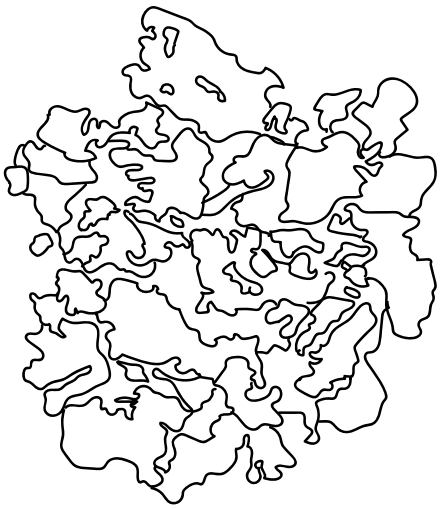
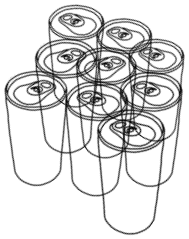
D R O S S .

■ *The residue material of the aluminium smelting process*





A L U M I N I U M

■ *A material exploration project on aluminium dross*

D I P L O M A
T I M C K N U T E N
F A L L 2 0 2 0

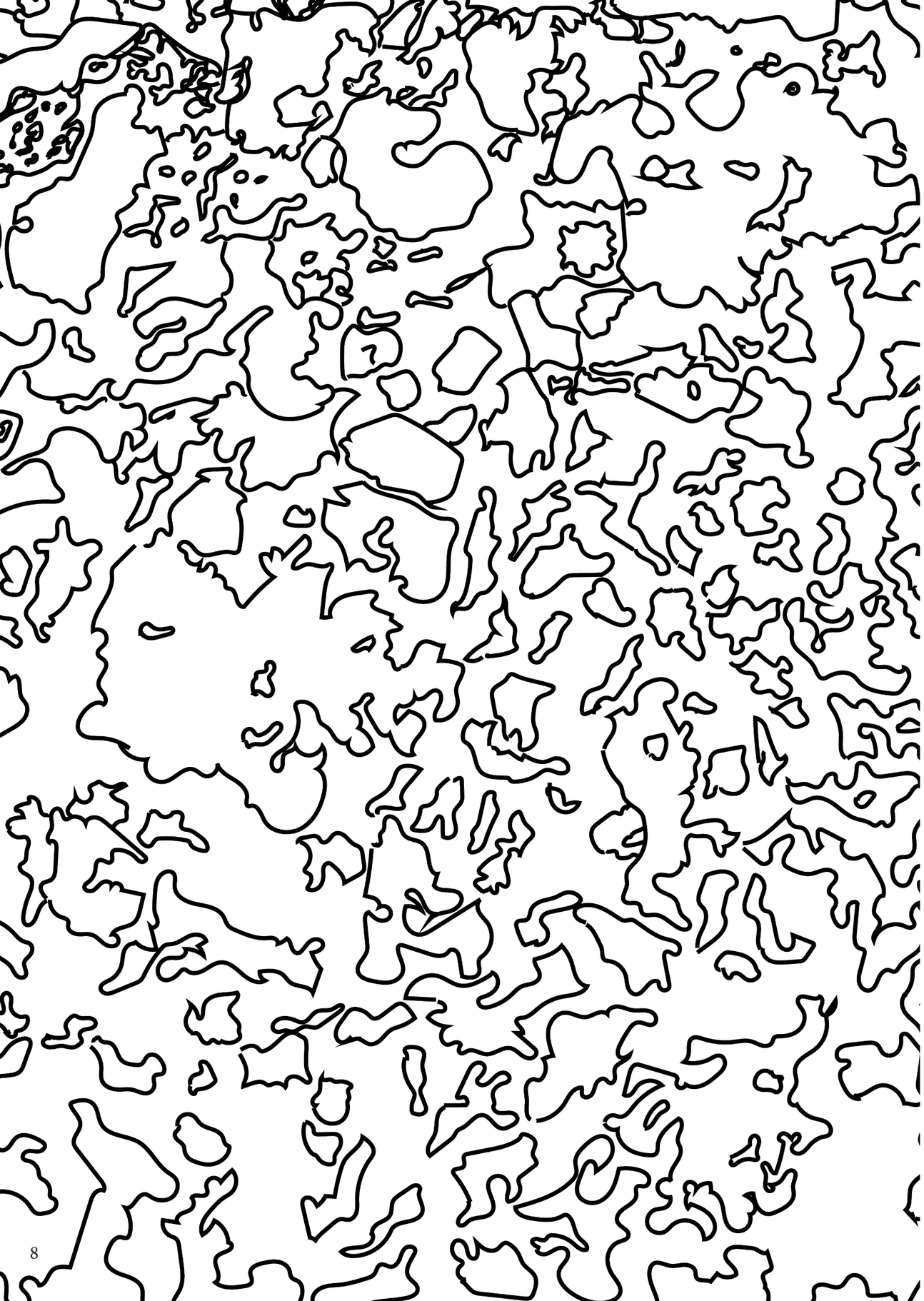
Supervisor: Steinar Killi

The goal for this project was to explore dross and convey the findings and uses as a foundation for further design exploration.

ABSTRACT

Dross is a by-product of the aluminium smelting process. During the smelting all the solid impurities float to the top creating a protecting cover on the molten aluminium. This is called dross and this project aim to explore how to map out and communicate the uses of this combination of impurities as one material. This project was initiated out of my interest in material exploration. Having done several projects on conventional materials prior to this I wanted to investigate a lesser-known material to see how my customary methods of exploration could be applied and how to adapt to achieve a successful result. As this is the first attempt to consider the value of aluminium dross there were little to no information about how to work with it. Throughout the five months of this project, I discovered nine textures, made three objects out of the material that serve as a representation of the potential of aluminium dross and a handbook for how it can be explored further.

INDEX



PART 1

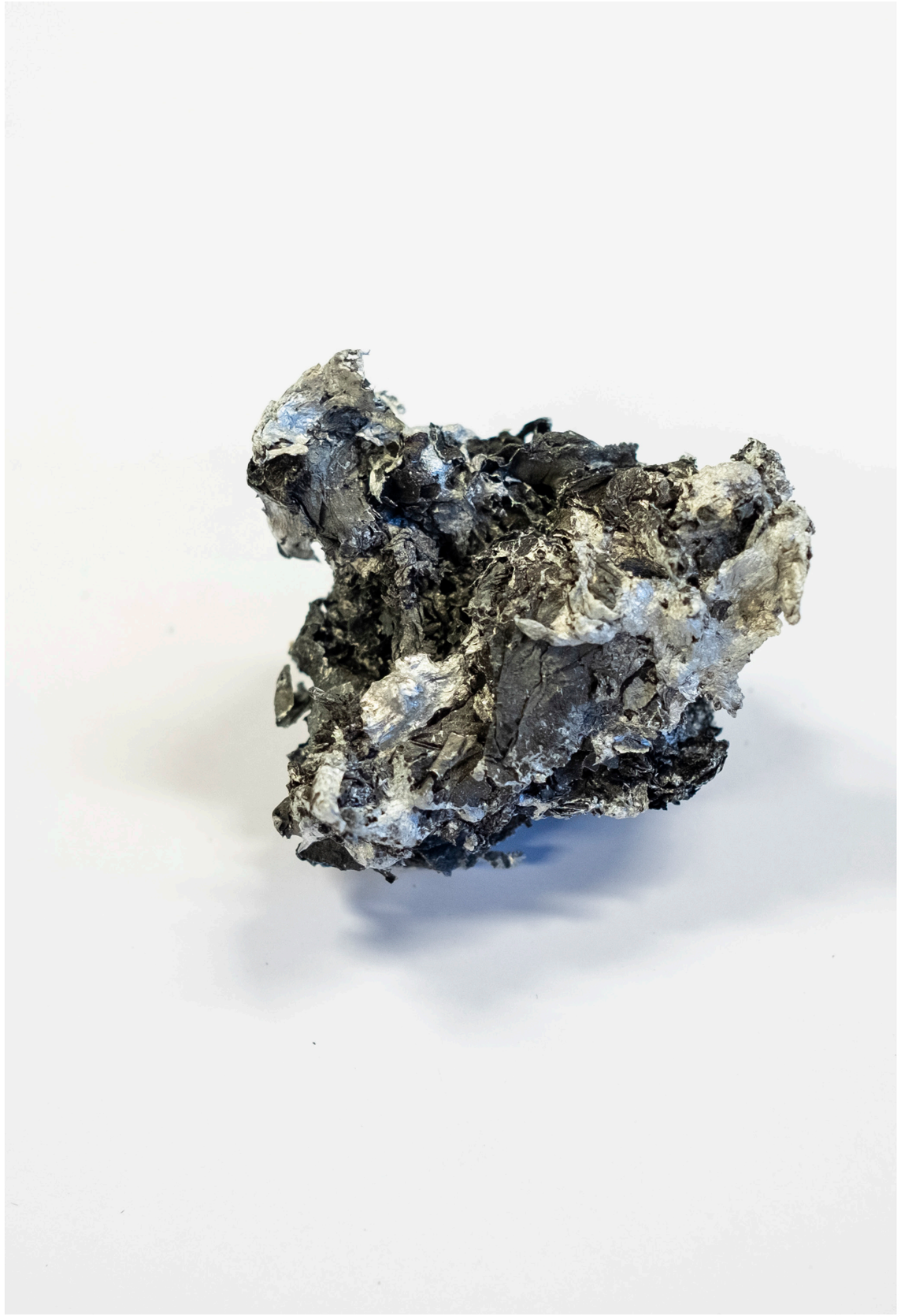
INTRODUCTION

INTRODUCING ALUMINIUM DROSS

Aluminium has a broad span of uses and can be altered by mixing in small amounts of other metals such as magnesium, zinc, copper, lead and more to cater to a specific use. An alloy created for a specific product or purpose will have a particular blend. For example, Hydro producing the aluminium for the case backs of iPads will develop a specific alloy blend that consist of a variety of other metals and will create the characteristics that Apple are looking for. After the aluminium is created Hydro is left with a lot of slag from the aluminium development, this is dross and is sent up to Real Alloy in Molde, Norway where the aluminium is extracted the from the dross and sent back to Hydro, this is a very energy consuming operation. The dross is extracted several times until it's no longer economically justifiable. Real Alloy are then left with powdered aluminium oxide and salt slag. The aluminium oxide is sent to Germany to be used in cement and the salt slag is disposed of.

The problem with dross is when aluminium scrap is recycled, the iPad case back that has a certain aluminium blend is mixed with many other blends which are developed to fit their own specific use. This will result in the dross differentiating for each recycled batch, making it difficult to predict the content and thereby the attributes. That is one of the reasons it is difficult to find a use for dross. Picking up a piece of recycled dross you will find it to be reasonably easy to break apart as it does not bind well but mix in a little aluminium and the dross becomes remarkably more robust.

pencil tracing of aluminium dross texture



WHY DROSS?

My main interest in design lies in material exploration and how to manipulate it. I have prior to this project done several types of wood, ceramics, fiberglass and self-developed composite material exploration projects. I initially intended to work with aluminium, but as I researched the material, I came across aluminium dross, the byproduct of the aluminium smelting process. Dross as a residue material has few known uses and other than the Wikipedia description of aluminium dross there was surprisingly little information about how to process it other than just extracting the aluminium, which is how the aluminium industry currently treats it. I decided to continue with this material as it was an interesting contrast to my previous projects while at the same time being material exploration, which I'm familiar with. The many unknown factors of dross led me to explore if the method I used could be applied to other material exploration projects in the future. I found the from-ground-zero approach of having to learn everything from building a furnace to define the unobserved attributes interesting, but I could never have foreseen the complicated challenges that came with the task.

BACKGROUND

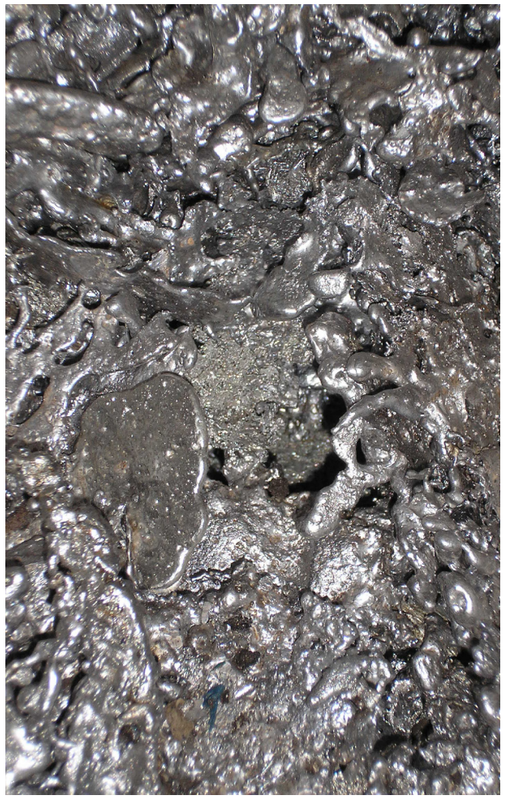
Dross is generally split into two types: white and black dross. White dross contains larger quantity of aluminium and comes from the primary aluminium refining process. It roughly contains between 18% and 70% aluminium. Black dross on the other hand contains less aluminium and is generated from recycled aluminium. It’s a mixture of aluminium oxides and dross, with a content of 12 to 18% recoverable aluminium. This project will be working with recycled aluminium and thereby using black dross exclusively. The difficulty of not finding use for aluminium dross is not a recently discovered problem, but there is an abundance of this by-product and the salt-slag is, as of now, being thrown in landfill. As my experimentation does not have access to the industrial level equipment the results will differ. The smaller quantities of aluminium and dross casted will mean that this project will not need to add salt to cool down the mixture, meaning that all the material will be utilized, and no salt-slag is to be disposed of. On the other hand, casting raw aluminium scrap such as aluminium cans will add other materials such as paint, labels, and other impurities. These impurities float to the top as the pure aluminium is heavier and will at times influence the outcome.

GOAL AND CHALLENGES

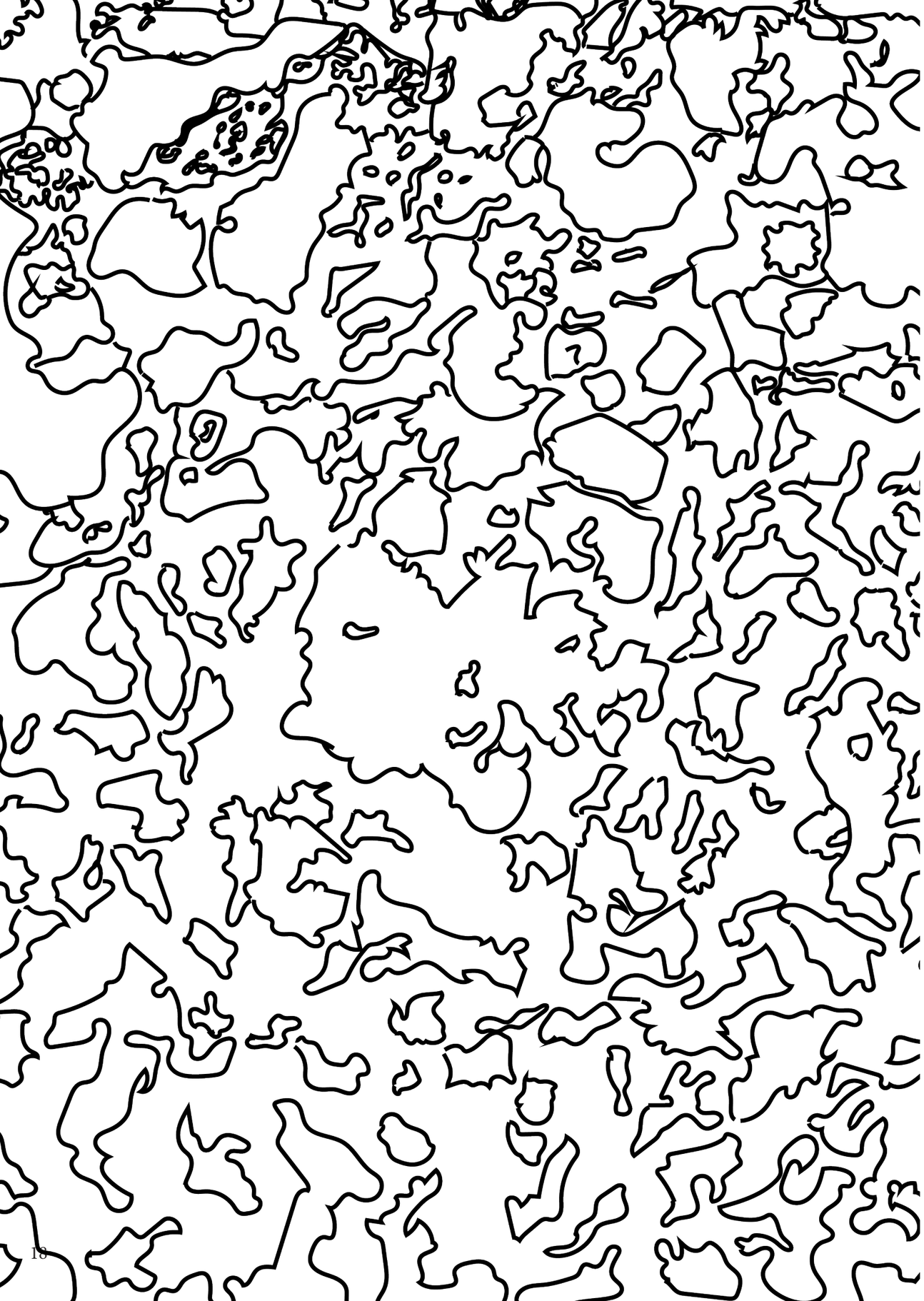
The goal for this project is to explore and manipulate dross to the extent to which I will have a building material, which I will then form after the attributes of the material into a product of interior design. If this project could utilize dross and give it a more sustainable life cycle it would turn the aluminium industry to a more sustainable option and reduce the waste of recycling aluminium. The outcome would ideally be an exploration of dross as a unwanted by-product of the aluminium production line to become a more sustainable material with a purposeful use. For me to then test my form giving abilities according to the attributes of this new composite material.

The main challenge this project faced was that dross never consists of the same amounts of residue, meaning that though a large part of it is aluminium it contains different levels of magnesium, iron, sodium, copper, beryllium, iron, lead, etc. Depending on the ratio this will give varying results when casted. Scrap aluminium from recycling such as soda cans will add labels and plastic film in the mix as well. The goal was to communicate the findings and uses of dross, a rest-material with inconsistent levels of impurities. Consistent results are essential when trying to map out a new material, so getting around that was the first step towards mapping it for experimentation.

The second challenge was sustainability. Parts of dross is currently used as filler in asphalt production but creating a new lifecycle that could see this as a green material was a challenge that seemed fairly straightforward until my understanding of the material and its process revealed that all my attempts all had it end up back in the landfill.



Aluminium coated dross



PART 2

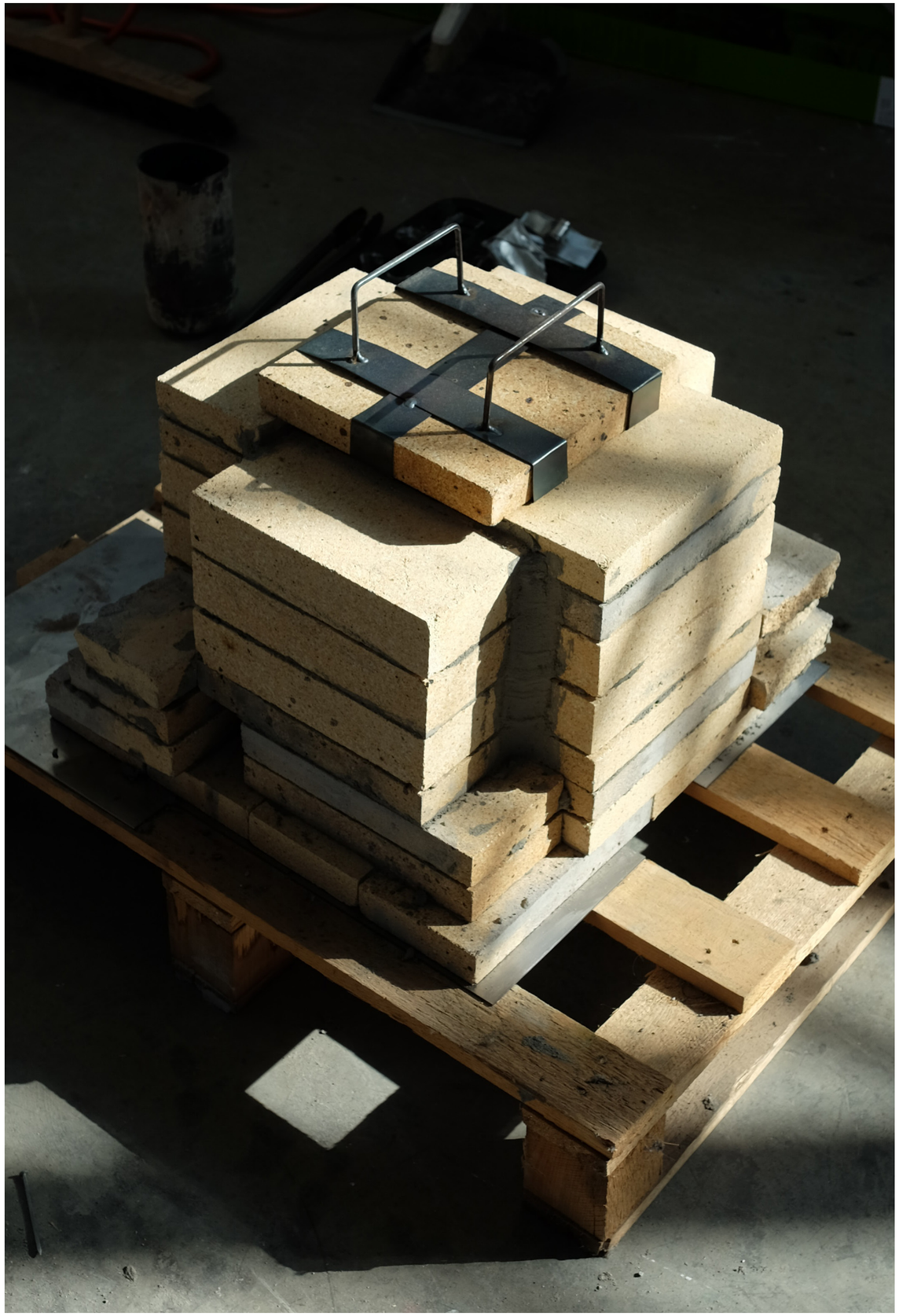
THEORETICAL AND PRACTICAL EXPLORATION

INTRODUCTION

Starting this project not knowing the outcome made me look to how I could record my findings in an orderly fashion to separate valuable from inconsequential results. The answer was an experiment diary form that would be filled out for each experiment to then implement the changes in the next experiment. For almost every experiment a choice would have to be made to determine the most beneficial foundation for further exploration. As this project was equal part finding value in dross and equal part value of the process, the method used for determining value should not be a method for dross specifically, but something that could also be applied to material exploration projects in general. This was, compared to the pragmatic approach of the diary, a method that was more design oriented.

GROUNDZERO

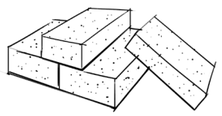
Finding value in a material with as little prior design-exploration as dross led to choosing a method that could alternate trajectory as the project progressed to cater to me separating valuable from inconsequential results. The aluminium and dross recycling industry don't shape or develop dross, but process it to extract aluminium and that's it. As the experts I talked to had never worked with dross in that way before, information like how well it binds and the amount of detail possible when casting it was something that I had to find out by myself.



THE FURNACE

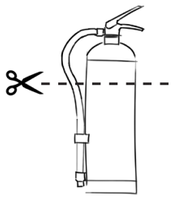
It took a week to finish the furnace. Building the furnace, I had to decide on a size which was tricky as I didn't know how much space I would need as I didn't know the outcome. The reason for this is that the aluminium dross is easier to get consistent results with if it's smelted in the mold, so the size of the mold aka the objects plus some should fit inside the furnace. I had to adapt to the size when casting but looking back I would have gone with a similar size to the 20x20cm inside space. The furnace was build using firebricks and fire-resistant mortar. For the mortar not to crack during burning it must be completely dry which takes three to four days. I placed the furnace on a wooden pallet but found out the hard way I needed a more fireproof base and ended up building a steel base to protect the ground underneath better. The crucible it is made from a fire extinguisher with the top cut off, this was done as the shape and steel wall thickness were favorable to making one myself. I chose to use propane over coal as this method of heating up the furnace seemed like the faster to heat up to 700 degrees meaning less time spend waiting before experiments.

FURNACE COMPONENTS



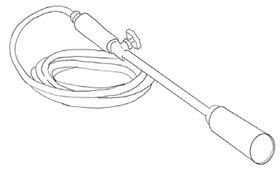
42x FIREBRICKS
50mm thick brick used to build the furnace

FIRE RESISTANT MORTAR
used to bind the firbricks as well as being fire proof

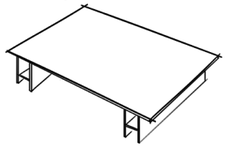


FIRE EXTINGUISHER
cut the extinguisher 3/4 from top and use as crucible

PORPANE TANK
heats the furnace, the easiest method in my opinion

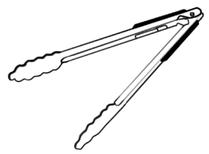


WEED BURNER
used to direct the heat through holes in furnace

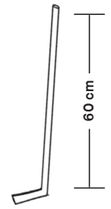


STEEL BASE
self made steel base, used to shield ground from heat

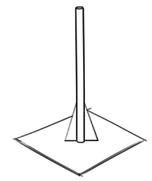
CASTING TOOLS



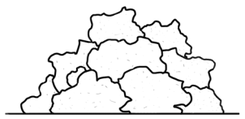
STEEL TONGS
used to handle crucible, dross lumps, other heated objects



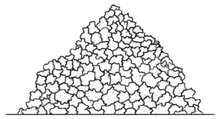
STEEL STIRER
used to stir and mix dross and aluminium to create texture



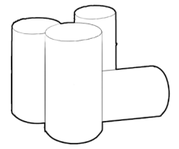
STEEL STAMP
used to fuse dross and aluminium and for flat textures



DROSS (x1)
aluminium scrap burned once will create dross lumps

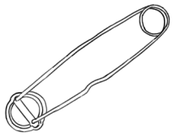


DROSS (multiple)
burn dross lumps and grind it to mold it with higher detail

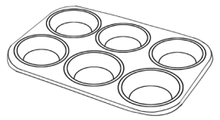


ALUMINIUM
Regualr aluminium or pure aluminium scrap for casting

ALUMINIUM CANS
when burning make sure they are completly disintegrated

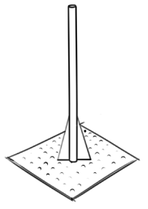


IGNITER
creates a spark that ignites the propane weed burner

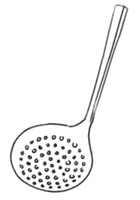


STEEL MUFFIN PAN
used to save excess aluminium from casting

PESTLE AND MORTAR
used to grind dross lumps



STEEL DRAIN STAMP
preassurize dross/aluminium creating a top coating



STEEL DRAINER
used to submerge floating dross in aluminium

EXPERIMENT DIARY

The day-to-day diary is a method I used to keep track of material findings and to later help me see patterns in my material exploration to determine value. The form is made to gather information on the reflection done after an experiment and how it might be improved to get better results. It also has an inventory list so I would know how to replicate the test should I choose to go back. The aspect of value is also listed shortly, this is done for two reasons one is the obvious; did I think this had any value at time of experimenting? the other is to go back and see what I thought had value through the project to get an overview of my path from the beginning.

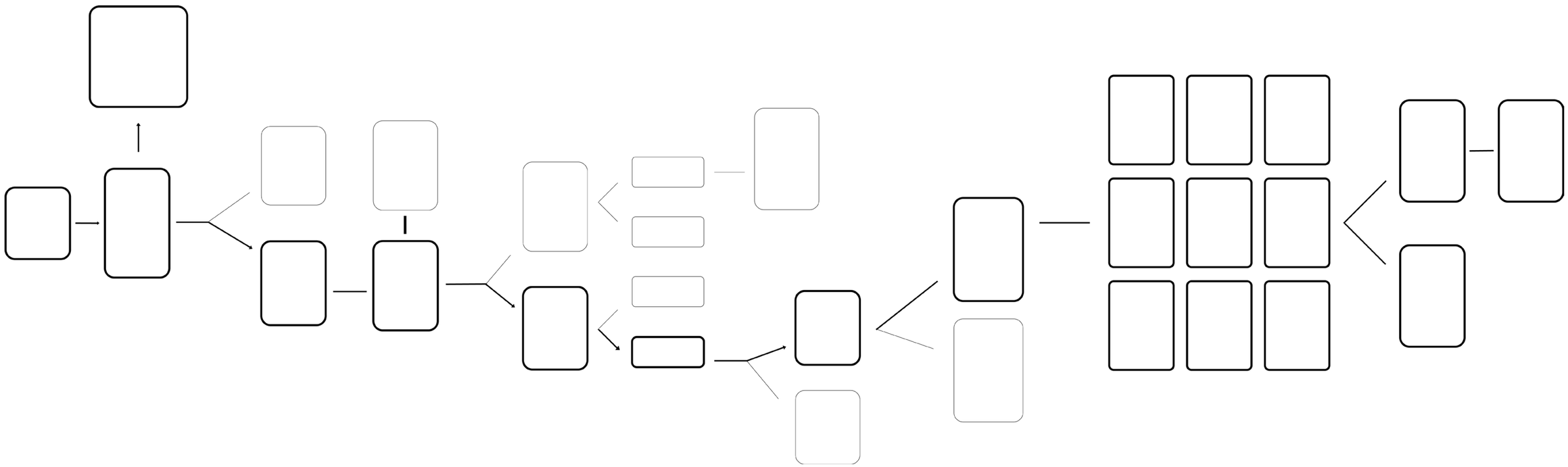
DAY / DATE	#
HEADLINE OF EXPERIMENT **Explaining the experiment and observations made**	

QNT	INVENTORY LIST	NOTES
-	Tools	What could have been done differently?
-	Molding equipment	How to improve this experiment?
-	Casting equipment	Does it have enough value to continue exploring?
-	Dross/aluminium amount	

EXPERIMENT: FAILED OR SUCCESSFUL (or both)

DETERMENING THE VALUE

This method was created to also be relevant for other material exploration projects, but works most efficiently together with an experiment diary, but it needed to have some consistent results before this method could be initiated. Once the material became familiar and the struggles where more detail oriented it was clear that dross is not a material that would suit a functional use. Recognizing the aesthetic value was a process of tracing the successful experiments across a timeline map and predict where the pattern might continue. A difficult aspect was that though I listed some of the earlier experiments as successful they collectively didn't have any similar characteristics to draw a conclusion on the pattern.



INTERVIEW

Jan Petter Angvik
Production supervisor at Real Alloy

The insight from Jan Petter was very rewarding, but recycling dross does not require casting or shaping dross with any precision and so the information was mostly focused on the process and how the result of my small-scale casting might deviate from the large machinery used at Real Alloy. The most usable information I got out of the interview was that they use salt when extracting the aluminium from the dross. It is used to cool down the aluminium, so it doesn't burn itself up (the faster you cool down the aluminium the less aluminium evaporates saving material). However, the salg combined with aluminium extracted dross turns into a salt slag mesh that is easier to handle for the industry but will in the end be thrown in a landfill. I saw an opportunity here as I wouldn't need to separate the dross from the aluminium so cleanly. The aluminium that the dross included actually worked as a binder and became the foundation for the following exploration.

The complete interview can be found at the back of the report.

LEARNING THE DISTRIBUTION

The first data I collected was through the post processing of the first material test. Once cut open it enabled me to see the flow direction of the aluminium when poured, which showed that the dross would follow the main flow and divert away from the edges. It also led me to pursue the fusing of dross and aluminium as this seemed like it could have potential.

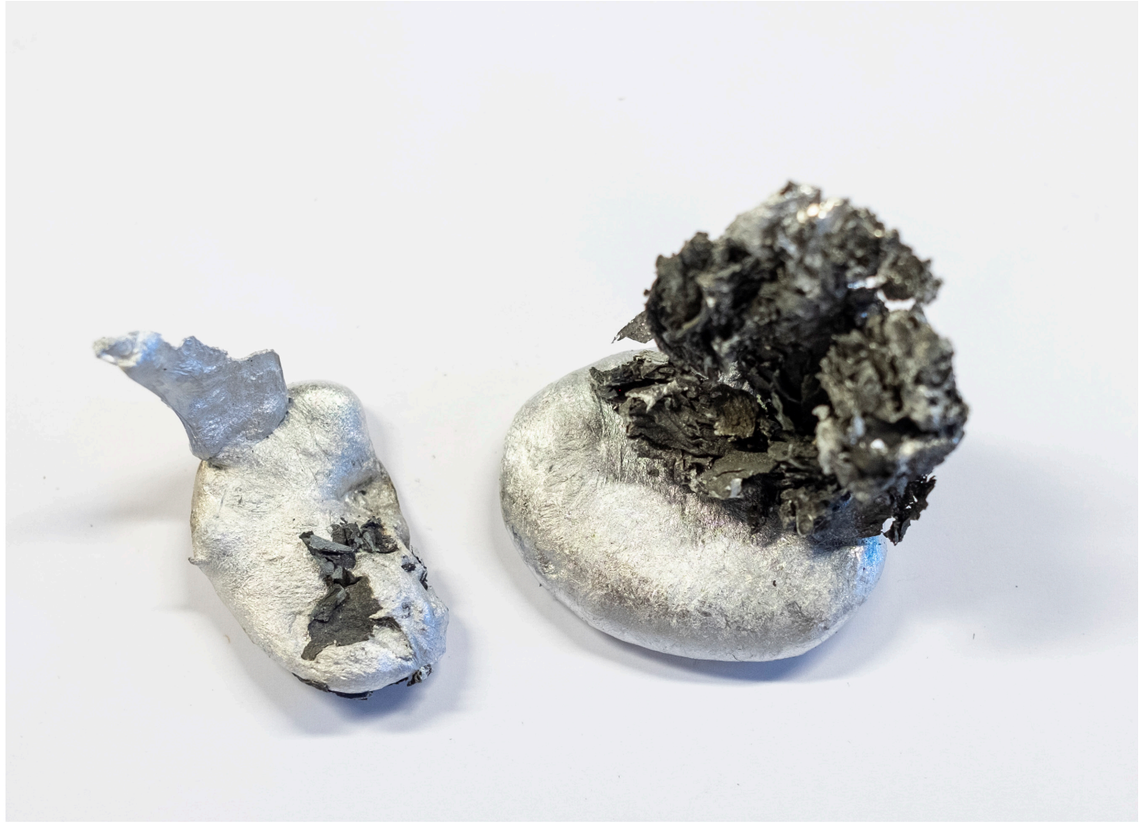
MONDAY 31.08	#5

POST PROCESSING MATERIAL TEST #1

Cutting, sanding and testing the attributes of the aluminium dross tests. Some contain more aluminium than others. It is clear that some of the dross test were not fully melted even though i stired it. Cutting the test open revealed that the dross was mostly on the surfaces. It looks like the flow of aluminium have pushed the dross to the sides and top.

QNT	INVENTORY LIST	NOTES
2	Aluminium mixed with dross	Some of the aluminium dross were still scrap, it just fused. 10 more minutes should do it. Try to preassurize the dross down in the aluminium to fuse it.
1	Aluminium shavings	
1	Aluminium and dross fused	3 pipe preassurized dross testing Pour 1 untouched, just as is Pour 2 mixing the dross and aluminium Pour 3 layers of alu, dross, alu, dross
5	Bundels of dross	
-	Mixed residue (testable?)	

EXPERIMENT: SUCCESS



FIRST TEXTURE

It will be a month before I go back to look at the second test I did to find this is where my project had the most value. The test included 3 pipes where I would test fusing aluminium and dross in three different ways. The experiment ended abruply as two of the pipes failed. The one that made it didn't fuse well, but did have an interesting texture. It was noted but the next experiment was

TUESDAY 01.09	#6

SECOND BURN (FIRST WITH NEW FURNACE)

With the new setup the first batch i threw in was already molten after 5min. Everything was going well for the first 20 minutes then the pallet caught fire and things got pretty hectic. The molten aluminium looked ready to go so I poured it into the first pipe which imidetly started leaking, I moved on to the next which turned out ok, but I ran out of material so I only got one out of three test. It makes it difficult for comparison so I'm preparing to make two new tests tomorrow.

QNT	INVENTORY LIST	NOTES
40	Aluminium cans	Weld bottom of pipes better. Layer the dross and aluminium so it fuses better. Find a solution to move the furnace around, maybe on something that dont burn... Probably only need the one propane tank for the next burn. Texture after sanding was interesting
9	Aluminium and dross tests	
4	Aluminium scrap sheets	
3	Steel pipes to pour tests in	

EXPERIMENT: FAILED (2/3 failed)/SUCCESS (1/3 was completed)

STAMP FUSING

The experiment of stamping the dross together to fuse it did not work as intended as the stamped surface did not create a good surface for binding the next load of dross.

THURSDAY 03.09	#8

STAMP FUSING THE DROSS

I created a pipe and filled it up with dross. For each “handfull” of dross I stamped it to fill out the pipe. Seemed to bind the dross untill I opened the pipe to realize that the dross did not bind to itself as I had stamped the dross to create a flat surface, making the next “handfull” of dross unable to bind.

QNT	INVENTORY LIST	NOTES
1	Steel pipe	To bind it better, don’t stamp it often, but wait until all the dross have fill the mold then preassurize it. It might be difficult as the dross cools down, it might not bind as well as when it’s hot.
1	Previous test	
1	Stamp tool	

EXPERIMENT: FAILED

DROSS CORE

The dross core test was an idea that was tested out to compare the attributes of a aluminium rod with an aluminium rod with a dross core. It led to some weight reduction, but it was impractical as the further results showed that the dross moved too much around and would rarely stay centered.

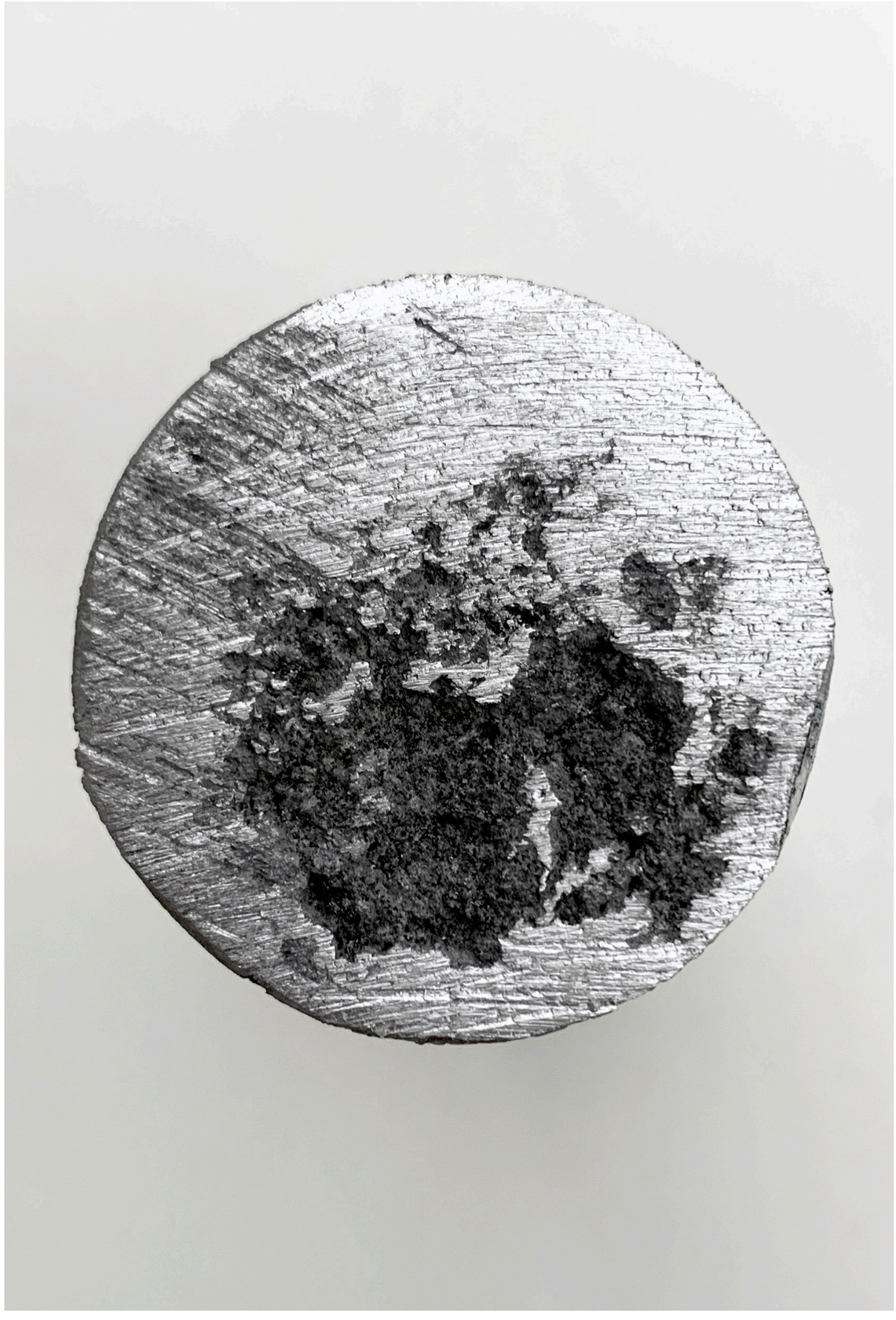
MONDAY 07.09	#10

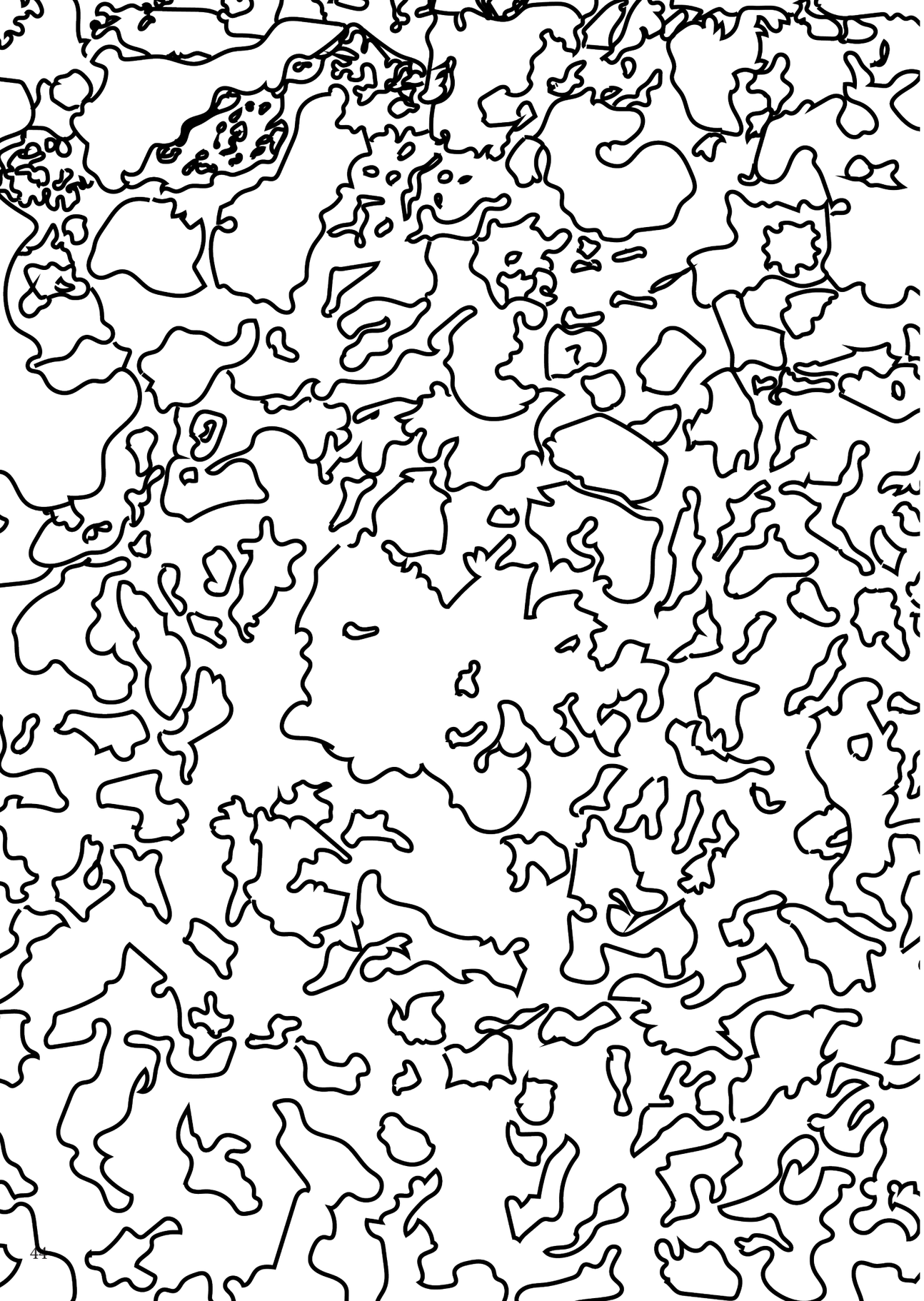
CASTING DROSS CORE

Casting the core test was fairly unproblematic. I filled an aluminium pipe with dross and again placed that in a steel pipe that was heated to the aluminium pipe was molten and had fluidly fused with the dross. It fused as good as I would think so over all a successfull test.

QNT	INVENTORY LIST	NOTES
-	Metal grinder	The dross core was somewhat lighter, but after casting it I don't really see any real value in it. I'm leaning towards the aestetics of dross rather than its functionallity.
-	Sandpaper (180, 260, 320 gid)	

EXPERIMENT: SUCCESS





PART 3

PROCESSING

INTERPRETATION OF COLLECTED DATA

It took a lot of testing for me to get familiar with the material and get to a point where I could start manipulating the results. I was still lacking consistent results as I would cast the same test twice and get different results. The information I had at this point was an understanding of how the flow of aluminium mixed with dross will hinder the dross from reaching edges and corners, how well dross binds with itself and with aluminium, the weight difference between the two and the discovery of the texture. The flow of aluminium and how it affected the dross distribution turned out to be useful in the later stages of this project as the focus turned more to the visual attributes. Fusing dross and aluminium was initially done with the intention to develop joinery, but the structural qualities of dross did not support that theory. However I find ways to implement this knowledge later on. The weight difference would not be used in a functional manner, but to visualize dross/aluminium ratio in models. The four outtakes from the early experiments show the progress of fusing dross and aluminium in various ways to trying to create a functional. After working with dross for a month and going through the experimentation diary I realized that the value of dross was probably not going to be a functional one. I recognized that with the resources at my disposal finding a functional use for dross was not the most efficient way of developing dross into a material of value.

TUESDAY 01.09 — #6

SECOND BURN (FIRST WITH NEW FURNACE)

With the new setup the first batch i threw in was already molten after 5min. Everything was going well for the first 20 minutes then the pallet caught fire and things got pretty hectic. The molten aluminium looked ready to go so I poured it into the first pipe which imidetly started leaking, I moved on to the next which turned out ok, but I ran out of material so I only got one out of three test. It makes it difficult for comparison so I'm preparing to make two new tests tomorrow.

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9	Aluminium and dross tests	
4	Aluminium scrap sheets	
3	Steel pipes to pour tests in	

EXPERIMENT: FAILED (2/3 failed)/SUCCESS (1/3 was completed)

MONDAY 31.08 — #5

POST PROCESSING MATERIAL TEST #1

Cutting, sanding and testing the attributes of the aluminium dross tests. Some contain more aluminium than others. It is clear that some of the dross test were not fully melted even though i stired it. Cutting the test open revealed that the dross was mostly on the surfaces. It looks like the flow of aluminium have pushed the dross to the sides and top.

QNT	INVENTORY LIST	NOTES
2	Aluminium mixed with dross	Some of the aluminium dross were still scrap, it just fused. 10 more minutes should do it. Try to preassurize the dross down in the aluminium to fuse it.
1	Aluminium shavings	
1	Aluminium and dross fused	3 pipe preassurized dross testing Pour 1 untouched, just as is Pour 2 mixing the dross and aluminium Pour 3 layers of alu, dross, alu, dross
5	Bundels of dross	
-	Mixed residue (testable?)	

EXPERIMENT: SUCCESS

THURSDAY 03.09 — #8

STAMP FUSING THE DROSS

I created a pipe and filled it up with dross. For each "handfull" of dross I stamped it to fill out the pipe. Seemed to bind the dross untill I opened the pipe to realize that the dross did not bind to itself as I had stamped the dross to create a flat surface, making the next "handfull" of dross unable to bind.

QNT	INVENTORY LIST	NOTES
1	Steel pipe	To bind it better, don't stamp it often, but wait until all the dross have fill the mold then preassurize it. It might be difficult as the dross cools down, it might not bind as well as when it's hot.
1	Previous test	
1	Stamp tool	

EXPERIMENT: FAILED

MONDAY 07.09 — #10

CASTING DROSS CORE

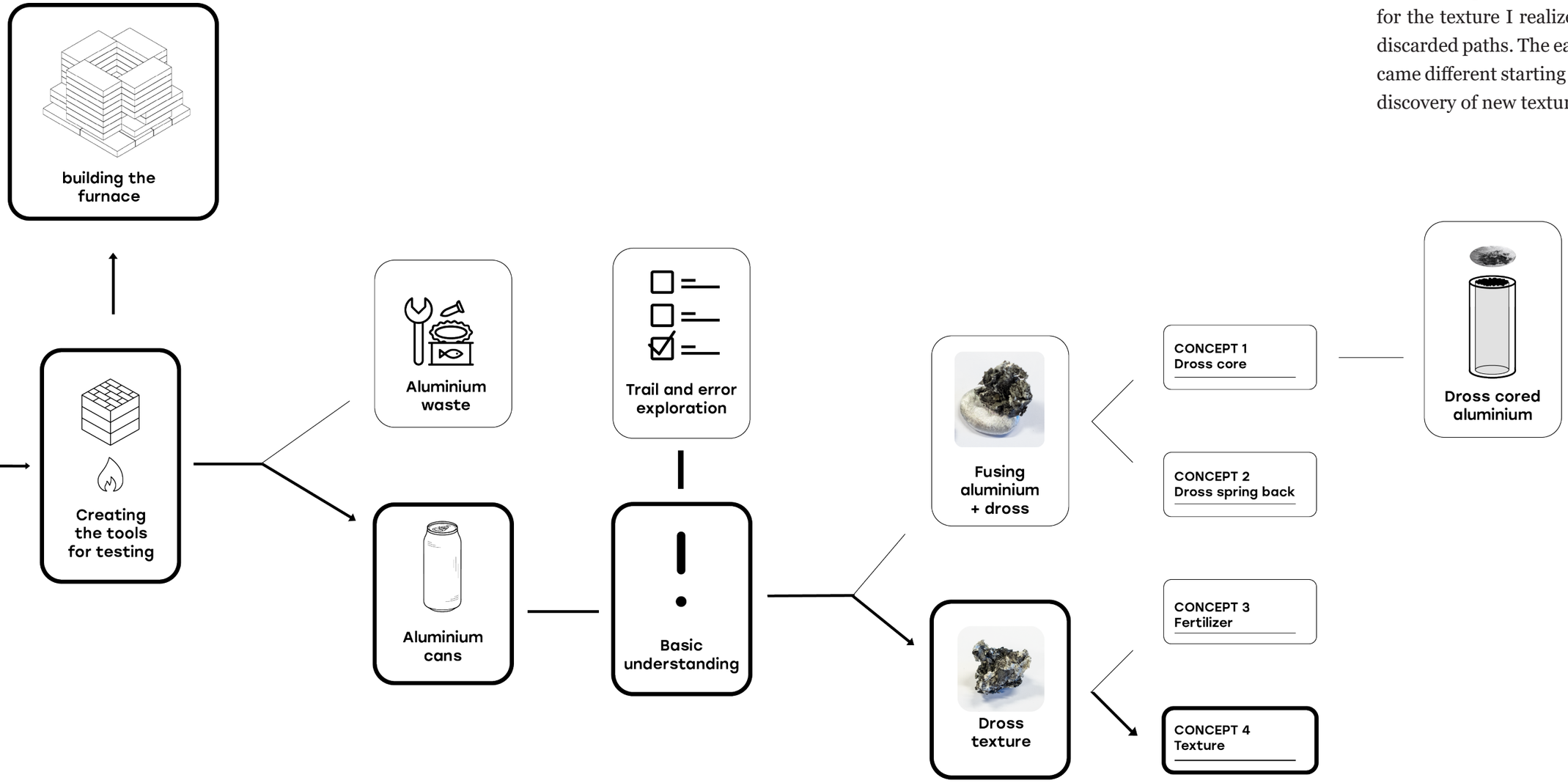
Casting the core test was fairly unproblematic. I filled an aluminium pipe with dross and again placed that in a steel pipe that was heated to the aluminium pipe was molten and had fluidly fused with the dross. It fused as good as I would think so over all a successfull test.

QNT	INVENTORY LIST	NOTES
-	Metal grinder	The dross core was somewhat lighter, but after casting it I don't really see any real value in it. I'm leaning towards the aestetics of dross rather than its functionallity.
-	Sandpaper (180, 260, 320 gid)	

EXPERIMENT: SUCCESS

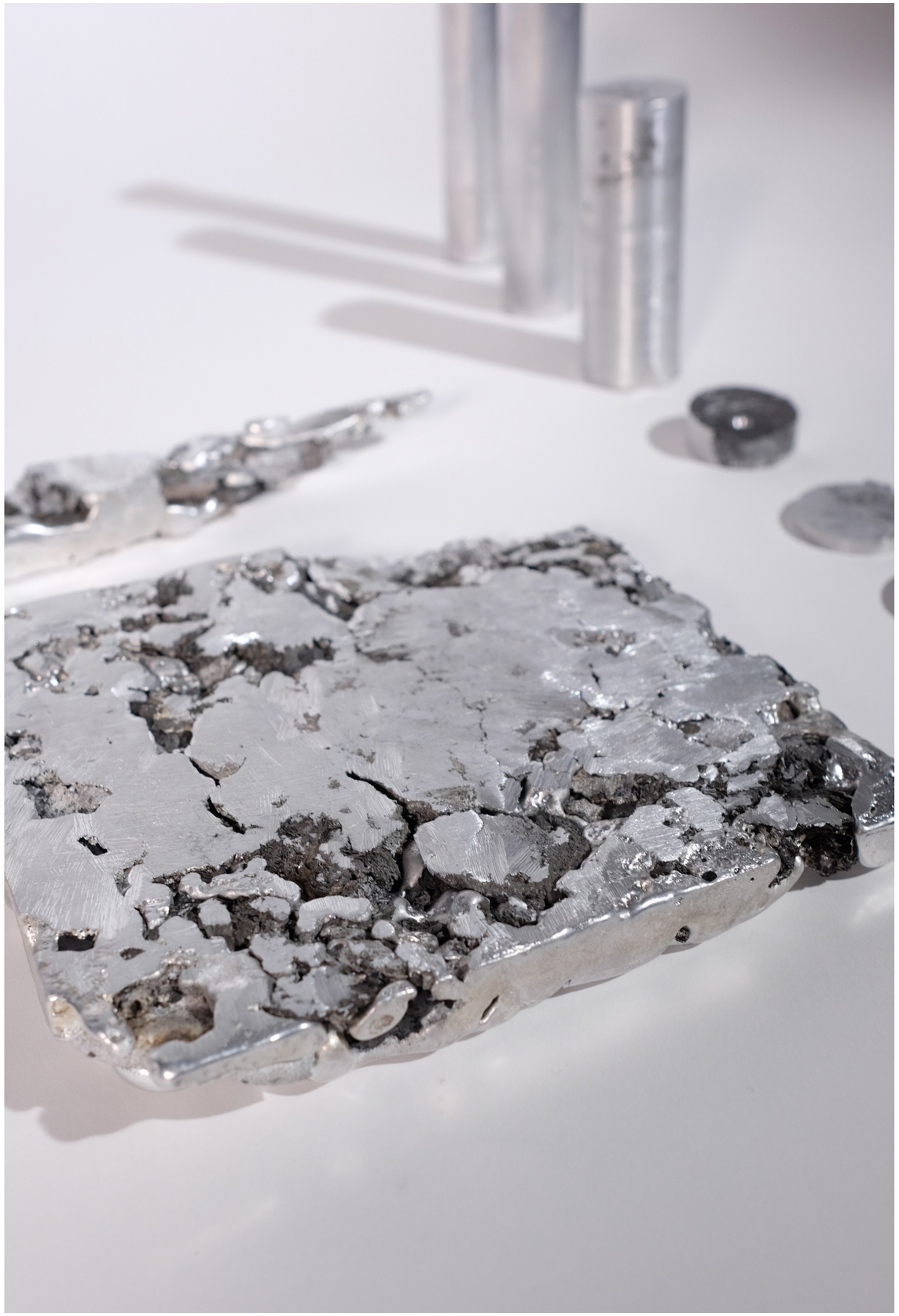
TRACKING THE PROGRESS

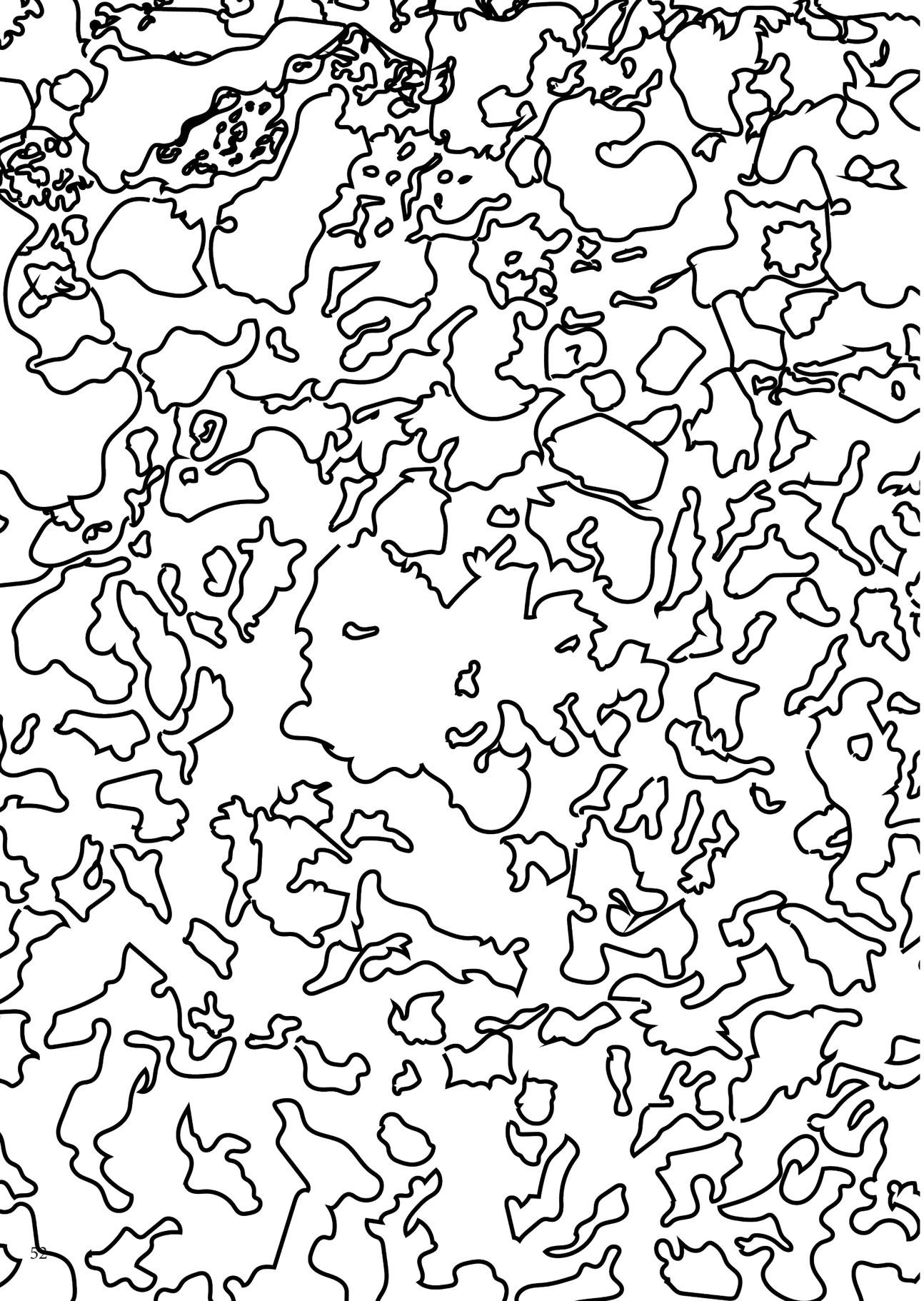
Creating the progress map revealed that every attempt to assign dross a value based on functionality ended in failure as the structural qualities were not durable enough. The one path that was not explored was the texture from the early test. In the process of creating a direction for the texture I realized the value of the discarded paths. The earlier attributes became different starting points towards the discovery of new textures.



WHY I DECIDED FOR TEXTURE

Dross is as you know by now a very unstable material in the sense that it consists of several materials. During the early testing I learned that dross is not extraordinarily structurally strong, it will become solid but not enough to give a consistent result where you can rely on the outcome. An early test revealed that the material has an incredibly unique texture and that the texture is never repeated twice. So, I decided to find as the many different visual attributes and uses the texture of dross potentially could have. The texture has some defining elements that makes it visually interesting from a designer standpoint. The contrast of the light and reflective aluminium versus the dark “pits” caused by dross was the one aspect of dross I found remarkable. I concluded that if the texture never repeats there had to be several other textures I could produce.



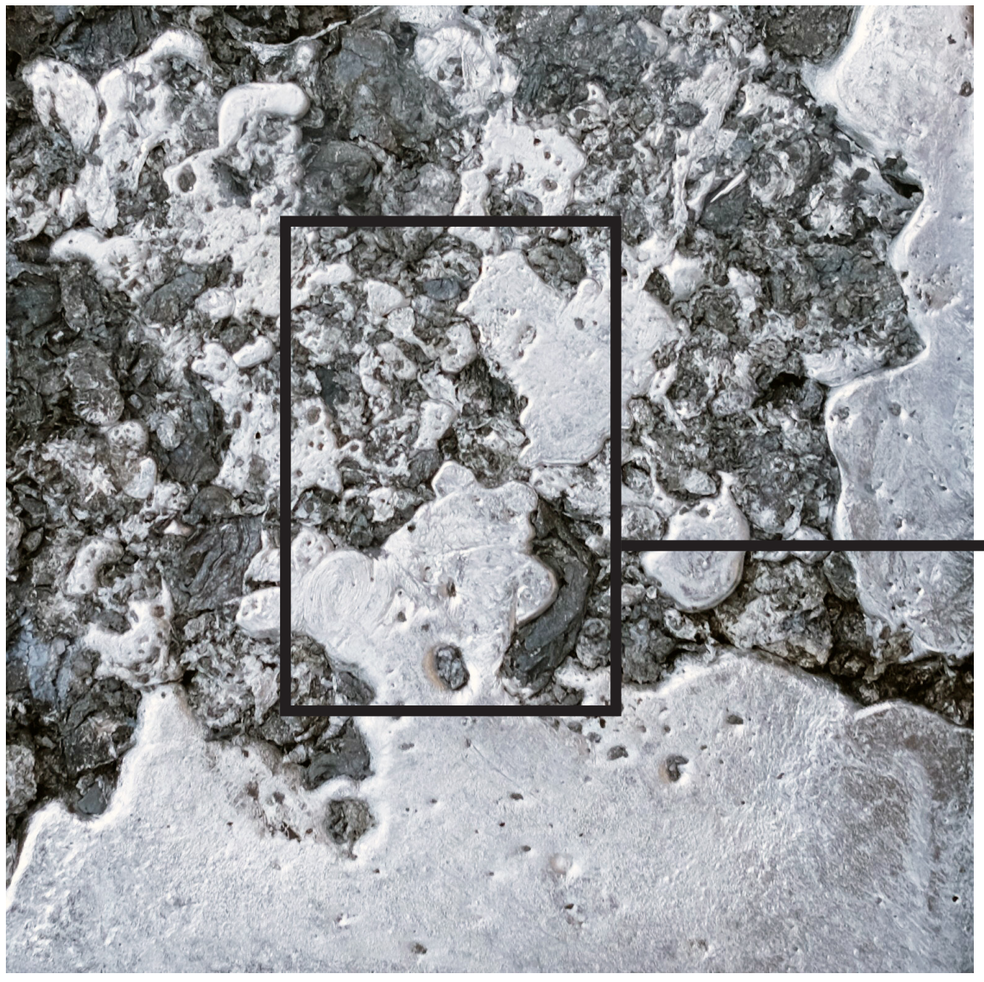


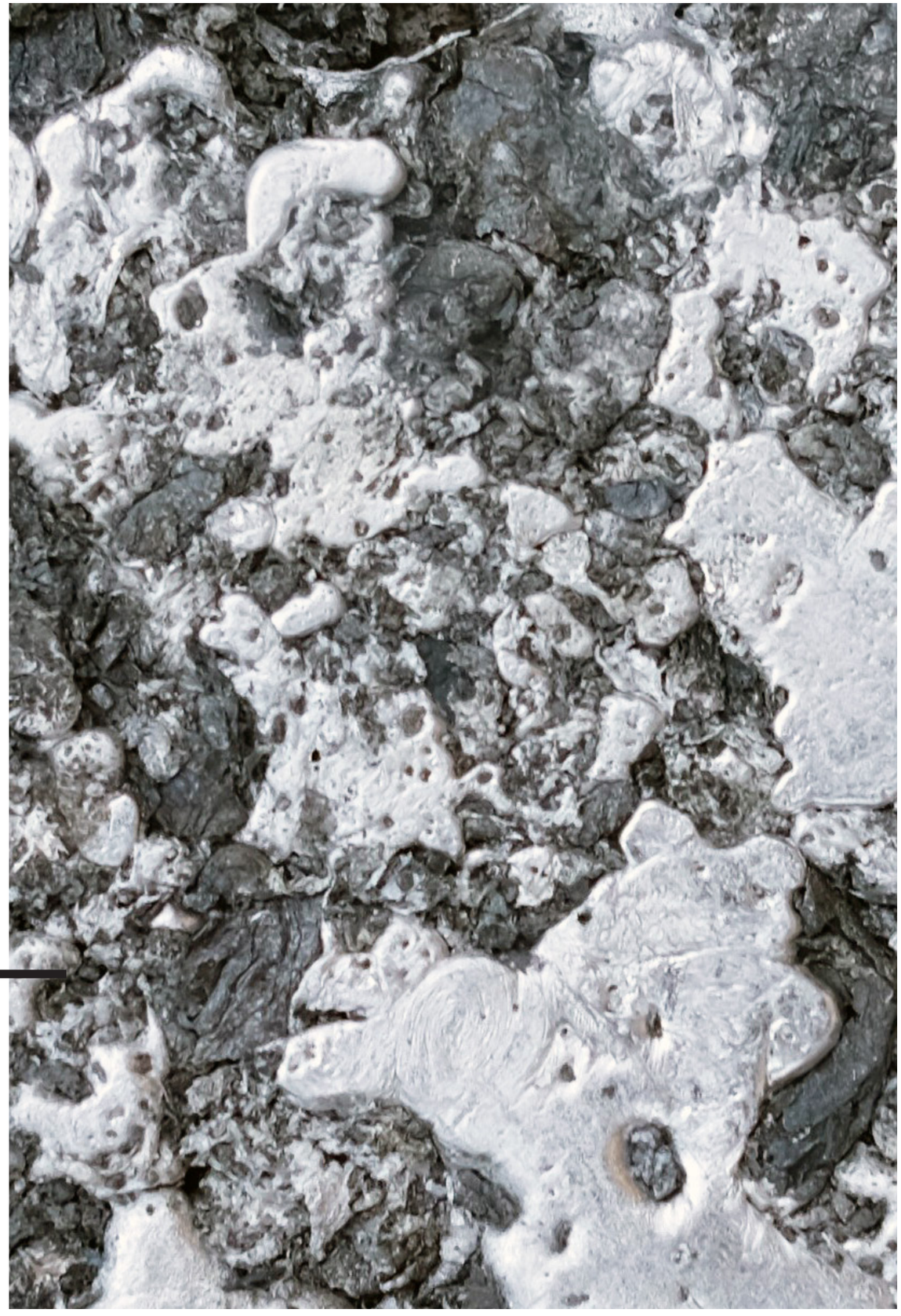
PART 4

EXPERIMENTATION

INTRODUCTION

The experimentation phase revolved around creating visually unique textures and thereby aim to develop the value of dross. The visit to the dross recycling facility in Molde taught me about the various states of dross before and after aluminium extraction. The methods used to efficiently process dross was not possible for me to replicate as the scale affected the end result. But it did open up for me to replicate the methods in my own way and with focus on developing unique textures.





REAL ALLOY, Molde

Aluminium dross recycling facility

I had spoken to Jan Petter Angvik, the production supervisor at Real Alloy, who ended up inviting me to Molde to have a look at their facility and how they recycle dross. The function of this facility is to extract aluminium from dross as efficiently as possible. They receive dross from several aluminium productions in Norway wanting to extract the aluminium from their dross. The remaining dross is after extraction mostly aluminum oxide and salt. The salt is used to separate the dross from the aluminium as well as cool down the dross to preserve its aluminium content for further extraction. If not cooled rapidly the aluminium will stay at a high enough temperature to evaporate itself. The salt/dross slag that is left over at the end is not recycled but transported to landfills.

The picture to the left shows the dross and salt-slaf floating on top the molten aluminium after the

TYPES OF INDUSTRIAL DROSS

The various types of dross produced at the Real Alloy facility are made with machines that can't replicate with my setup due to the size and mechanisms. The dross sorts pictured on the next page are surprisingly visually similar to one another other than that some sorts are grinded. Visually there was not much inspiration to gather, but the different processes gave me ideas on how to process the dross I was working with.

The types are

Recycled aluminium cans (similar to my own casting results some cans had not been melted all the way)

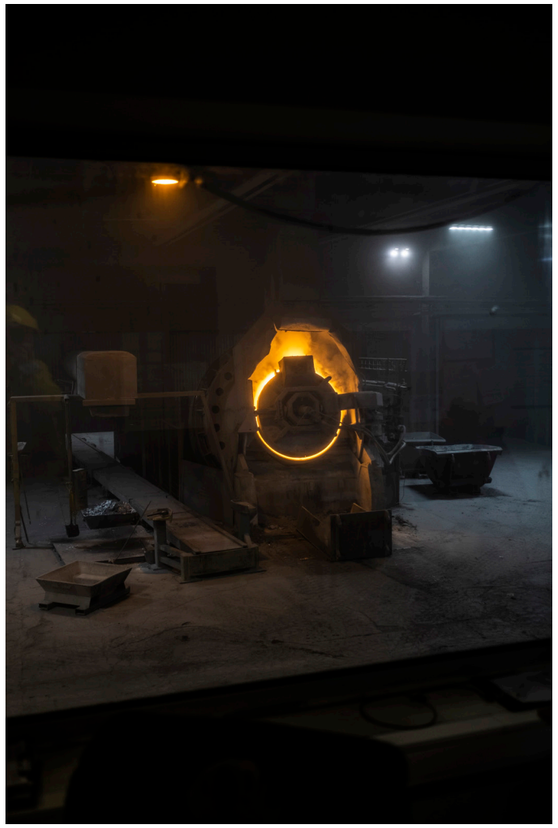
Preassurized dross, this is named so as the dross is heated up then preassurized to extract aluminium. I adapted this idea to use preassure to fuse and flaten the texture.

Drum cooled dross, is the type of dross that will be extracted and cooled in a rotating drum. The scale is a big factor for this to work so it restricts me from recreating this type.

Air cooled, pretty straight forward, it is cooled in the open, much like how I conduct the cooling of my experiments.

Grinded dross, is dross shapes roughly grinded. This is done after the dross has been through at least one extraction

Finley grinded, similar to the above, but grinded to a finer powder.



LOT 9

Straight from customer
Recycled aluminium cans

LOT 14

Air cooled dross

LOT 12

Preassurized dross

LOT 22

Grinded dross

LOT 13

Drum cooled dross

LOT 22.5

Finely grinded dross

DRAIN THROUGH TEXTURE

Being able to separate dross from aluminium opened for manipulating the texture. The separated dross would be cooled off and grinded to then be sprinkled in a mold. This way the dross wouldn't shy away from the sides and corners once the aluminium was added. Pouring molten aluminium over the dross resulted in a two-sided model, one was near pure aluminium and the opposite side was covered with dross. Though the importance of the find was in post processing when cutting the top "lid" of the model to show the dark air pockets in contrast to the aluminium. Compared to the first texture test this was more durable, though that was mainly because of the higher amount of aluminium.

Using a pencil to sketch over the textures highlighted the characteristics. This brought out the variety of the textures casted so far and was a method I used to record the variety textures that was casted using the same method.

THURSDAY 10.09	#12

POURING ALUMINIUM OVER DROSS

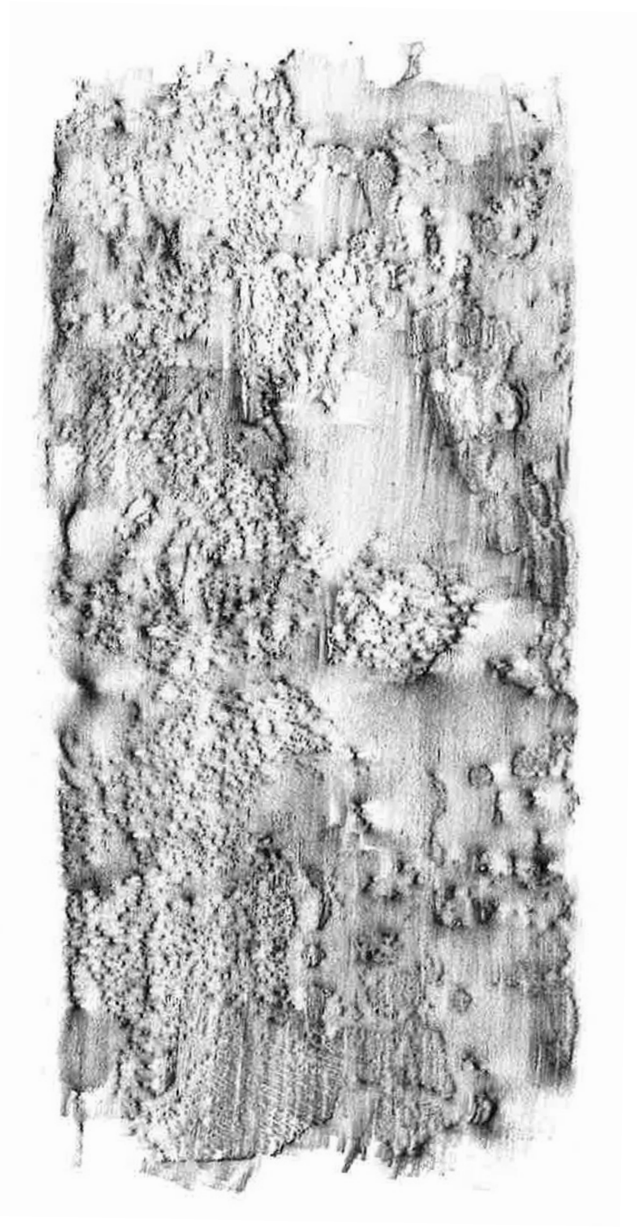
The box for the sand casting of the dross core test is ready. It's 300mm high which mean the test will probably come out as 200mm ish. I would prefer to have the cylinder shape as small in diameter as possible, but the real issue it how to cast the dross in a cylinder. I'm thinking I will have a pipe with a plate welded on the bottom and scrape and pour the dross in and push it down so it hopefully fuses enough to maintane the cylinder shape.

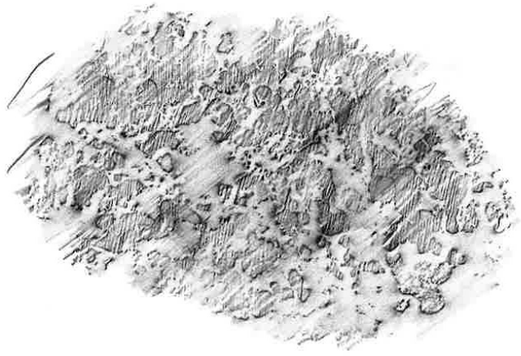
QNT	INVENTORY LIST
5	300x300mm plywood
-	Casting sand

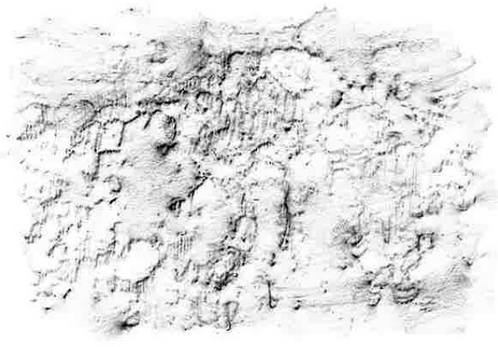
NOTES

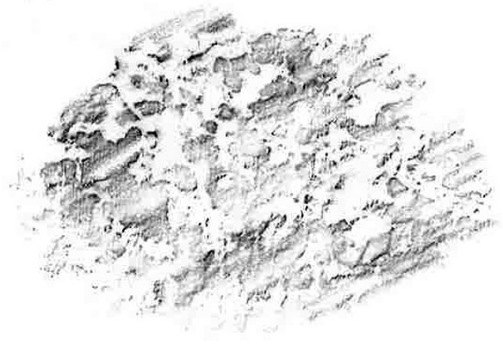
Should have made the sand casting box higher than 300mm, so the bend test could be done easier.

EXPERIMENT: SUCCESS









DROSS/ ALUMINIUM RATIO

By submerging the floating dross into the molten aluminium I was able to get consistent durability with different ratios of dross/aluminium. The one pictured to the right is 50/50 dross/aluminium in volume before casting. The method proved to be very usefull when scaling up from flat surface textures to modeling shapes, but the real turning point was to place the mold in the furnace insteead of mixing the dross and aluminium in the crucible to then pour it in the mold. This gave me a lot more control over the situation and led to a variety of uniqe textures.

TUESDAY 27.10 | #13

ALUMINIUM FLOW THROUGH TEST

Texture No. 7 this will use the same molding technique as the previous texture, but with a different ratio of dross/aluminium. A very practical texture as it will be visible unique with the advantage of being durable as the aluminium works as a coating and binder. The texture is roughly 1 part aluminium to 1 part dross in volume.

QNT	INVENTORY LIST
1	Perforated steel plate
8	Steel wall pieces
4	Steel rods
-	Casting sand

NOTES

I think I might be onto something here. it seems that when the dross is placed in the mold beforehand and the aluminium is heated to the point where the liquid sinks it creates a really solid outcome. I have to check the consistency

EXPERIMENT: SUCCESS

CONSITENT RESULTS

WEDNESDAY 04.11 | #13

POST CAST: MAJOR BREAK THROUGH!

Major break through. The aluminium reduction test was never completed, but the casting structure I made proved to have some advatages for getting consistent results. Instead of having a perforated bottom plate, I filled the bottom with a thin layer of casting sand. I then poured dross from previous test that is pretty fine grinded in the mould and placed over aluminium over. I had it in the furnace for about 10min when the aluminium was molten and the dross started to move upwards. I stoped the furnace and let it air cool.

QNT	INVENTORY LIST	NOTES
1	Aluminium reduction tool	The arms on the structure needs more reinforcement as the heat started to softed up the thin steel arms holding up the structure tool down below. I will try to make simple shaped and cast therafter. I'm not sure if I'll still need casting sand, but ill try with just to be safe.
1	Layer of casting sand	
1	Handfull of grinded dross	
1	Dross/aluminium slab	

EXPERIMENT: SUCCESS

CASTING TOOL IMPLEMENTATION

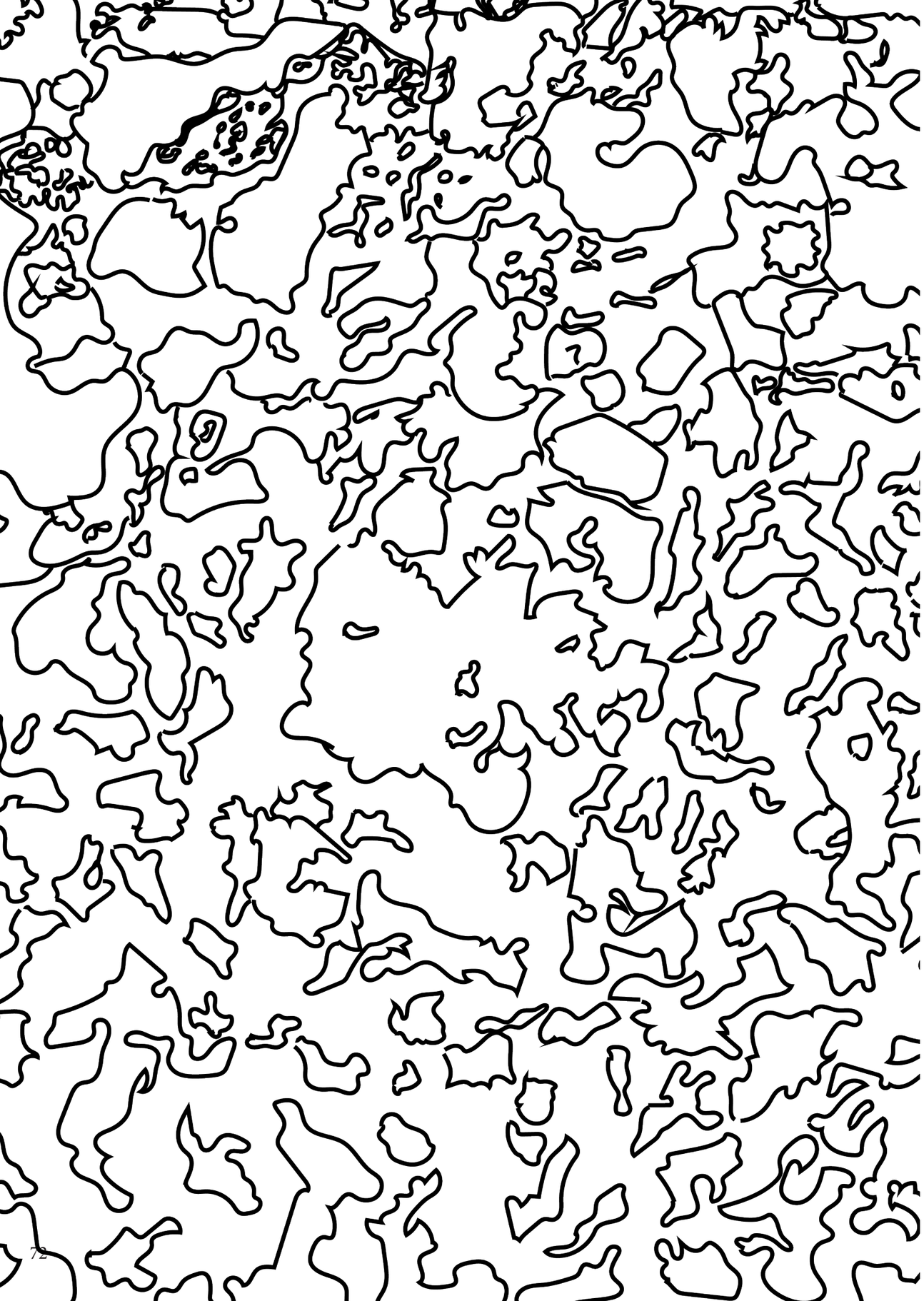
FRIDAY 13.11 | #19

MOLD CASTING

I've been mold casting as I've started calling it. This really seems like the way to get various textures with consistent result. I've sliced all the tests up to see how well the dross and aluminium have spread out and they all look it's pretty evenly distributed. Casting dross in the mold led me to develop tools to manipulate the texture samples. This texture was created by stiring the molten mixture.

QNT	INVENTORY LIST	NOTES
1	Steel stiring tool	stiring the dross when the aluminium is molten will blend it, but it's hard to know if the dross has moved all to one side before seeing the cooled outcome.
1	Steel mold	
1	Handfull of casting sand	

EXPERIMENT: SUCCESS



PART 5

PRODUCT DEVELOPMENT

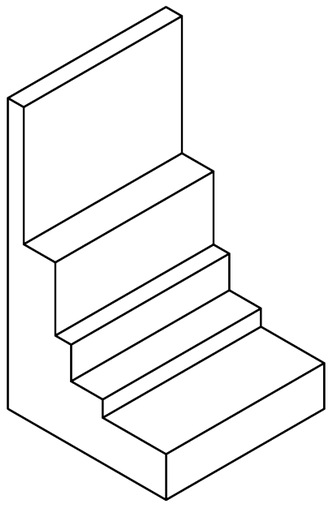
TRANSLATING TEXTURE INTO SHAPE

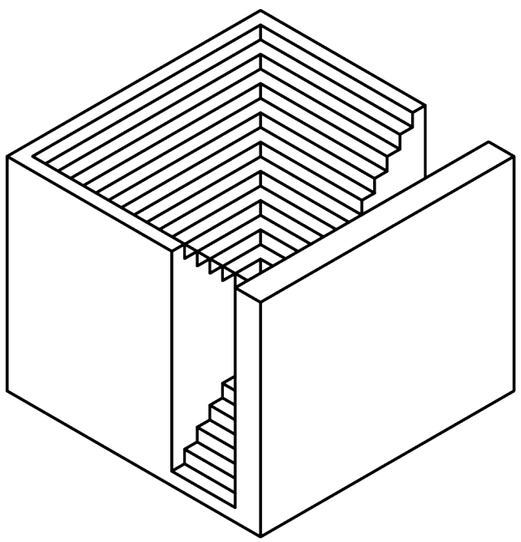
Converting the developed textures into models was a challenge as casting dross is not a particularly easy in itself. Making models that would represent these textures in three dimensions had me turn to the analyzing of the attributes so see what a good fit would be. I found a design style that suited the casting method, the attributes and the characteristic of dross very well. This helped me design shapes for detail limitation testing as well as structure products.

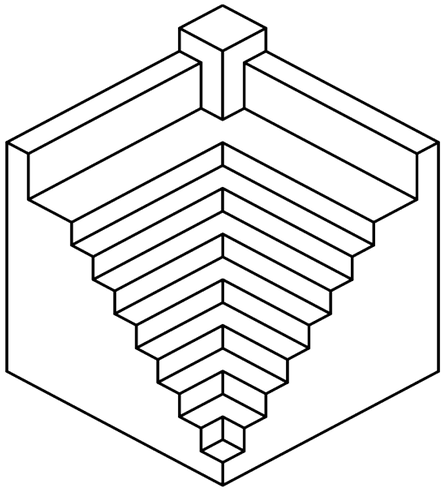
VISUAL PARAMETERS

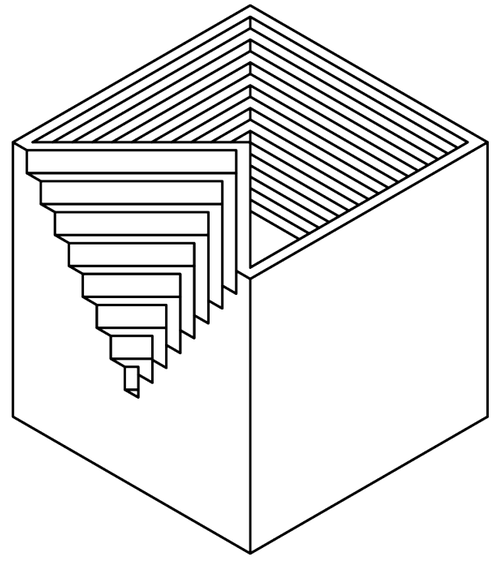
When designing the model for the visual parameter tests I came across Carlos Scarpa. A brutalistic and modernisitc architect that designs using classical geometrical shapes. I discovered that brutalism is a design style that suits this material perfectly. The geometrical characteristics of brutalism are generally large voluminous shapes and perceived as rough. This correlates well with the attributes of dross and are one of the reasons I chose to showcase a product in that design style. The voluminous shapes give room for the dross and aluminium to be mixed evenly, removing some of the weak and difficult aspects of casting dross.

The design I chose was the one pictured top right on the opposite page. I chose this as I felt this had the most unique shapes and would therefore be the best representation of the various casting limits of dross.



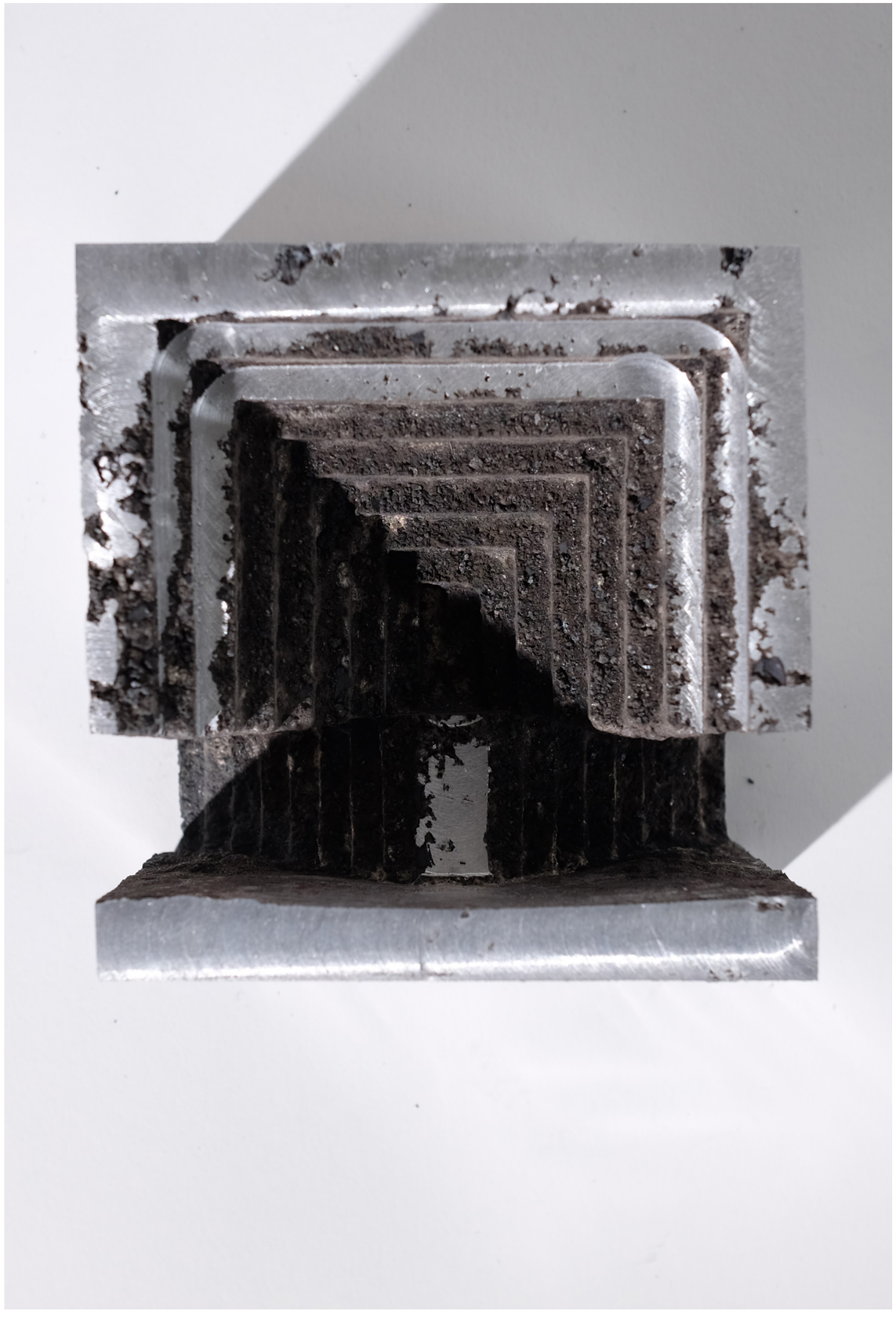






HIGH DROSS amt.

The first test I casted was the one with a high dross to low aluminium ratio, same as the NO. 7 texture. This, as expected, proved to be too unstable as parts of the dross didn't bind well and fell off. Though failing to hold it self together, it did provide the information of what happens when the casting mixture has too much dross.



HIGH ALUMINIUM amt.

The second test was based off of one of the textures (NO. 1) where I would fill the casting sand mold with dross then add aluminium. It did create a separation between the two materials, where the dross would be at the bottom of the mold (meaning the top when flipped after casting) and the aluminium at the top. This method does fuse the two very effectively and that resulted in a heavier, more durable parameter than its

SHAPING THE TEXTURE

Designing a product, I was intrigued to explore how the dross texture would work with light. I sketched out a couple of simple geometrical shapes that followed the guidelines of the visual parameter models. I ended up casting figure 3, as this was one of the models that had mass and would have an easy to mold to make so giving myself room to fail at the attempt of casting it. The lampshade is of the same dross/aluminium ratio as the visual parameter model with high aluminium content. Using the mold-casting technique I created the lampshape mold out of steel and filled it with dross and aluminium scrap in layers.

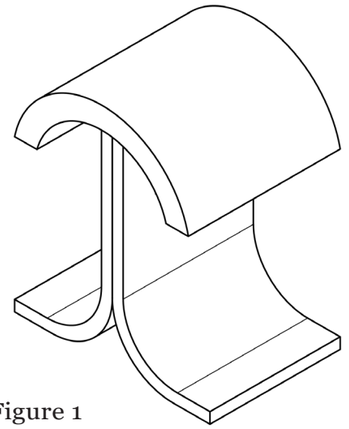


Figure 1

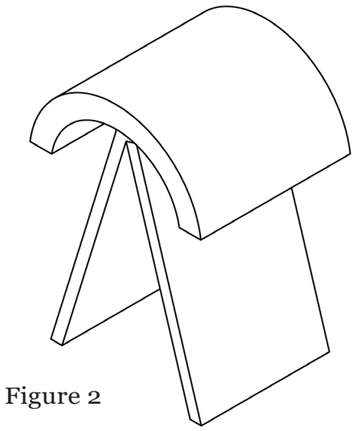


Figure 2

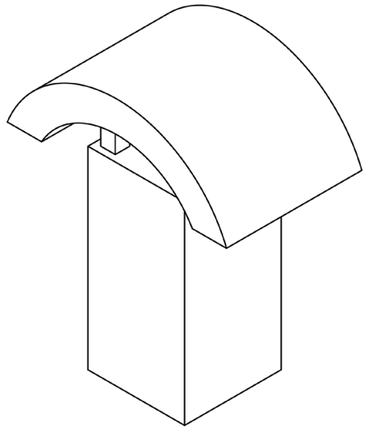


Figure 3

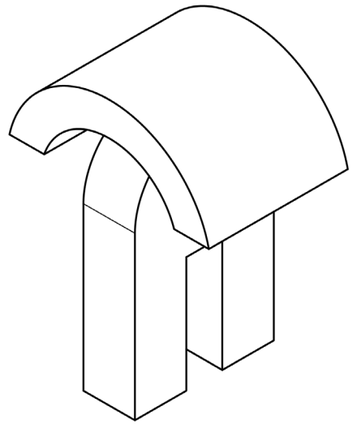


Figure 4

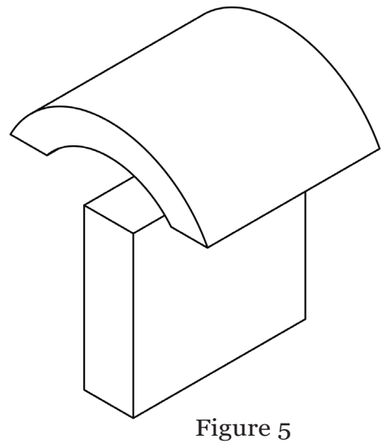


Figure 5

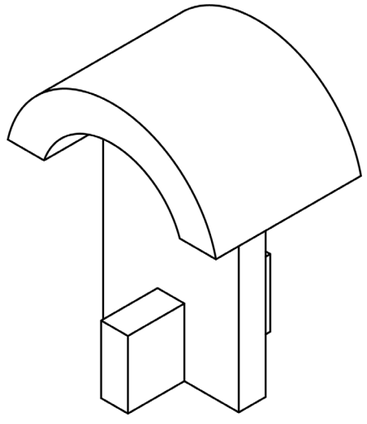


Figure 6

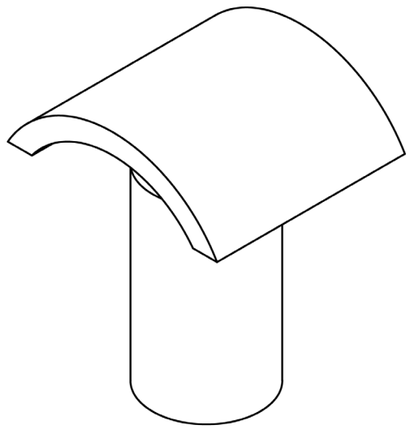


Figure 7

MONDAY 30.11 | #24

CREATING THE LAMPSHADE STEEL MOLD

The lampshade mold was pretty straightforward. The mold pictured on the right is how the final one came out. Filled it with dross and aluminium layers.
Now I just have to wait for the rain to stop so I can cast it.

QNT	INVENTORY LIST	NOTES
1	2D drawing to trace shape	The more upright (higher) a mold is the easier it is to blend - true or false?
5	Metal sheets	Create a tool that will be able to fit in the mold to stir the dross around.

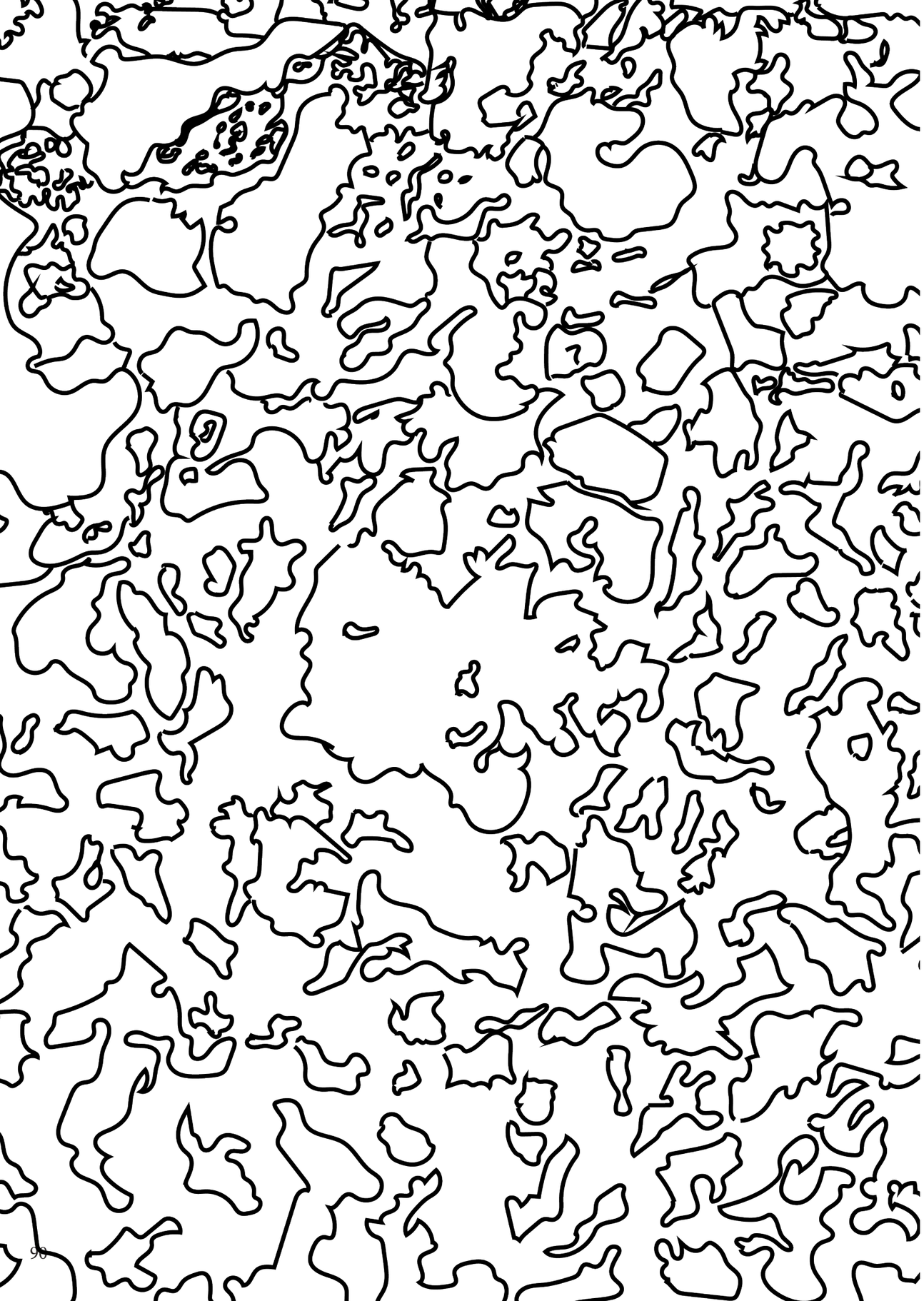
EXPERIMENT: SUCCESS

CREATING GUIDELINES

For this project to be successfull the discovered value of dross had to be translated into something that would grasp all the information I had learned to be able to create a foundation for future projects to continue the exploration. There was a lot of information to convey and to be understood. The answer was to concentrate the important findings in day-to-day diary into guidelines. Selecting what was important information that would make it to the handbook was fairly simple as the textures would show off the diversity in the material, while also, with instruction, teach the many casting and molding tecniques that I had used. The variety of methods gives a better understanding of what's possible and where I found limitations.

THE GUIDE INTRODUCTION

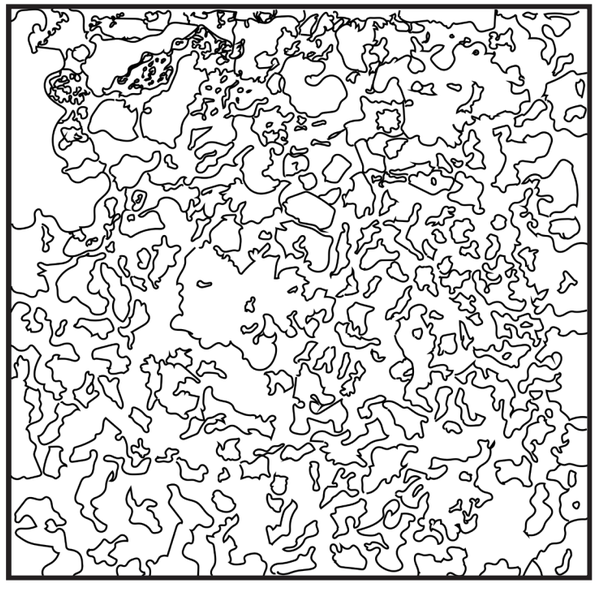
"This is a designer's guide to experimenting and designing with aluminium dross. Over a period of five months, I've worked with dross and mapped out my findings and turned them into this handbook for designers wanting to experiment with dross. The instructions aim for designers who have never worked with dross, but want to design and explore its possibilities. Do take in concideration that the instructions will only focus on the aspect of dross and as this material is an by-product of aluminium basic experience with smelting and casting aluminium is expected.
The manual will go through the following steps:
1) an inventory list of tools needed to cast dross and recreate the various examples.
2) a guide on how to build a propane furnace.
3) eight different textures and how to recreate them.
4) a suggestion on the potential use of dross and how to design with it."



PART 6

RESULT

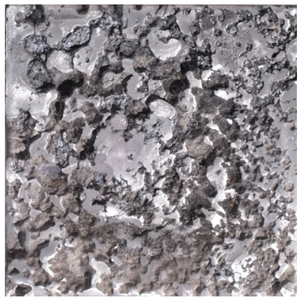
NINE
TEXTURES



NO. 1

NO. 2

NO. 3



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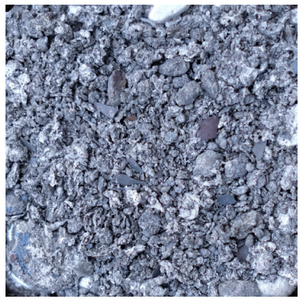

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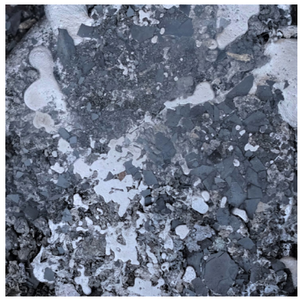
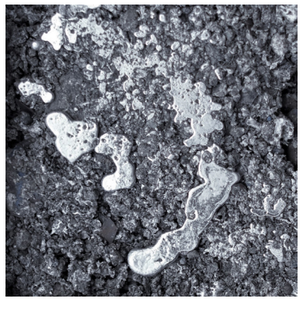
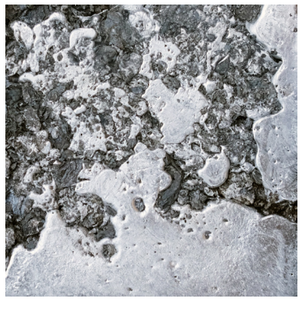


NO. 6

NO. 7



NO. 8



NO. 9

TOP LAYER	**NO. 1**
TOP LAYER*	**NO. 2**
BOTTOM LAYER	**NO. 3**
FINE GRIND	**NO. 4**
STAMPED	**NO. 5**
PREASSURIZED	**NO. 6**
LOW ALUMINIUM	**NO. 7**
MED ALUMINIUM	**NO. 8**
HIGH ALUMINIUM	**NO. 9**

TOP LAYER NO. 1

To attain this texture the dross and aluminium will be heated to melting point within the mold, hence important that the mold has a higher melting temperature than 700 degrees. The top layer will be affected by the stirring and mixing of dross and aluminium hence the flow in the texture. Keep in mind that in most cases the top layer in the mold will be the bottom layer of your model.

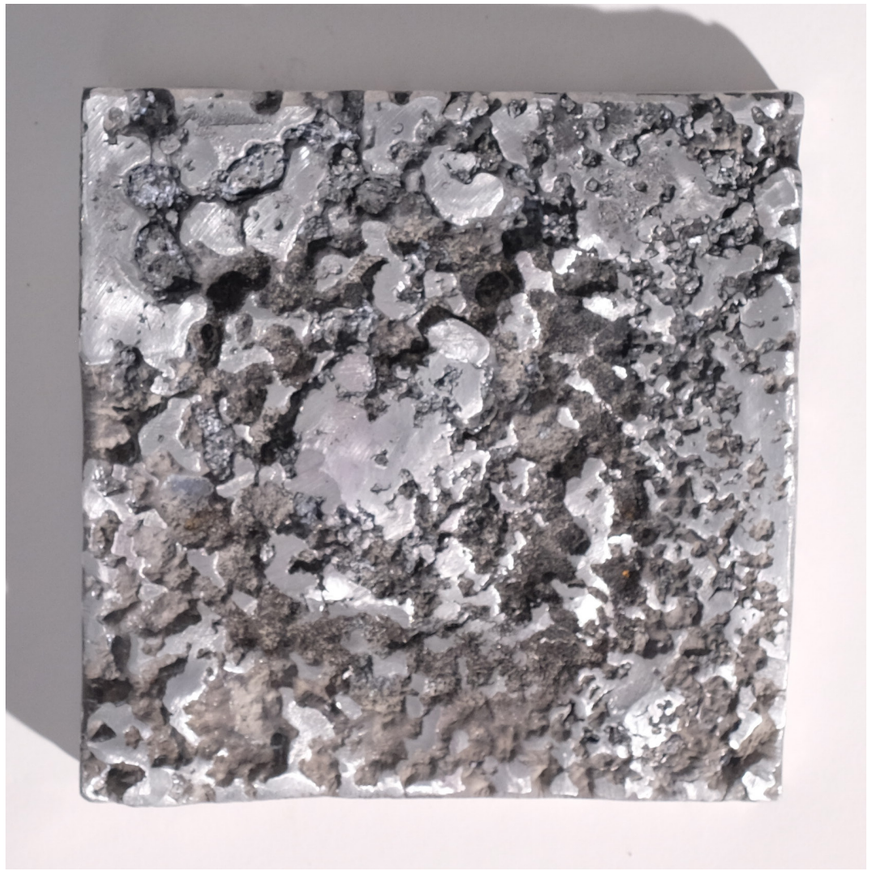
amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
low	medium	steel mold casting sand pour guide	steel stirer aluminium multi burned dross	high

TOP LAYER* NO. 2

Compared to texture no. 1 this top layer has more depth. This is achieved by pushing the dross down with a steel drainer (they float back up) to create an aluminium coating. 3D printing is the preferable molding method because of the height required when submerging. It can be difficult to remove the model from a steel mold because of the large contact surface.

amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
medium	medium	3D print Paint dip Salt dip	steel drainer aluminium multi burned dross	high

BOTTOM LAYER NO. 3



This texture requires you to have smelted aluminium once before as you will need to collect dross and grind it to sprinkle it in the mold. This texture occurs at the bottom of the mold, which will in most cases be the top layer of the model, casting it bottom up gives a better finish. Be careful when pouring the aluminium as this can move the dross around.

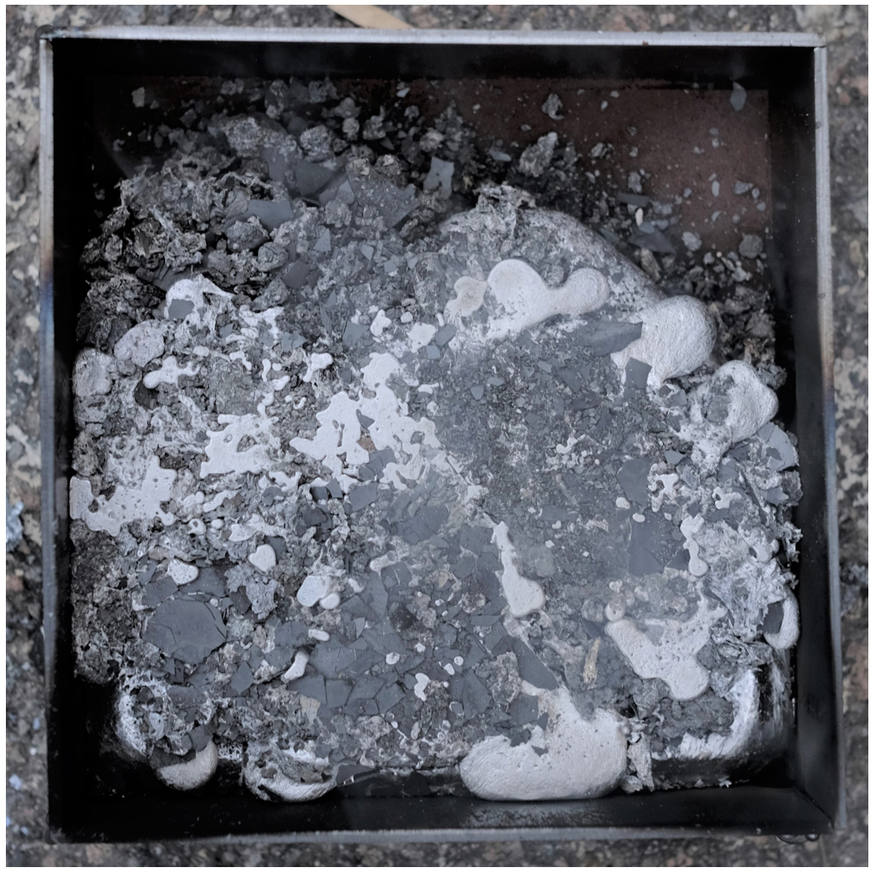
amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
low	medium	3D print Paint dip Salt dip	steel drainer aluminium multi burned dross	high

FINE GRIND NO. 4

Dross separated from molten aluminium and finely grinded to then be mixed in with molten aluminium will look like this. You obtain this texture by melting the aluminium then sprinkle dross on top and carefully push it down until mold is full. When pushing the last layer down do it slowly so the molten aluminium can flow through and bind the dross.

amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
medium	medium	steel mold casting sand	stamp drainer aluminium multi burned dross tongs	medium

STAMPED NO. 5



The texture of stamped dross is easy to recreate as a surface but is quite challenging to mold. The trick with this texture is to fill the mold with dross lumps from the crucible and not pressurize until the mold is full. The challenge is that the longer the dross is left out of the heat the less it will bind, making this is a rapid procedure.

amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
medium	medium	3D print Paint dip Salt dip	steel drainer aluminium multi burned dross	medium

PRESSURIZED NO. 6

This texture occurs from preassurizing the dross slowly. It's a method that will bind a dross heavy mixture, but won't fuse well to aluminium. Grind down the top layer 1mm ish and the texture is very aesthetically beautiful. As the dross is burned it turns dark but is still mostly aluminium on the inside, thats the reason for the high contrast after grinding it down.

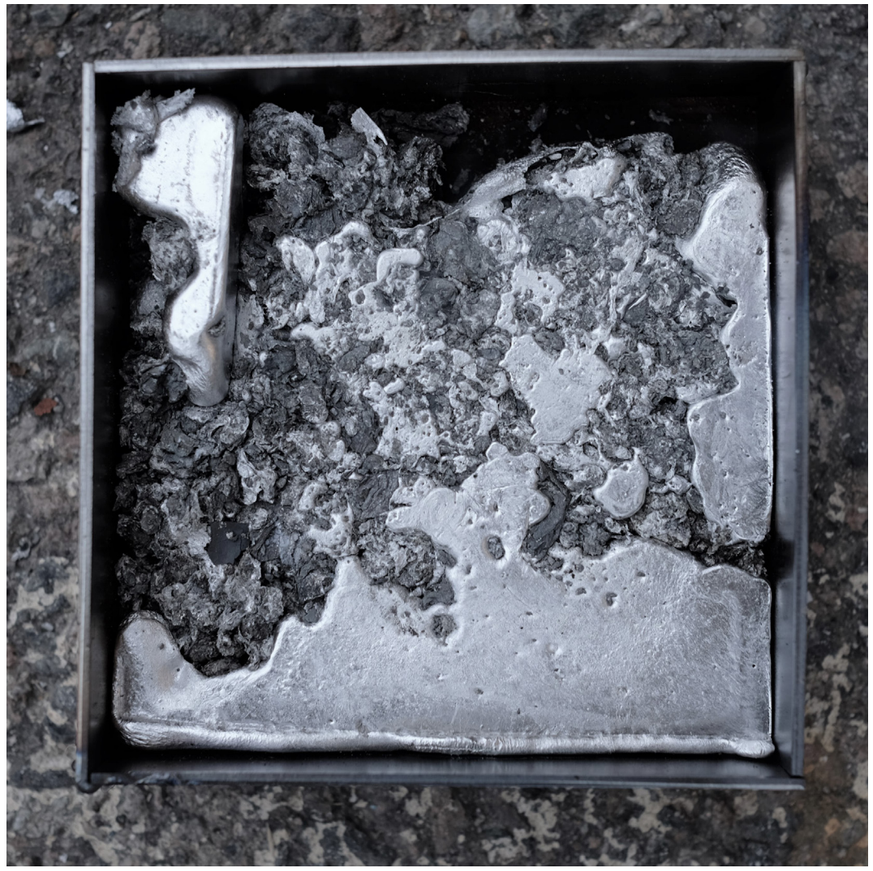
amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
high	low	steel mold	steel pressurizer dross lumps aluminium scrap	medium

LOW AL NO. 7

Casting dross with a small amount of aluminium will give you a rough texture but it will be less coherent as aluminium works better as a binding material than dross. A difficult aspect of this process is to get the dross/aluminium ratio right. Too much dross and the texture won't bind properly, too little and the aluminium will flood the dross and the texture will be submerged.

amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
high	low	3D print Paint dip Salt dip	steel drainer aluminium multi burned dross	medium

MEDIUM AL NO. 8



Texture No. 7 this will use the same molding technique as the previous texture, but with a different ratio of dross/aluminium. A very practical texture as it will be visible unique with the advantage of being durable as the aluminium works as a coating and binder. The texture is roughly 1 part aluminium to 1 part dross in volume.

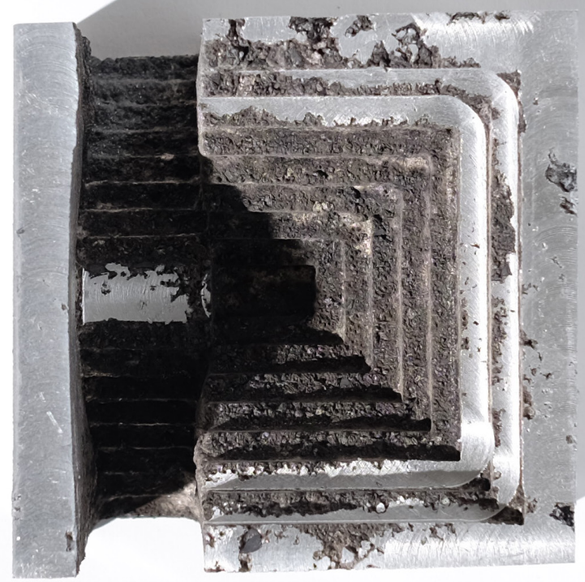
amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
medium	medium	3D print Paint dip Salt dip	steel drainer aluminium multi burned dross	high

HIGH AL NO. 9

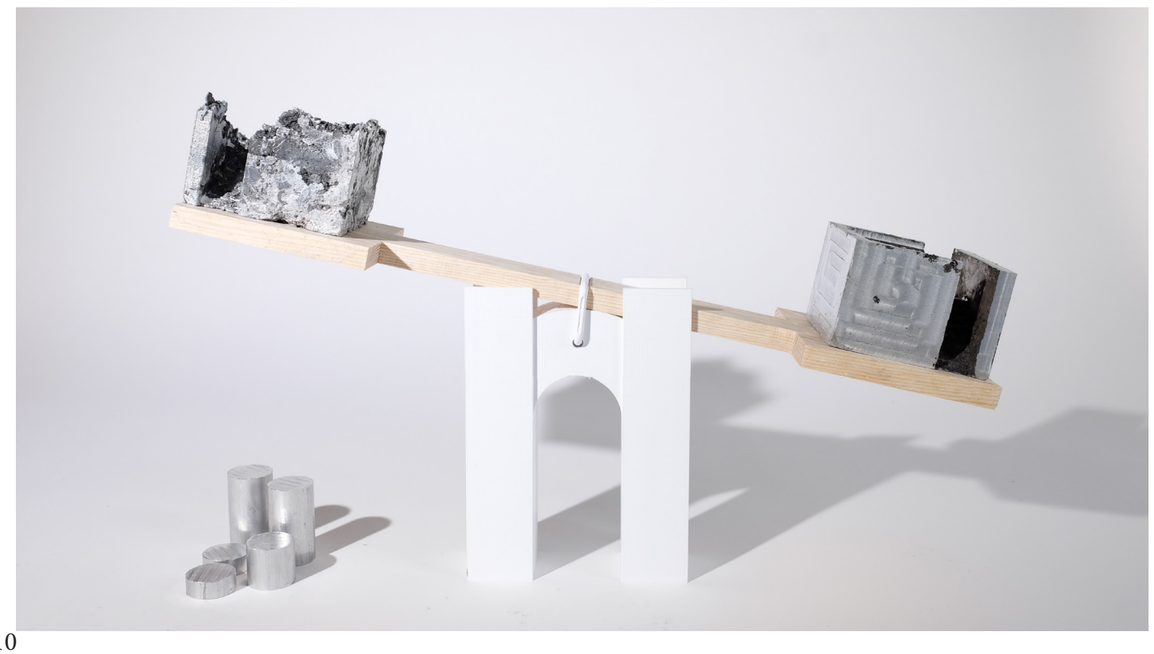
Use this if you're looking to have just a patch or a part of the model with dross texture. This will be the heaviest, but also the most durable as it will have a substantial ratio of aluminium making it very dense. I should mention that it is difficult to place the dross exactly where you want it in the model as dross float in and on molten aluminium. A tip, use lumps instead of grinded dross.

amt. DROSS	amt. ALUMINIUM	MOLD	TOOLS	DURABILITY
low	high	3D print Paint dip Salt dip	steel drainer aluminium multi burned dross	high

HIGH DROSS amt.

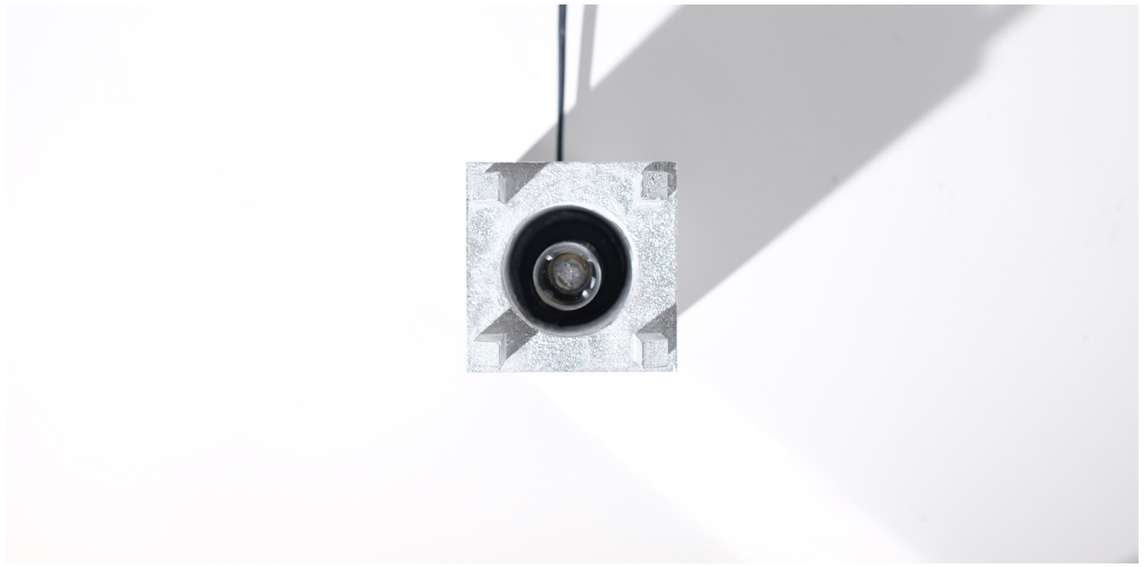


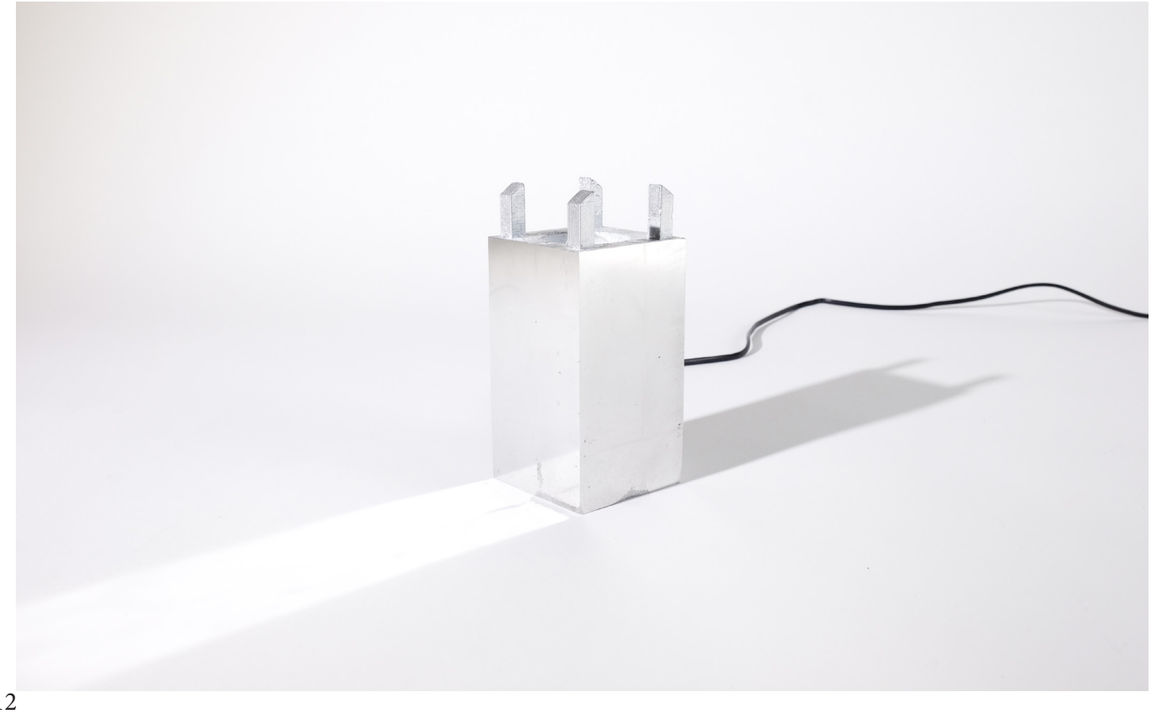
HIGH ALUMINIUM amt.



WEIGHT/ ALUMINIUM amt.

The above visual parameters exemplify the level of detail possible to obtain with different ratio of dross vs aluminium levels. The test to the left is molded with SUS and RSA and the test to the right is molded with steel and casting sand. The left model has the same ratio of dross as texture no. 6 (20/80 ish). The test on the right is done with a similar dross/ aluminium ratio as texture no. 7 (40/60). Smaller details requires a casting ratio that is majority aluminium as molten aluminium is more fluid than dross. As seen on these examples the aluminium have on neither been able to pierce the bottom layer of dross, but it is showcased how thoroughly it has pierced through on each of the models. The left one is made with a dross heavy mixture causing it to not bind properly and break apart. The other consists of an aluminium heavy mixture making the bottom layer the only dross apparent area.





THE DROSS ALUMINIUM LAMP

Aluminium lamp with dross lampshade. The dross lampshade is an example of texture no. 8 (dross/aluminium ratio: 50/50). The lampshade, compared to the sharp edges of the aluminium base, creates a rough contrast that brings out the qualities of dross. The lampshade's inside dross texture reflects light down to the ground and diffusing the sharp light.

This brustalistic lamp is an suggestion on how to shape and solidify dross at a visual appealing material.

The aluminium dross handbook in full is added as an attachment to this delivery.

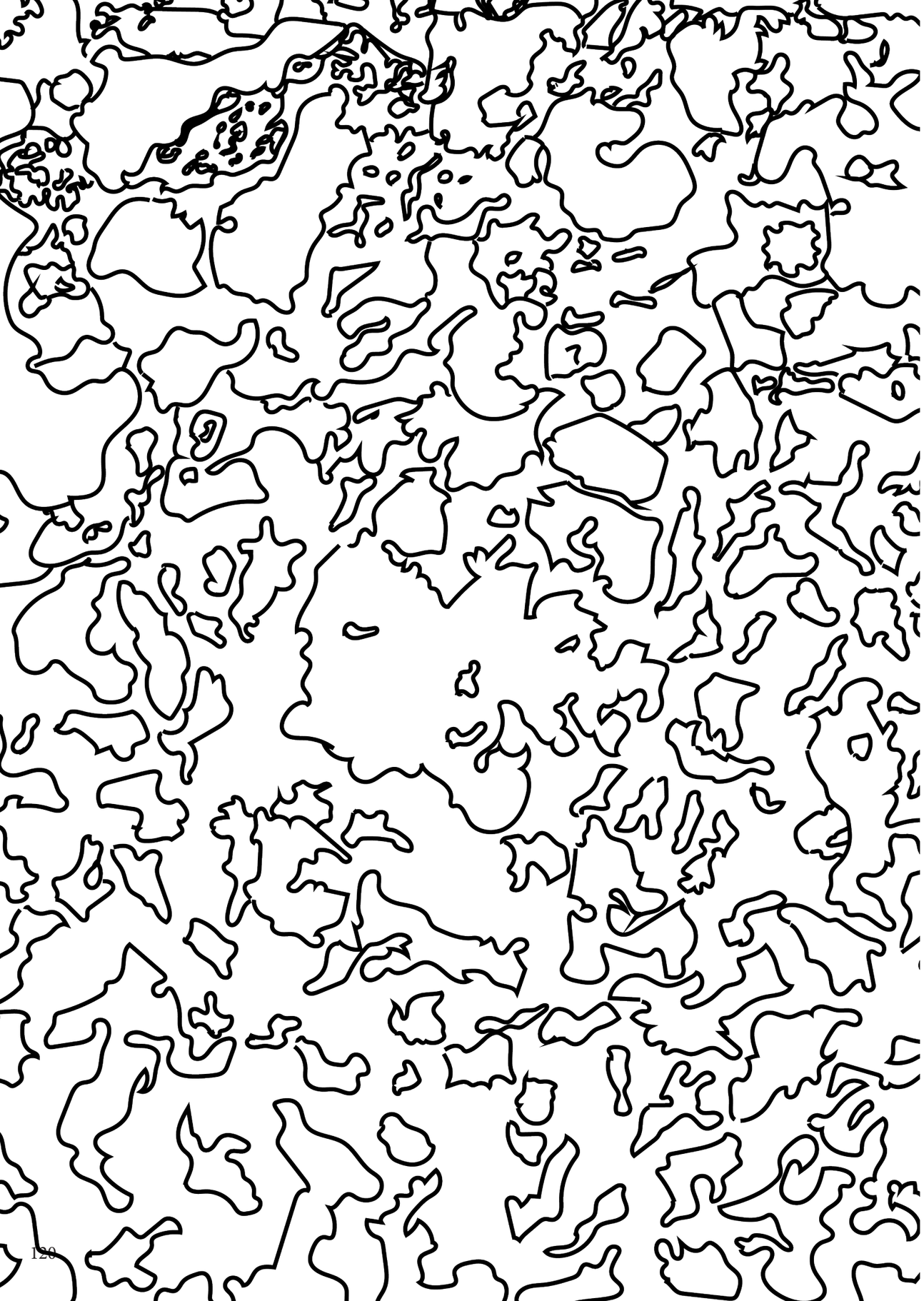
The aluminium dross

HANDBOOK

How to cast aluminium dross

AHO diploma Fall 2020

Tim C Knutsen



PART 7

CONCLUSION

CONCLUSION

As stated in the first pages of this report the goal for this project was to explore dross and convey the findings and uses as a foundation for further exploration. The findings consist of the aesthetic texture of dross and how the problematic characteristic of its randomized structure have been developed into its value. The other goal was how to efficiently convey the findings for further exploration and development. The material exploration had a slow start as there was no previous work on dross that was relatable to base this project off.

DESIGNERS VALUE

Material value differentiate from profession to profession. An engineer typically values functionality, while on the other side of the spectrum an artist might value visual and cultural attributes. For designers however a material can be valuable for a variety of additional reasons, social perception, environmental impact and reusability to create new and innovative design solutions. Prior to this diploma dross was just an unwanted by-product that costs the aluminium industry a lot of money. This project did not seek to disrupt the dross/ aluminium industry, but to discover a way to give this by-product value within design.

APPLICATION OF METHOD

This method needed the diary to have some results before it could be applied. Once the material became familiar and the struggles where more detail oriented it was clear that dross is not a material that would suit a functional use. Recognizing the aesthetic value became a memory game of cross checking the attributes with design styles to be able to shape it in. The method used to achieve this was through to systematically noting down the progress of exploration. When enough data was collected a progress giga map was created to visualize the choices that were made. This enabled me to track the progression and anticipate where the pattern would lead. I believe that this method can be applied successfully to other material explorations, but with different level of success rate depending on the project. Projects working with dross from other metals and projects on new materials in general are projects similar to this and will possibly get most use out of this method, as this method is created to find and develop value and can be directly applied. The method could be useful for projects on alternative and conventionally developed materials as well, but not in the same direct way as the essential value is

CORONA VIRUS

Due to the global pandemic, there has been some repercussions for us as diploma students. It has been hard to get in contact with producers and other key figures in the industry. For this project there has been several conferences and meetings that have not taking place due to the restrictions made by the Norwegian government. Even though it has been challenging, I have tried to do the best out of the situation.

WHATS NEXT?

The next step for this project is to further the development and value of dross as a design material. Had this project been longer I would've continued to develop the shape further. The foundation for this material is now explored and documented and is open for interpretation so it will be very interesting to see how this will be picket up for further development.

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All photos are credited me, Tim C Knutsen

INTERVIEW

Jan Petter Angvik
Production supervisor at Real Alloy

What is dross?
Dross is what manufacturers shave out of their furnaces before and after casting metal. It is slag that contains elements they do not want in the aluminum and alloy metals that are not dissolved in the aluminum and oxidized oxide.

Can you explain the recycling process of dross for Real Alloy?
Real Alloy keeps all dross separated before going in the rotary kilns where we add salt and it melts. We casts sows (basic mould) of approx. 500 kg which is marked with customer code and number for recognition. This is our only product

What uses are there for dross?
Pure aluminium is sent back to who ever we got the dross from and the aluminium oxide is sold to the cement industry, used in asphalt and such.

How low amount of aluminium should the dross contain before it's not profitable to extract?
We can extract aluminum down to about 5% profit. But it is obviously not profitable.

What material attributes does dross have?
Before recycling, it is classified as hazardous waste and afterwards it is pure aluminum that will be casted. The residual product is salt slag which contains the last residual aluminum, salt and alumina.

What is left after dross extraction?
Aluminium, Aluminium oxide and salt.

How structurally strong is dross?
There is a range from solid lumps with almost pure aluminum to powder form and it is pressed dross that is burnt that is so porous that you can pick apart with your fingers. There is a very large range on the chute according to how it has been treated in the foundry where it originates.

If I were to make a positioning graph to place dross tests, what extremes do I have to choose from?
We have a range in dross from powder form and up to lumps of up to 2 tons. It is from various presses, gas-cooled dross, drum-cooled dross and dross that have been cooled with salt.

Hydro's safety data sheet from 2012 suggests that dross can be potentially carcinogenic and toxic, to what extent is dross dangerous?
It depends on what is in the alloys that are produced, for example in the primary aluminium industry beryllium is added in some aluminum to give the right property that customers want.

At what stage is it dangerous? During production or finished recovered? Or both?
This is in very small quantities. To get an overview of this, you probably need to go directly to the manufacturer of the dross (Hydro Holmestrand) to get specifications.

Primary and recycled aluminum can be dangerous for various reasons (primary with beryllium and recycled with uncertain knowledge of what the mass consists of). How are the aluminum boxes in relation to this?
This is something that is a big topic. We have about 30 different types of dross from both primary and secondary aluminum, all of which are different.

How is the structural strength? Is the solid dross I work with solid because of the aluminum content?
Now I do not know what kind of Dross you work with so it will be difficult to answer. We have a range in Dross from powder form and up to lumps of up to 2 tons. The oxide that is our finished product after treatment is in a incoherent powder form.

What is mechanical recycling?
This is safe by using a shredder and sorting the various metals afterwards.

What other recycling methods are / are used?
A magnet, eddy current, spectrometer with air separation or manual sorting can be used. Expect there to be many other ways as well.

Recycled boxes will create another type of solid dross?
About the extra materials such as epoxy inside, magnesium top, labels, paints etc. This will burn up in the processing and will be separated out in a filter system.

What alternative ways can dross be circulated?
I can not comment on alternative ways of treating dross. It is circular in that it is recycled by us and the aluminum is taken out and the customer gets it back. The salt slag that we create is crushed and the remaining aluminum is taken out and melted by us. This is sold out in the market. The oxide is purified and used in various products such as cement. The only waste we have are foreign bodies that are in the chute and are not melted (iron and concrete that can come together with the chute). Today, salt is the only thing that is not recycled.

Why add salt?
To cool down the dross. This is done because the aluminium is burning up when the dross is too hot so the faster you cool the dross down the more aluminium content you will preserve.

What materials does dross consist of?
Aluminium, Magnesium, Silesium, Sinc, Copper, Iron, Magan , Titanium, Nickel, Lead, Natrium, Beryllium and more.

Thank you to

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Hydro Holmestrand

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Unit manager, Hydro Karmøy

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Hydro Karmøy

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