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METAL-EPOXY- CONCRETE DIES FOR EXPLOSIVE FORMING

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ABSTRACT
In our search for die-materials that are not restricted by limitations of size, in the process of producing sufficiently large masses by explosion forming, we have adopted a form of construction in which epoxy-faced concrete is used for the die-cavity. This kind of technique is used to make a plaster master of the die-cavity, which is then coated with epoxy resin, reinforced with fiber glass. An adequate amount of reinforcement rodding and steel plates has its place in construction.
The method of making dies for large and complicated components, using the explosive- forming technique is described here.
Keywords: Explosive forming dies.

1. INTRODUCTION
To find the optimum parameters for explosive forming new parts, a theoretical analysis is necessary, as well as the experience gained from previous programs. These ones offer some general guidelines and some limits which restrict the search area.
There are many problems associated with explosive forming- dies. One of this problems is the time needed to load and unload the die. A vacuum must be maintained between the part and the die to prevent air compresion in the die. The need to release this vacuum has led to complication in explosive-die design and to sealing problems that have slowed down the handling procedure [1,2,3]
Another problem for explosive forming is choosing the die- materials. We consider that ductile iron has the best characteristics for the process, but as the size of parts increases, the cost and problems involved in handling become significant.

2. DIES CONSTRUCTION
In our search for die- materials that are not restricted by the limitations of size, in the process of producing sufficiently large masses, we have adopted a form of construction in which epoxy-faced concrete is used for the die- cavity. The technique that we use begins with making a plaster master of the die- cavity. This master is then coated with epoxy resin, reinforced with fiber-glass, having a thickness of aproximately 1cm. A metal box is placed over the master. An adequate amount of reinforcement rodding is placed inside the section so created and a high strength lightweight concrete is poured into it to make the die. When the concrete has set solid, the concrete with the epoxy-resin facing, attached to it, is removed from the plaster master.
Figure 1. shows the plaster male model of the die-cavity, which is coated with epoxy-resin. The metal box placed over the plaster model serves as a shutter and it is prepared for pouring of the concrete. Inside the metal box is placed the reinforcement rodding (Figure 2).

Figure 1. The master coated with epoxy resin reinforced with fiber-glass

Figure 2. Reinforcement roddings placed inside the metal box

One of the ways of bettering the concrete characteristics, is the use of synthetic resins for cement. Table 1 shows a comparison between a normal concrete and three marks of concrete with syntetic resins: concrete with epoxy-resin, concrete with metacrylic-resin and concrete with unsaturated polyester-resin.

Table 1 Characteristic values for four concrete marks[4]

Material characteristics	Concrete with cement B 500	Concrete with epoxy-resin	Concrete with metacrylic-resin	Concrete with polyester resin
Density [kg/dm^3]	2,4	2,24	2,3	2,3
Elasticity modulus[KN/mm^2]	30	32	38	30
Compressing strength[N/mm^2]	30	100	120	110
Breaking strength[N/mm^2]	5	20	25	20
Bending strength [N/mm^2]	8	35	38	30
Thermal coefficient of expansion	11	13	13	13
Thermal conductivity [W/mk]	1	0,8	2	1
Damping coefficient	0,01	0,02	0,015	0,015
Contraction [mm/m]	0,2	0,015	0,015	0,015
Slow yielding [mm/m]	0,8	-	-	-
Consolidate duration [days]	2,8	1	1 h	1
Dynamic viscosity [10^{-3}Ns/m^2]	100	30	0,1	150

Table 2 presents the representative mechanical caracteristics of unsaturated polyester-resin type NESTRAPOL 220 [4], with and without fiber glass reinforcement.

Table 2 Mechanical characteristics of unsaturated polyester-resin NESTRAPOL 220[4]

Characteristics	Unity of measure	Resin	Resin + fiber glass %		
			30	50	65
Breaking strength	N/mm^2	50	105	230	550
Specific elongation	%	5	2	2,2	1,7
Bending strength	N/mm^2	90	190	290	520
Shock strength	N/mm^2	50	780	1050	1620
Compressing strength	N/mm^2	165	240	305	500
Longitudinal elasticity modulus	N/mm^2	3900	8000	10100	2700

Analyzing the values of table 2, we observe that plastic materials reinforcement leads to a substantially growth of these physic-mechanical characteristics.
The effect depends on the following factors:

- the type of reinforcement material selected;
- the manner of this disposal;
- the ratio of reinforcement material;
- adherence of reinforcement material with the plastic matrix.

The composite materials, reinforced with fiber glass are used the most, this being justified by the pretty low cost of fiber glass.They use many kinds of fiber glass, and the mechanical characteristics for four of these, are presented in Table 3.

Table 3. Mechanical characteristics of fiber glass used to reinforce the plastic materials [4]

Characteristics	Unity of measure	Glass			
		E	S	D	C
Density, q	kg/m^3	2540	2490	2160	2490
Breaking strength, R_m	N/mm^2	3515	4675	2500	2815
Longitudinal elasticity modulus at 22^0C	N/mm^2	73815	87000	52000	70300
Specific elongation at 22^0C	%	4,8	5,4	4,7	-
Specific strength, R_m/q	$s^{-2}\,m^2 10^6$	1,38	1,88	1,15	1,13

Glass E is a calcium and aluminium borosilicate and has the largest utilization in industry. Glass S has the best characteristics at elevated temperatures and contains SiO_2(65%), Al_2O_3(25%), MgO(10%). Glass D has a good dielectric characteristics, and glass C has a good resistance at acids.
The die at the superior face is endowed with a holding down ring. This must have sufficient strenght to withstand repeated impacts from the exploding charge, without forming.
Because concrete exhibits very low properties in tension, it is essential that tool design for explosive forming considers the nature of shock waves produced, to assure wave reflection in compressing. Tension forces produced by shock waves reflected of the encasement material can cause rapid deterioration of the die surface.

3. EXPLOSIVE FORMING

Sheet material is stainless steel 347-ASTM A 240, having the thickness of 3,18 mm and the diameter of 1140mm. Two pieces in torus form, with an outside diameter of 869 mm and an inside diameter of 419mm, have been formed using as an explosive the HITEX-NH8 type. Each piece is formed in two shoots and after the first shoot heat treatment is made. Figure 3 shows the die ready for underwater detonation, while figure 4 shows the piece drawn into forming die.

Figure 3. Die ready for underwater explosion

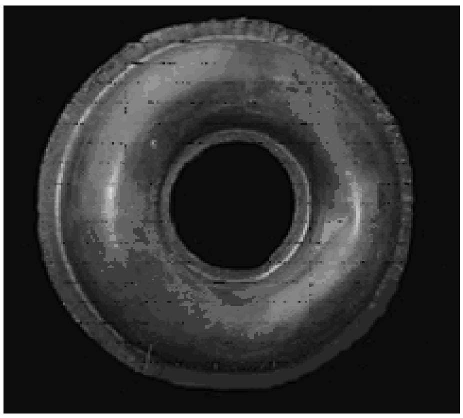

Figure 4. Piece of stainless steel, drawn by explosive forming

The method used in these experiences is the tank-forming underwater. The blank is clamped to the die with a vacuum-tight joint. A vacuum of approximately 6…8 mm Hg is then drawn in the cavity between the sheet and the die. After the vacuum has been drawn, the explosive charge is positioned at a carefully calculated distance from the work-piece. Next, the die and the charge assembly are lowered into the water tank and the charge is detonated. The die with the formed part is then removed from the water and the parts are taken out for inspection.

4. CONCLUSION

The purpose of this article is to show one example of metal-epoxy-concrete die construction for explosive forming of a complex piece. The technique used is to make a plaster master of the die-cavity, which is then coated with epoxy resin, reinforced with fiber glass. An adequate amount of reinforcement rodding and steel plates is placed in construction. The efficiency of this die has been verified by making two pieces of stainless steel.

5. REFERENCES

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