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"A DFA Analysis Applied to Evaluate and Improve the Assemblability of an Automated Plasma Cutting Machine"

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Topics

1) Introduction

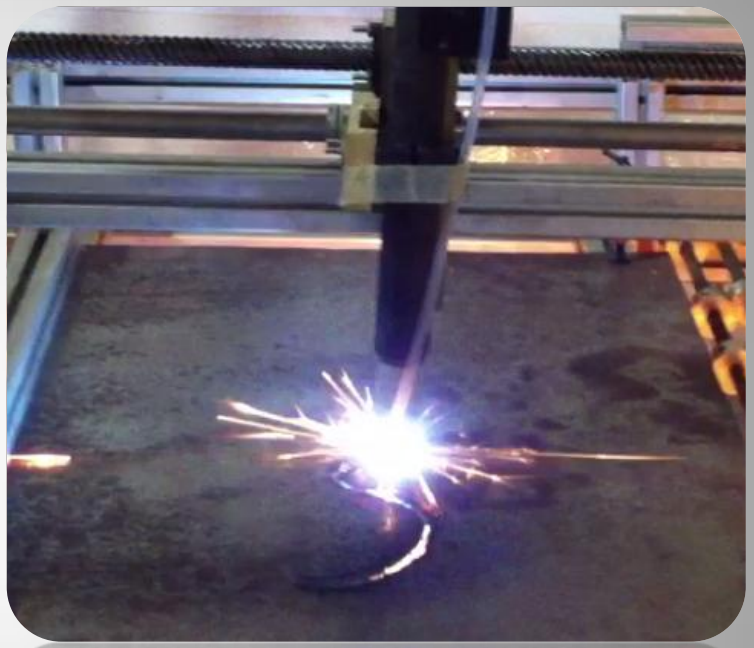
- This paper focuses on the analysis of a plasma cutting machine according to DFA methodology and studies its benefits.

- Also it shows our finds during the implementation of the DFA as the base methodology to foresee already design problems and help to evaluate new design modifications to it.

1) Introduction

1.2) Plasma cutting machine

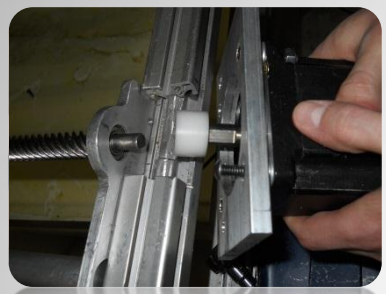
Based on the CNC (Computer numerical control) methodology a plasma cutting machine is a device that allows to cut different materials using the four state of matter, plasma.



The UACJ plasma cutting machine has been under developing through various student projects

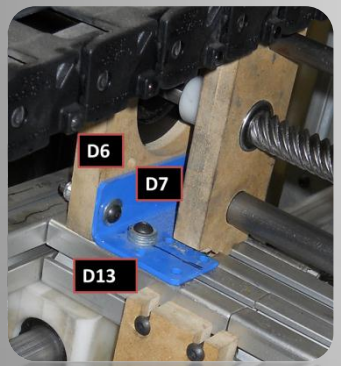
1) Introduction

1.3) Project Main Activities



Comparison between DFA index with and without improvements

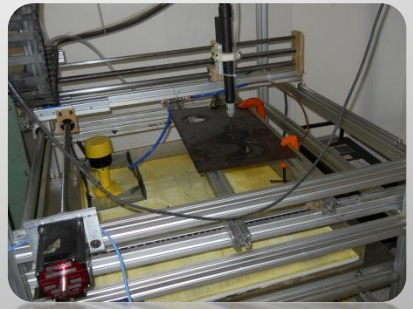
Design improvements



Development of the DFA.

Understanding of the plasma cutting machine subsystems.

Identify and quantify all the components of the cutting system.



Part ID	No. of items (RP)	Tool acquire time (TA)	Handling time(seg) Fig 3.15 TH	Insertion timer per item TI Figure 3.16	Total operation time TA+RP(TH+TI)	Minimun Part Count
B1	1	0	1.3	2.6	3.9	0
B2	1	0	1.3	2.6	3.9	0
B3	1	0	1.3	2.6	3.9	0
B4					0	
C1	1	0	1.8	2.6	4.4	0
C2	1	0	1.5	4.8	6.3	1
C3					0	
D1	1	0	1.5	2.6	4.1	0
P18	4	2.9	1.5	7.9	40.5	0
P19	4	2.9	1.43	19	84.62	0
P20	4	2.9	1.69	1.8	16.86	0
P21	4	2.9	1.5	7.9	40.5	0
P22	4	2.9	1.43	11.9	56.22	0
P23	8	2.9	1.69	1.8	30.82	0
D2	1	0	1.13	2.6	3.73	0
D3	2	0	1.5	7.4	17.8	0

2) Development

Minimum Part Count

Part ID	No. of items (RP)	Tool acquire time (TA)	Alpha Angle	Beta Angle	Total angle of symmetry (alpha+beta)	Handling Difficulties Y/N ?	Thickness (mm)	Size (mm)	Handling Code	Handling time(seg) Fig 3.15 TH	No access or vision difficulties	Restricted Vision Only	Obstructed Access only	Easy to align	Not easy to align	Secured by separate operation or part: No holding down required	Secured by separate operation or part: Holding down required	Secured on insertion by snap fit	Insertion Code	Insertion timer per item TI Figure 3.16	Total operation time TA+RP(TH+TI)	Minimun Part Count
B1	1	0	90	90	180	N	46	134	OO	1.3	X	0	0	X	0	0	X	0	O2	2.6	3.9	0
B2	1	0	90	90	180	N	80	1050	OO	1.3	X	0	0	X	0	0	X	0	O2	2.6	3.9	0
B3	1	0	90	90	180	N	40	69	OO	1.3	X	0	0	X	0	0	X	0	O2	2.6	3.9	0
B4					0																0	
C1	1	0	360	180	540	N	120	120	20	1.8	X	X	0	X	0	0	X	0	O2	2.6	4.4	0
C2	1	0	360	180	540	N	400	300	10	1.5	0	X	0	X	0	0	X	0	12	4.8	6.3	1
C3					0																0	
D1	1	0	180	180	360	N	40	180	10	1.5	X	0	0	X	0	0	0	0	O2	2.6	4.1	0
P18	4	2.9	360	0	360	N	10.83	40.78	10	1.5	X	0	0	X	0	0	0	0	32	7.9	40.5	0

Handling time

Insertion time per Item

Total operation time

Tool acquire time

No. of items

2) Development

Handling Time

	Grosor > 2mm		Grosor < 2mm
Simetría	tamaño > 15 mm	6mm < tamaño < 15 mm	tamaño > 6mm
sim<360	1.13	1.43	1.69
360 <= sim < 540	1.5	1.8	2.06
540 <= sim < 720	1.8	2.1	2.36
sim=720	1.95	2.25	2.51

Sym= alpha+beta angle

Source :Product Design for Manufacture & Assembly Revised & Expanded
Boothroyd Dewhurst

2) Development

- No. of items(**RP**)
- Tool acquire time(**TA**)
- Handling time (**TH**)
  - Thickness, mm?
  - Size, mm?
  - Total angle of symetry
- Insertion time per item(**TI**)
  - Restriction vision?, Obstructed access only? Holding down required?

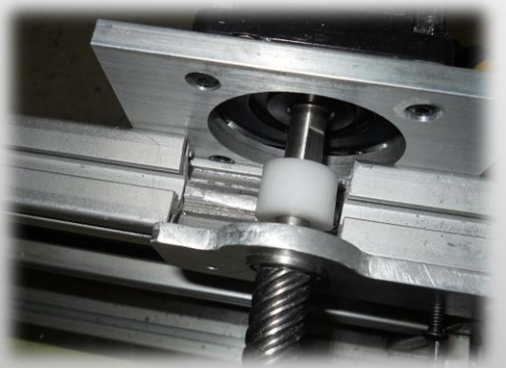
- Total operation time ($\boldsymbol{t_{ma}}$)
  - TA+RP(TH+TI)
- Mínimum part count ($\boldsymbol{N_{min}}$)

$$Ema = {}^{N_{min}t_a}/_{t_{ma}}$$

2) Development

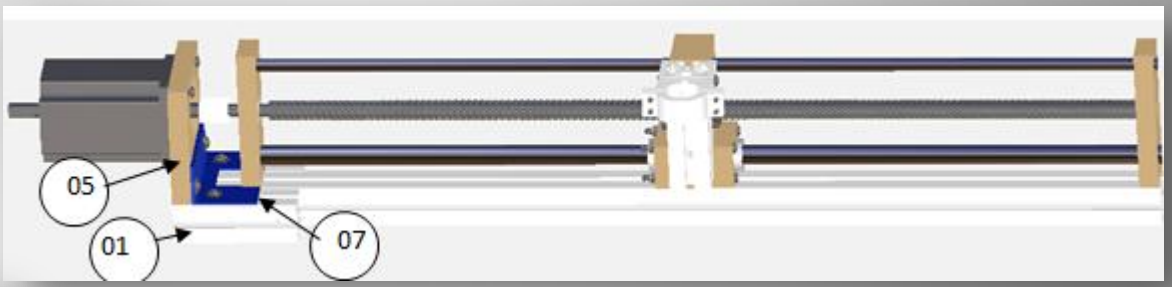
2.2) Plasma cutting machine subassemblies

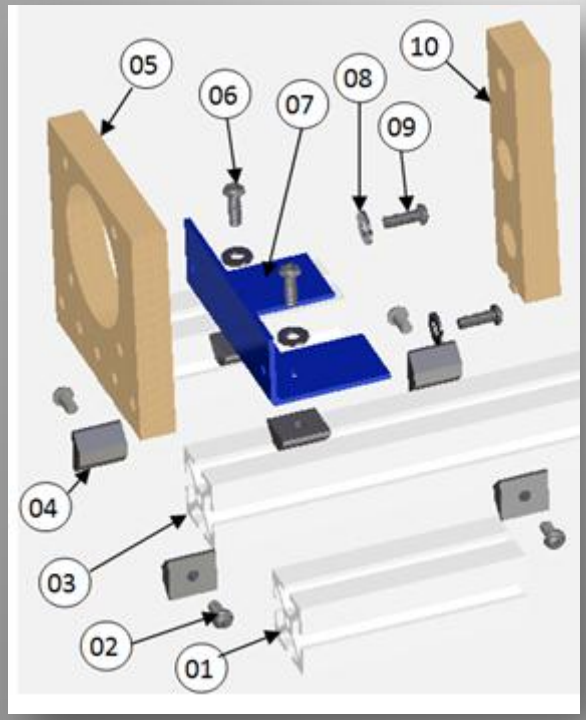
- Motor X support subassembly
- Motor Y support subassembly
- Torch holder support subassembly
- Plasma cutting machine structure
- Material holder subassembly



2) Development

2.2.1) Motor X support subassembly analysis

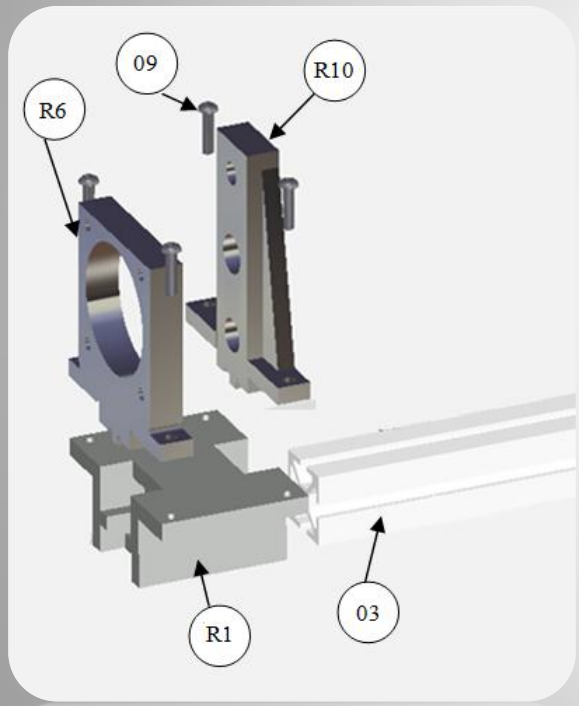




Part ID	No. of items (RP)	Tool acuire time (TA)	Hand-ling time TH	Insert-ion time TI	Total time TA+RP* (TH+TI)	Mini-mum Part Count	
03	1	0	1.13	0	1.13	1	Place base part
04	6	0	1.5	2.6	24.6	0	Add
02	4	0	1.8	5.2	28	0	Add and screw
01	2	2.9	1.13	29	63.16	0	Add and screw fasten
05	1	0	1.5	5.2	6.7	1	Add and hold down
07	1	0	1.8	5.2	7	0	Add and hold down
08	4	0	1.69	1.5	12.76	0	Add
06	2	2.9	1.8	5.2	16.9	0	Add and screw fasten
09	2	2.9	1.8	5.2	16.9	0	Add and screw fasten
10	1	0	1.95	1.5	3.45	0	Add
	24				180.6	2	Totals

2) Development

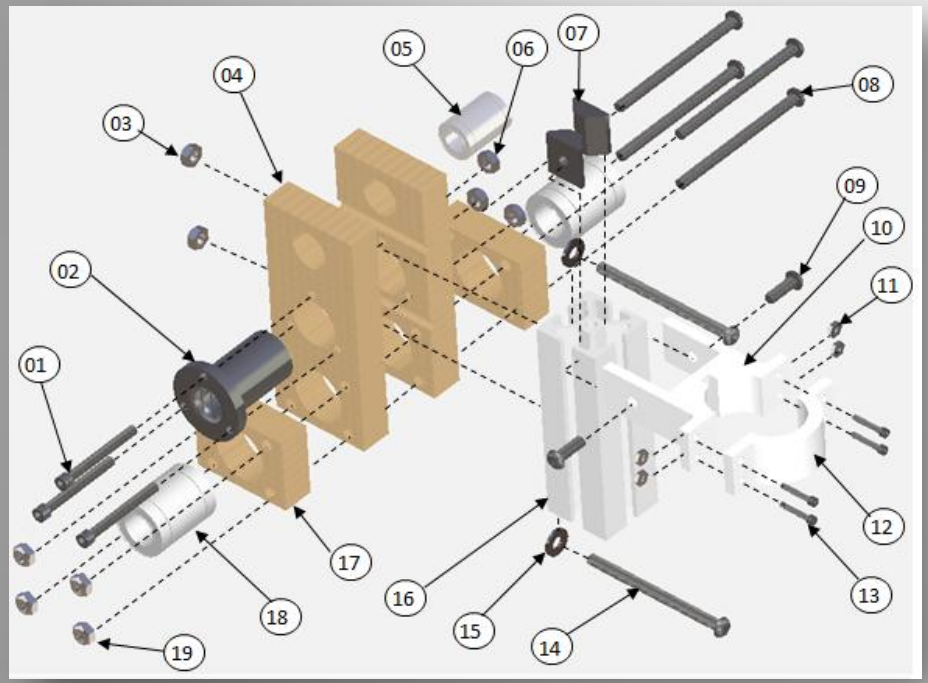
2.2.1) Motor X support redesign subassembly analysis



Part ID	No. of items (RP)	Tool acquire time (TA)	Hand-ling time TH	Insert-ion time TI	Total time TA+RP*(TH+TI)	Mini-mum Part Count	
3	1	0	1.13	0	1.13	1	Place base part
R1	1	0	1.5	2.6	4.1	1	Add
R5	1	0	1.5	5.2	6.7	0	Add and hold down
9	2	2.9	1.8	5.2	16.9	0	standard operation
R10	1	0	1.95	1.5	3.45	0	Add and hold down
9	2	2.9	1.8	5.2	16.9	0	standard operation
					49.18	2	

2) Development

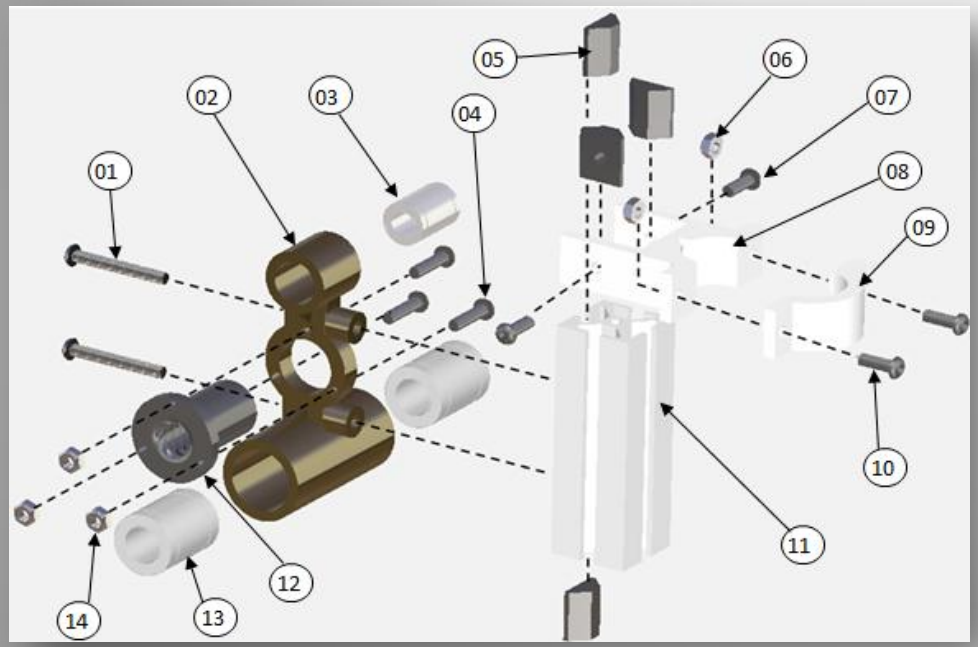
2.2.2) Torch support subassembly analysis



Part ID	No. of items (RP)	Tool acquire time (TA)	Hand-ling time TH	Insert-ion time TI	Total time TA+RP*(TH+TI)	Mini-mum Part Count	
17	1	0	1.5	0	1.5	1	Base part
04	2	0	1.95	1.5	6.9	0	Add
17	1	0	1.5	1.5	3	0	Add
08	4	0	1.5	1.5	12	0	Add
19	4	2.9	1.13	5.2	28.22	0	Add and screw fasten
15	2	0	1.69	1.5	6.38	0	Insert washer into screw
14	2	0	1.13	5.2	12.66	0	Add
03	2	2.9	1.13	5.2	15.56	0	Add and screw fasten
16	1	0	1.13	5.2	6.33	0	Add
	0			4.5	4.5	0	Fasten
09	2		1.5	1.5	6	0	Add
07	2	2.9	1.5	5.2	16.3	0	Add and screw fasten
10	1	2.9	1.95	1.5	6.35	1	Add and screw fasten
12	1		1.8	2.6	4.4	0	Add and hold
13	4		1.5	1.5	12	0	Add
11	4	2.9	1.13	5.2	28.22	0	Add and screw fasten
02	1		1.5	1.5	3	0	Add
01	3		1.5	1.5	9	0	Add
06	3	2.9	1.13	5.2	21.89	0	Add and screw fasten
05	1		1.13	1.5	2.63	1	Add
18	2		1.13	1.5	5.26	2	Add
	43				212.1	5	Totals

2) Development

2.2.2) Torch support redesign subassembly analysis



Part ID	No. of items (RP)	Tool acquire time (TA)	Hand ling time TH	Insert-ion time TI	Total time TA+RP*(TH+TI)	Mini-mum Part Count	
02	1	0	1.5	0	1.5	1	Base part
01	2	0	1.95	1.5	6.9	0	Add
05	2	2.9	1.5	5.2	16.3	0	Add and screw fasten
11	1	2.9	1.13	5.2	9.23	0	Add and screw fasten
05	2		1.5	1.5	6	0	Add
07	2	2.9	1.5	5.2	16.3	0	Add and screw fasten
08	1	2.9	1.95	1.5	6.35	1	Add and screw fasten
09	1		1.8	2.6	4.4	0	Add and hold
10	2		1.5	1.5	6	0	Add
06	2	2.9	1.13	5.2	15.56	0	Add and screw fasten
12	1		1.5	1.5	3	0	Add
04	3		1.5	1.5	9	0	Add
14	3	2.9	1.13	5.2	21.89	0	Add and screw fasten
03	1		1.13	1.5	2.63	1	Add
13	2		1.13	1.5	5.26	2	Add
			26		130.32	5	Totals

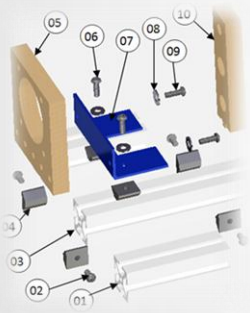
2) Development

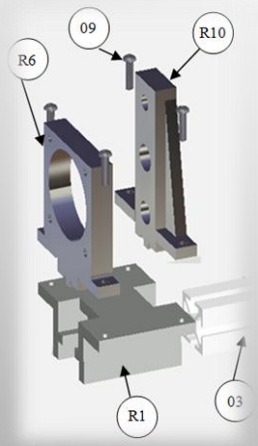
2.3) DFA index results

Motor support subassembly

Before Redesign
DFA index = 3.3%
No. components=24
No. operations=10

After redesign
DFA index = **12.2%**
No. components=**8**
No. operations=**6**

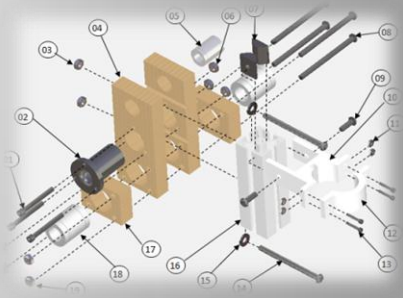


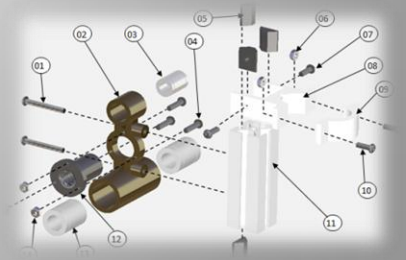


Torch holder subassembly

Before Redesign
DFA index = 7.07%
No. components=43
No. operations=10

After redesign
DFA index = **11.51%**
No. components=**21**
No. operations=**15**





3) Conclusions and further developments

- The DFA index is a measure that has helped us to objectively measure the design proposals from the point of view of assembly.
- Further analysis includes the cost estimation of the designs to complement the time savings with cost savings. In the case discussed here, the machine is under development and, cost estimation will be a main source of information to evaluate the design.