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Compatibility Study of Replacement Material for Cold Cutting Machine

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ABSTRACT

This paper discussed the compatibility study on the possible materials to replace the existing material used in the cold cutting machine (CCM). The current CCM required a weight reduction and up to 33% was achieved. A reverse engineering process was carried out to investigate the structure and material used. The information gathered to be an input for materials analysis using a Cambridge Materials Selectors software. A comparison of possible replacement materials such as Aluminum Alloy, Carbon fiber reinforced plastic (CFRP), Glass fiber reinforced plastic (GFRP) and titanium alloy was conducted. A prototype cold cutting machine was fabricated and the weight was compared.

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INTRODUCTION

The CCM is used to cut a large diameter pipe on-site thus it has stringent criteria to fulfill. It is named cold cutting as it uses pneumatic system which to avoid spark at the flammable area. The conventional pipe cutting process usually produces spark and hazardous when it is applied to the off-shore and live plant environment [Perfect Emerald]. Other than that, the conventional cutting prepared weld surface separately from the beveling process machine and it is time consuming compared to the CCM, both cutting and bevelling process of pipe surfaces preparation were done consecutively.

The weight of the CCM is the major issue to overcome. The range of diameter pipe will determine the size and consequently the weight of the machine. Reverse engineering process was conducted by disassemble the parts that are consists of the mains parts include rotating split frame, stationery split frame, tool slide and adjustable clamping pad extension [E.H Wachs]. The reverse engineering study was done using PRO Engineer software 5.0 [Pahl and Beitz].

The selection of a compatible replacement material was identified based on the three major input of the function; i.e. the shape, the manufacturing process, cost, market availability and the main concern is the properties of the materials [M. F. Ashly]. These criteria were obtained from the reverse engineering process and the outcome was the input to the materials selection process. In general, engineering materials was divided into four major classes that are metals, ceramics, polymers and composites [W. D. Callister]. The selection of materials was made based on main classes of materials properties such as mechanical, thermal, wear, and corrosion or oxidation. The possible replacement materials for lightweight criteria are aluminum alloys, carbon fiber reinforced plastics (CFRP), glass fiber reinforced plastics (GFRP) and titanium alloys.

2. Methodology:

Reverse Engineering:

The CCM was design to be split into two two-halve circle that opens to mount around the outside diameter of in-line piping or slips over open-ended pipe. Figure 1 shows the components of the CCM that include the rotating ring, stationary ring, slide mounting, pinion housing, and clamp legs.

The dimension of the parts was measured and transferred into drawings by using the PRO Engineer software. PRO Engineer 5.0 is a parametric, integrated 3D CAD/CAM/CAE solution created by Parametric Technology Corporation (PTC). The application runs on Microsoft Windows platforms, and provides solid modeling, assembly modeling and drafting, finite element analysis, and NC and tooling functionality for mechanical engineers. Figure 2 show the drawing of the parts by using pro-engineer of (a) stationary split frame and (b)

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rotating split frame whereas Figure 3 represent the assembly drawing of the CCM (a) sectional view and (b) full assembly.

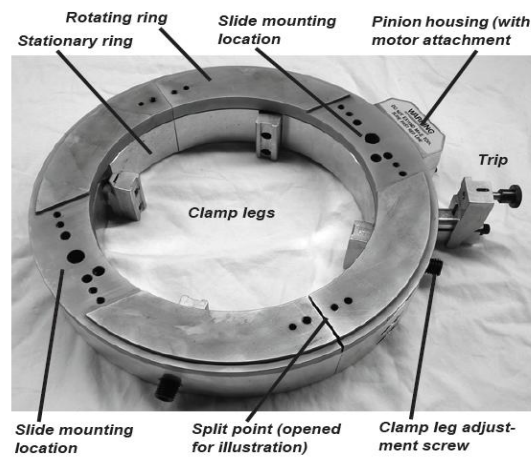


Fig. 1: The components of cold cutting machine.

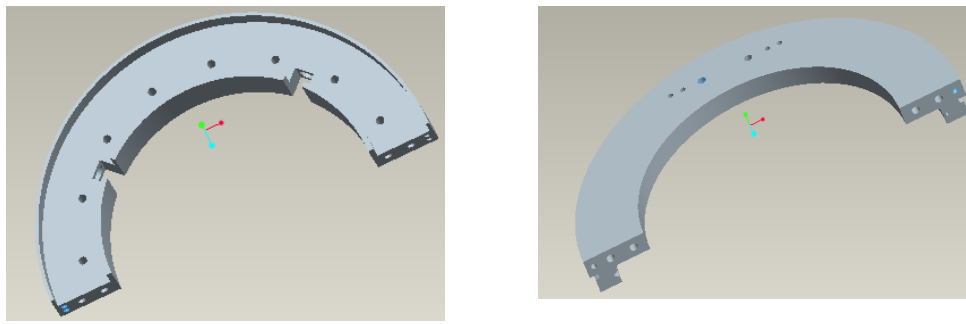


Fig. 2: Pro-E drawing parts (a) Stationary split frame (b) Rotating split frame.

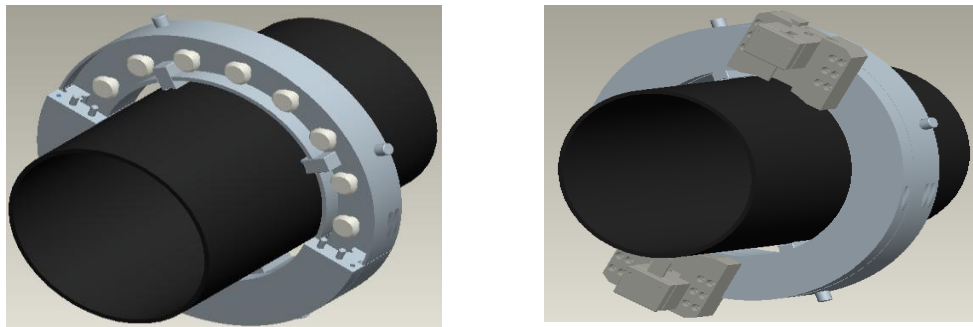


Fig. 3: Assembly drawing of (a) Sectional view assembly (b) Full assembly.

Materials Selections:

The main criterion for the replacement materials is lightweight, hence the weight factor is set to be maximum at 5 weightage and similarly to the second criterion, cost, followed by properties of the materials with weightage of 3. Table 1 summarised the factor rating weightage for each criteria for the replacement materials selection.

Table 1: Criteria and factor rating weightage.

CRITERIA	FACTOR RATING WEIGHTAGE
Lightweight	5
Cost	5
Availability in Market	4
Strength	3

RESULT AND DISCUSSIONS

The materials selection for replacement materials of CCM was priorities based on the weight criteria. Figure 4(a) above show the plot of materials density against fracture toughness for selected materials. The plot illustrate that the best desirable condition will be on the top left section which will give low density and high fracture toughness. Referring to the plot, CFRP show the lowest density followed by GFRP, aluminum alloy and titanium alloy. Considering both density and toughness criteria, both GFRP and aluminum alloy are considered acceptable. Cost criteria comes second after weight and a plot of materials price against tensile strength is shown in Figure 4(b). Referring to the plot, aluminum alloy gives the best price with reasonable tensile strength followed by GFRP but lowest tensile strength, titanium alloy and CFRP.

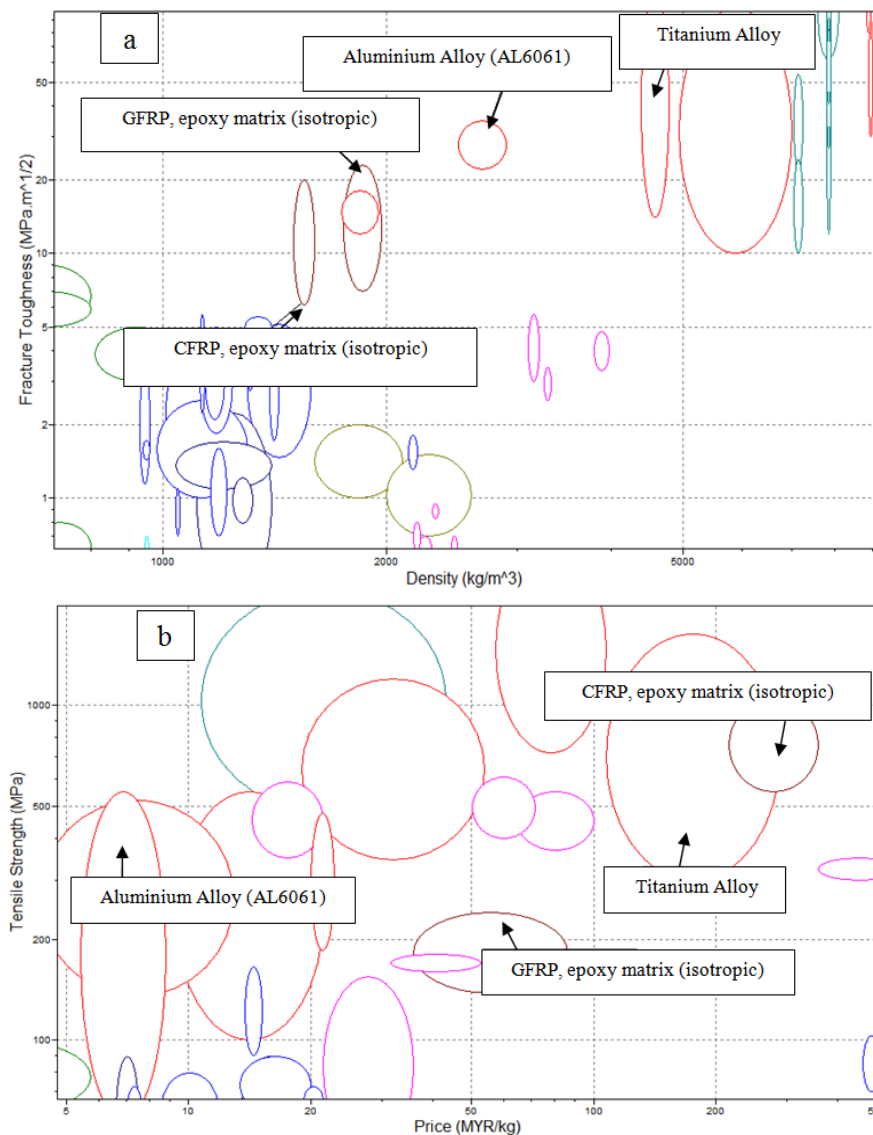


Fig. 4: Materials Cambridge selector (a) Plot density against fracture toughness (b) Plot price against tensile strength.

Table 2 below is based on survey made from supplier that summarise the criteria and weight factor for the materials [W.D. Callister]. The matrix evaluation is done by getting a product of 'Weight factor' and 'Rating' for each material and the scores were summed up and ranked from the highest to the lowest value. It was found that the highest rank is aluminum alloy.

The rate of weight reduction obtained was studied. The weight data of CCM parts for original and fabricated is shown in Table 3. Massive weight reduction was found in stationary and rotating split frame that contribute to 55.2% and 31.6% weight reduction respectively. The scope to this research is focusing on the frame parts, i.e. rotating and stationary split frame, thus, the clamping set, tool post and bearing were not fabricated and the weight

remain as the original parts. The main distribution of CCM's weight is on the frame hence in reducing total weight of CCM, the critical part is the frame. The total weight of original CCM is 66.48 kg whereas the fabricated CCM is 44.24 kg that show weight reduction of 33.5%.

Table 2: Matrix evaluation on selecting material.

CRITERIA	WEIGHT FACTOR	MATERIALS				WEIGHT FACTOR X RATING			
		Al Alloy	GFRP	CFRP	Ti Alloy	Al Alloy	GFRP	CFRP	Ti Alloy
Lightweight	5	3	4	5	2	15	20	25	10
Cost	5	5	4	2	3	25	20	10	15
Availability	4	5	4	3	2	20	16	12	8
Tensile Strength	3	3	2	4	5	9	6	12	15
				Total		69	62	59	48
				Ranking		1	2	3	4

Table 3: Weight reduction.

Description	Original Weight /kg	Fabricated Weight /kg	Weight Reduction/kg	% Reduction
Stationary Split Frame	25.80	11.56	14.24	55.19
Rotating Split Frame	25.32	17.32	8.00	31.60
Clamping Set	1.68	1.68	-	Original parts
Tool post	11.44	11.44	-	Original parts
Bearing	2.24	2.24	-	Original parts
TOTAL	66.48	44.24	22.24	33.45

Conclusions:

The selection of materials was successfully carried out using Cambridge Materials Selectore software with materials such as Glass fiber Reinforce Plastic (GFRP), Carbon fiber Reinforce Plastic CFRP, titanium alloys and aluminum alloys were compared. Matrix evaluation technique was used and weight, cost and tensile strength criteria were selected. Aluminum Alloy 6061 was found to be the best replacement materials among possible materials studied. The reverse engineering process was done by transferring CCM dimensions to the Pro-E software. The fabricated parts are focused on main parts i.e. stationery and rotating split frames. The overall percentage of weight reduction between the fabricated and the original CCM is 33.5%.

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REFERENCES

- Michael F. Ashly, 1999. (Department of Engineering, Cambridge University, England), Second Edition 1999 (Materials Selection In Mechanical Design).
- Pahl and Beitz, 1995. "Engineering Design", - Information on general design process and formulating specification, chapter 3 to 5. Springer. Stuart Pugh, University of Strathclyde; second edition 1995 (Total Design; Integrated methods for successful product engineering) m/s 98
- Perfect Emerald Sdn Bhd, 2011. Company Profile: Controlled bolting; on-site machining; leak sealing.
- Wachs Company, E.H., 2007. User's manual Part No. 60-MAN-01, Revision 7, August 2007; copyright © 2007 E.H Wachs Company.
- William D. Callister, Jr., 2007. Materials Science and Engineering An Introduction, 7th Edition., Mc Graw Hill.