794)
25	5,975,516	(154,449)	(24,345)	(\$178,794)
26	5,821,067	(155,078)	(23,716)	(\$178,794)
27	5,665,989	(155,710)	(23,084)	(\$178,794)
28	5,510,279	(156,344)	(22,450)	(\$178,794)
29	5,353,935	(156,981)	(21,813)	(\$178,794)
30	5,196,954	(157,621)	(21,173)	(\$178,794)
31	5,039,333	(158,263)	(20,531)	(\$178,794)
32	4,881,070	(158,908)	(19,886)	(\$178,794)
33	4,722,162	(159,555)	(19,239)	(\$178,794)
34	4,562,607	(160,205)	(18,589)	(\$178,794)
35	4,402,402	(160,858)	(17,936)	(\$178,794)
36	4,241,544	(161,513)	(17,281)	(\$178,794)
37	4,080,031	(162,171)	(16,623)	(\$178,794)
38	3,917,860	(162,832)	(15,962)	(\$178,794)
39	3,755,028	(163,495)	(15,298)	(\$178,794)
40	3,591,533	(164,161)	(14,632)	(\$178,794)
41	3,427,371	(164,830)	(13,964)	(\$178,794)
42	3,262,541	(165,502)	(13,292)	(\$178,794)
43	3,097,039	(166,178)	(12,618)	(\$178,794)
44	2,930,863	(166,853)	(11,941)	(\$178,794)
45	2,764,010	(167,533)	(11,261)	(\$178,794)
46	2,596,477	(168,215)	(10,578)	(\$178,794)
47	2,428,262	(168,901)	(9,893)	(\$178,794)
48	2,259,361	(169,589)	(9,205)	(\$178,794)
49	2,089,772	(170,280)	(8,514)	(\$178,794)
50	1,919,492	(170,974)	(7,820)	(\$178,794)
51	1,748,519	(171,670)	(7,124)	(\$178,794)
52	1,576,849	(172,370)	(6,424)	(\$178,794)
53	1,404,479	(173,072)	(5,722)	(\$178,794)
54	1,231,407	(173,777)	(5,017)	(\$178,794)
55	1,057,630	(174,485)	(4,309)	(\$178,794)
56	883,146	(175,196)	(3,598)	(\$178,794)
57	707,950	(175,910)	(2,884)	(\$178,794)
58	532,040	(176,626)	(2,168)	(\$178,794)
59	355,414	(177,346)	(1,448)	(\$178,794)
60	178,068	(178,068)	(725)	(\$178,794)
61	(0)	(0)	0	\$0
62	(0)	(0)	0	\$0
63	(0)	(0)	0	\$0