Herald 291

Chapter 291 Brick Manufacturing (Part-1)

Alexander having confirmed there was something missing from the waterwheel design first made Diaogosis grimace a bit and then he felt stumped.

He thought back again and again on what could be added, but to him, the entire structure looked finished and complete.

'I guess I'll have to wait and see," Diaogosis thus finally gave up and decided to wait for Alexander's answer until the time came.

"Does my lord have a specific place where he wants to build the waterwheel?" Diaogosis asked.

"The Cisrians hills to the back of us will do. After all, I know of at least three huge springs that run through there. You can choose whichever springs you like," Alexander knew this answer because he had certainly scouted the place where he planned to build the waterwheel beforehand.

And in reality that was really the only place to build large-scale waterwheels as Zanzan city did not have any large rivers near it.

"And should I build the umm…." Diaogosis looked down at the paper as he had forgotten the name and read, "The ball milling machine too?"

"Hmmm," Alexander remunerated on whether it was necessary to also build a prototype of the relatively simple structure.

Its operation was pretty simple as it worked by taking in the required amount of clinkers and gypsum chucks and simply spinning it to grind the pebbles to a fine powder.

And conveniently this rotating motion would also finely mix the two minerals, producing Portland cement in the same process.

According to his design, it would have a capacity of 20 tons of cement, with an additional 2 tons of iron balls (the total capacity was around 45 tons, but the drum could be only filled up half so that there was enough space for the tumbling action to happen) and would take 5 hours to complete the cycle, i.e- from filling the drum up, processing it and emptying the product.

This meant that it would have a production output of around 90 to 100 tons a day, or about 4 kilns worth of product.

Alexander felt that it would be good for the workers to get some practice on making the grinding mill, as they will be making a few very large ones in the future, and so said,

"Yes, build one smaller. One meter dia and just three meters in length will do. And make the walls ten centimeters thick (10cm)." Alexander gave the dimension, and at last added, "And make it out of concrete."

"Okay, my lord. I can finish the prototype in a week with a hundred men," Diaogosis set a very ambitious deadline for himself as he was eager to show off his abilities and snatch a peerage for himself.

"Mmmn, then inform me when it's completed and I will come for a visit," Alexander gently finished.

A significant thing to note here was unlike the others and a bit to Dioagosis's dismay, Alexander did not promise the man peerage.

He was still a little angry at the little tirade the stonemason had launched when Alexander even hinted at a slowdown of his projects and so Alexander felt the stonemason was a little too ambitious for his liking.

Instead, he decided to let the man get back to work, and was about to leave after bidding his farewells, when suddenly he called out as he remembered something vital, "Oh, I almost forgot. "How much stone does the quarry produce per day?"

Alexander knew the speed of the construction workers, but not the miners.

So he wanted to get that information.

"Mining stones is difficult my lord," Diaogosis rubbed his hand that had gone cold in the chilly weather as he said so, "Each worker can haul 20kgs, to, on a good way, 25 kilograms of stone. That's also what is produced elsewhere."

This last sentence was quickly added noticing Alexander's slight scowl as if he was unhappy with the numbers.

And Diaogosis was right.

Alexander did find the numbers too low.

According to the stonemason's numbers, his quarry could only make one hundred to hundred fifty tons of stone a day.

Whereas his demand for the stuff was in the thousands of tons.

And if one did the math for per worker, each men man was making the equivalent of just ten bricks a day, or one brick an hour.

Calling this snail's pace would be an understatement.

'I will need to go see what's up with the two hundred bricks a day thing," Alexander recalled Diaogosis's complaint and decided his next visit would be to find out why brick production was so low.

And so that was where he went next, passing through many dug-up and marked plots that had been originally designed to build the large residential buildings, but would soon be replaced with makeshift tents and very large common log houses.

Though Alexander had commanded the populace to be moved to the noble houses in the western district, he knew the nearly two hundred thousand people's lodging would be unable to be met solely by the vacate premises, and such measures would be necessary.

'I need to get more people to cut firewood,' Alexander thus planned to burn huge bonfires around these camps to help the people combat the cold a bit better.

With these future plans, Alexander and his bodyguards soon arrived at the brick-making site, which was outside the eastern gates.

The reason this production facility was outside the city was simple.

Because brick-making took up a lot of space.

From gathering tons and tons of clay to stacking the bricks over huge swaths of land to the large number of furnaces that Alexander had designed all took up a large amount of space that was not available inside the small city.

"I have seen the lord, welcome," As Alexander made his way into the premises, he was greeted by a messy-haired, thin boy with a big grin on his face.

He was dressed in immaculate clothes, with nice shoes and a pair of trousers with no creases, while the eight golden rings on his fingers glittered and sparkled under the sweet winter sun, dazzling Alexander.

'This guy is no good,' Alexander instantly made up his mind to change this boy just after glancing at his get-up.

This was not the uniform of a hard-working leader.

"Are you in charge of the brick-making? Where's Jazum?" Alexander skipped the formalities and got straight to the point, a clear sign of his displeasure.

"Ah, father said he was too busy with the kilns and the armors Your Grace instructed to make. So he left me in-charge," The boy let out a pleased, proud smile.

A smile that looked like that of a fool's to Alexander.

"Oh? Are you Jazum's son? What's your name?" Alexander gave a cold, fake smile.

"Yes, I'm his eldest son. My name is Jafor," The introduction was filled with pride and self-gratification.

'I need to root out this practice in the weeds,' Alexander only silently nodded while he promised to make an example out of the boy and his father for this abominable practice.

He would never let officials get posts based on familiar ties.

Not on his watch.

"Jafor, I have come to see how the brick production is going on. Please lead me," Alexander instructed as he gestured his arms forward as a sign to lead the way.

"Umm…ehh..yes, yes. Right away my lord," After dithering for a bit, the boy quickly invited Alexander to observe the complex, and provided additional commentary along the way.

Alexander let this foolish youngster's words enter through one ear and go out the other, as he was appalled by the working inefficiency that lay bare in front of him.

There was no division of labor.

One man would do everything.

He would use his shovel to dig earth, painstakingly clean it of any useless debris like broken roots, rocks, stones, and sometimes even broken pieces of pottery, add the appropriate amount of water to soften the clay, and then use a wooden mold to turn the clay into green brick.

He would then lay these raw bricks in front of him, after a while of which, once he had made a sizeable amount of the stuff, take these bricks one by one by hand to a nearby open kiln, and place them inside for preliminary firing.

"Why is one man doing all everything?" Alexander in a deep voice asked, cutting off whatever Jafor was saying.

"Ehhh?" Being abruptly interrupted, Jafor was a bit stunned at the question.

"What does my lord mean? So many men are working here. right?" Jafor then quickly retorted, looking at Alexander as if the latter was drunk.

'Idiot!' Alexander scowled at the dim-witted boy.

"I mean why is one man doing all the different tasks? Why are they not specializing?" He then spelled out the question for the boy.

"Specializing? What does the lord mean?" This seemed like a new word to Jafor.

"...." Alexander kept silent for a while, as he seriously considered whether to continue this conversion or to find someone actually competent.

He was very angry at Jazum for putting someone in charge of something that Alexander had not only not approved of but did not even know about.

'Some people think just because you don't talk like shit to them, they can get up on your head and dance on it,' Alexander very angrily cursed as he could slightly empathize with some of the nobles who behaved quite roughly with the common populace.

Because behaving cordially and pleasantly would make some of these ingrates get ideas.

Chapter 292 Jazum And Jafor

Alexander was oscillating between chastising Jafor or nurturing him.

Now, the reason for the latter was certainly not because he had a sudden change of heart and somehow decided to show the boy the error of his ways.

No, it was because he had taken a leaf out of Pasha Farzah and decided to emulate what that man had done with the boy named Fatrak, though it was in Alexander's best interest to make sure Jafor did not end up like Fatrak.

Using a son that always causes trouble was a fantastic way to bind a loving father.

But this latter consideration was challenged by the fact that leaving such a vital piece of the civil sector to such an imbecile was not a good idea.

'Well let's try and see anyway. It's only brick making anyway,' Alexander felt that brick-making was a fairly simple process, one so simple that Alexander felt even if one wanted to, there was only so much way he could fuck-up.

There was also the other consideration of getting some practice with these kinds of schemes and manipulations.

"Specialization means that one man does one or a very few number of tasks. Not all the tasks like the men they are doing now," Alexander elucidated, giving the example, "For example here, instead of a single person doing all the individual tasks, one man could have dug the earth, one man could have cleaned the clay, another could have shaped the bricks while the last man could have taken the bricks to the primary kilns."

"But my lord, aren't the men doing the same amount of work? The same amount of work will be done by the same number of men regardless of the processes right?" Jafor theoretically assumed.

'Well, his head might be full of shit, but at least it's not empty. Fortunately, he has something to work with,' Alexander said to himself half-impressed.

Though Jafor was wrong, he did have some theoretical arguments for his claim.

And so Alexander decided to use the same example the grandfather of economics, Adam Smith had used to explain the concept of division of labor.

"No, they will not do the same amount of work," Alexander refuted Jafor's claim while shaking his head, saying "And let me prove it to you by an example- the example of a sewing pin."

"Now, imagine an individual set out to create a single sewing pin." He started.

"If he decided to make everything from scratch, he would first have to mine the iron ores by himself."

"That means he would have to take his pickaxe and go a mine or worse, search for some iron deposits by himself."

"Then he would have to carry these iron ores back to his place, build a furnace, cut the firewood needed to run the furnace, and finally smelt the iron ore into steel."

"He would then have to forge that steel into a thin wire, cut that thin-shaped wire, and finally

sharpen it to a point to make a needle."

"And after all that he will only have a sewing pin which won't be of much use without fabric to sew."

Alexander at last asked, "Do you see the problem?"

This produced a look of realization on the boy's face and wordlessly nodded.

"Mmm, and that's why we don't do it like this," Alexander emphasized the point, further explaining,

"Because it's much easier and more efficient for some people to focus on mining, some people to focus on smithing and some people to run the shops that sell the sewing pins."

"In this way, all these people can take a small profit from the value they have added to the process and use that profit to buy more sewing needles than they would have been able to produce themselves,"

"Or anything else that they want to purchase for that matter."

And here Alexander made his point of refuting Jafor's claim, "So it can be seen the same amount of people, each doing one specific job will make more 'stuff' than individuals doing all the things by themselves."

"Understand?" Alexander at last pointedly asked.

"...Yes I see! I see my lord! You are right," Jafor fully agreed with Alexander as he repeated the words and then excitedly said, "Okay, from now on I will assign one man to only one task!"

"Mnnn, you are thinking in the right direction." Alexander nodded appreciatively.

But then added, "But it's not that simple. Remember not all steps of the job is equally hard. So equally dividing the tasks will not be efficient."

"If you did such a thing then some people might have too much work while others would have nothing to do and sit idle." Alexander pointed out.

"For example- in brick making, it takes a lot longer to dig up the earth than it takes to just simply take a lump of clay, throw it into the mold and produce a rectangular brick."

"So the workers must be distributed not evenly but depending on which part of the job needs the required amount of workers," Alexander suggested.

"So, how does Your Grace suggest I divide up the tasks," Jafor lightly asked for Alexander's expert input.

But Alexander was not going to give him a straight answer so easily.

Why would Alexander need to spoon-feed every tiny detail?

That's why Alexander waved his hands dismissively and said, "That's your job to find out,"

But as soon as he said it, he felt a tad bit bad about leaving the boy hung out to dry, as Jafor's later performance had melted a bit of Alexander's anger.

So he scattered some nugget of advice, "I will only say that you make sure none of the workers are idle. So there must be enough diggers to keep supplying the brickmaker with enough clay so that he can continuously keep making bricks."

"You must also make sure the bricks are taken to the primary kilns for blasting as soon as possible with as few men as possible." Alexander suggested, and then pointed out some of the other few flaws, "Also I see that the men are taking the bricks individually by hand. This is too inefficient."

"Use something like wheelbarrows or better carts. And that goes for the dug-up clay too. Use wheelbarrows to transport them to the brickmakers."

Alexander laid out a series of very common and easy steps to increase productivity.

"Yes, yes, my lord. All these will be done as soon as possible," Jafor rubbed his hands together as he promised so, letting out a toady smile.

"Mmm, I will come to inspect it in a few days." Alexander nodded and then asked, "Is your father at the cement kilns?"

"Ummm, yes. He should," Jafor was not 100% sure.

"Okay, I will see then," Alexander waved his goodbye.

And then just as he turned around, he sarcastically added, "Oh, I can see you have so many expensive rings on you. Would you mind lending me some? I'm too poor to buy one you see!"

"..." The boy furiously blushed as he turned his head down, furiously taking off his rings as he did so.

The sneer at which Alexander looked at him felt like being under a scalding fire.

Alexander then in a hard, harsh voice fiercely said, "You are here to work. Not to get married. Dress appropriately."

Saying this he turned on his heels and with heavy, imperious steps marched out.

And soon met up with Jazum who was busy making the blowers in a part of the southern district.

"My lord! Good day! How are you?" Jazum immediately gave a noble's bow as soon as he saw the pasha.

"Mmmm, I'm good. How goes the work?" Alexander then spent a little while getting to know the general progress of the new ten cement kilns.

"Jazum, a little word," After the cheery greetings subsided, Alexander then called the stonemason to a relatively quiet and secluded part of the construction site, a place where he planned to verbally hammer the over-inflated stonemason.

"I went to visit the brick site today. Haha, I'm assuming you were too busy with the kilns and the horse armors, right?" Alexander started the discussion cordially, in fact, it was almost too cordial.

But the stonemason did not seem to pick up on Alexander's simmering rage, and instead, almost emulating his son, or may his son was emulating him, gave a similar foolish big grin and said, "Oh, has my lord met Jafor? He's my eldest son. How was he?"

The stonemason seemed completely unable to grasp the tone of the conversion, thinking Alexander had called him here to praise his son.

'Not much EQ,' Alexander updated his evaluation of Jazum.

"Yes, I did," Alexander said in a very flat monotone voice, "I went there because Diaogosis had complained to me that he was getting only 200 bricks a day. Do you have any idea about this?"

The last sentence was asked in a very pointed tone.

"Ahhh, that," Jazum pronounced in a slightly pitched tone, nodding and saying, "Yes, Jafor must be getting used to his new position."

Then he brushed his hands and reassured in a breezy manner, "Don't worry my lord. Brick production will go up soon."

This casual and flippant attitude infuriated Alexander and the fact that such an irresponsible man had the nerve to wave his hand right in front of him made it very difficult for Alexander to keep his cool.

And this in turn made him fully re-evaluate this previously very highly regarded retainer, demoting him to not-so-reliable.

'This son-con might be trouble,' Alexander commented about Jazum.

Chapter 293 Brick Manufacturing (Part-2)

Alexander was not the only one that found Jazum's obliviousness distasteful.

And as if infected by his rage, Alexander's bodyguards too radiated anger and displeasure, finding such uninhibited casualness with their lord very inappropriate.

But all these subtle and even not-so-subtle clues seemed to go over the son-con's head, who seemed to be immersed in his proud son's memory.

"The brick kiln was supposed to be under your jurisdiction by my command." Alexander's voice was deep, his eyes narrowed, as he then clenched the words, "So who gave you the permission to pass that duty to another?"

This tone of questioning finally woke Jazum to the direction Alexander was steering the conversion, but instead of being scared and apologizing for this gross misuse of power, he on the contrary defended himself, saying, "Oh, my lord, but Jafor is a good kid. He is just figuring himself out and I'm sure he will work very hard and contribute much to Zanzan very soon."

Jazum, for all his intellect and architectural prowess, saw no problem with him arbitrarily placing his son in such an important position.

To him, it was all natural.

And this made Alexander helplessly comment, 'It's like we are speaking two different languages."

Of course, Jazum was not stupid.

But the reason why it looked like he was acting like an idiot was because he was fundamentally misunderstanding the question.

He simply did not share Alexander's concerns nor did he understand why it was a concern for Alexander/

To him, it was only natural that he would put his family in key important positions over the sectors he had jurisdiction over.

And this was because such was the prevailing custom of Adhania.

Sensing how deep the rabbit hole went, Alexander's azure eyes darkened like black thunderclouds had covered the sky and he said to himself, 'This has to be stopped.'

He was finding this repugnant practice arguably even more repulsive than the concept of bliss trainers.

Thus, to wake this delusional man from his illusions, he lambasted the stonemason in a loud booming tirade, "What do you mean your son will work hard! Who told him to work hard? When did you get to decide your son gets to work hard?"

Micro droplets of the enraged beast's spit showered over the flabbergasted face of the quivering stonemason, as the vituperation continued.

"I remember putting you in charge of the brick kilns. Did I put that brat in charge of the kilns?"

"How dare you appoint someone completely unqualified to oversee such a critical component of Zanzan?"

"Who gave you the guts to do so?"

"You are still a mere civilian and yet you dare override the pasha's words!"

"What will happen when you become a shordar (baron)? You already think you can appoint whoever you want without my permission. Next will you appoint yourself as Pasha?" Alexander's eyes glowed with rage as he finished his diatribe.

"I…I…I don't dare. I don't dare," Jazum answered shaking like a leaf, his eyes darting back and forth in confusion.

He just could not understand why Alexander found this natural act objectionable.

And hence he still did not apologize, but instead provided excuses, "My lord, I…I was too busy with all the work. And I just did not get the time."

"I…I will go to the brick kilns today. And I promise to increase brick production by tomorrow." He hastily promised.

The lack of an apology very much irked Alexander, and because he did not get the answer he was looking for, he just curtly excused the stonemason in a brusque tone, "No need. It seems you are too busy. I will find someone else. Dismissed!"

Alexander swung his sturdy arms in a high arching motion to signal Jazum to get out.

"...." Seeing the flared-up Alexander in such a foul mood, Jazum simply lowered his head, wordlessly bowed, and quietly and quickly dragged his body out of Alexander's sight, eager to escape the wrath of the usually gentleman Alexander.

And on the way out his mind swam with many thoughts, one of them being gratefulness that Alexander did not chastise him in his workplace, in front of all his workers and colleagues, but had tactfully chosen a remote corner of the grounds, away from most prying eyes and ears.

But this gratefulness was soon buried by the anger of Alexander bad-mouthing his son.

He was the apple of his eye, the peart of his heart and he would absolutely not let anyone disparage his pride and joy, not even the lord of the lands.

'*Sigh*, my mood for the entire day is ruined,' Jazum ground his teeth hatefully as he returned to bark orders at the worker on the new kilns.

And Alexander would the next day say this following note of caution at the council meeting, "My lords, I have a tiny bit of advice to share with you all." He would begin with that characteristic slight smile,

"Though I do not have a son of mine yet, I believe that sons can be just as much our pride as they can be our shame."

"And hence it is imperative that as lords, we all strive to guide our sons to the right path. They will be our successors and inheritors after all."

And he then finished the short speech with this ominous warning, while making a clear dig at Jazum, "Or else we will be exposing our weakness to our enemies and rival."

It would take the council a bit of time to understand the context of Alexander's advice, but after finding out about Jazum's little adventure of jumping above the pasha's directive and doing things his own way, resulting him in losing the brick-making facilities and getting basically demoted, the others would remember well to heed Alexander's advice.

But those were tomorrow's events, as right now, Alexander was talking to the man he had chosen to replace Jazum, his colleague, and a close co-worker, Krishok.

"How can I help, milord," He eagerly asked, meeting the pasha at the same place Jazum had met.

"Jazum has told me that he is feeling too overwhelmed with all the tasks he has been given. And feels he does not have the time to also manage the brink manufacturing plant." Alexander stated.

And with a light smile then asked, "So do you think you are qualified?"

"Yes, yes, of course. No problem," This tanner's reply was instantaneous, without a shred of any other consideration given, only producing a cunning glow in his eyes as he readily said so.

How could he not smell that something had happened between Alexander and the stonemason, resulting in the latter's dismissal from this post?

After all, he knew his colleague well enough to know that the man would never voluntarily give up such power and authority.

"Haha, good, I'm relieved," Alexander slightly chuckled at the expected answer.

Though Krishok was a tanner, Alexander was confident he could oversee the relatively simple construction of the new brick kilns.

He did build part of the cement kiln after all.

Thus as soon as Alexander finished praising Krishok, he took out the dread piece of paper and handed it over, "Here."

And stated his goals immediately afterward, "We will soon need to increase brick production to at least a million pieces per day by next year. And up to ten million within five years." Alexander's ambitious numbers seemed ludicrous for Krishok and it made him shake involuntarily in fright.

But in Alexander's eyes, this was not really much.

After all, the current five thousand workers under Diaogosis could already use 2.5 million bricks per day.

And this was just bricklaying.

When concrete manufacturing, which was a combination of bricks, sand, and cement, was taken into account, even the impressive number of ten million would start to look pretty inadequate.

"My lord, how big will the furnaces be? And how many?" Krishok had a wry, helpless tone to his voice.

Knowing Alexander, since he said it, Krishhok knew the Pasha also had thought of a way to do it.

And then it would be the tanner's turn to work day and night and bring that creation to life.

Hence he decided to skip the melodramatic phase, and simply and straightforwardly accept his fate.

'Hehe, I like the obedient ones,' Alexander was also pleased that he could skip the coaxing and reassuring phase for once.

"Read," Alexander simply gestured for him to open the folded paper.

Krishok thus did so and contrary to the horror he was expecting, he found the drawing to be relatively simple, just that of a huge dome, with six stoves similar to the ones used in the cement kilns that protruded inward attached to them, which had a type of connected pipe network running below the six of them which allowed fresh air to enter the dome.

"The dimensions are already there. You just need to charge the bricks, seal the entrance with brick and cement, and fire the stove. And voila, after four to days, you will get the bricks." Alexander provided some simple commentary on the already detailed written instructions.

Krishok too found the drawing, labeled the dome kiln easy to understand as he repeatedly nodded his head to express his understanding.

The new furnace was just a huge dome with a diameter of 11m and a one-story (3m) height.

It was a large entrance through which about 100,000 pieces of bricks or 200 tons of charge would be placed inside, after which the entrance would be sealed with bricks and mortar, and the stoves fired.

And once done, the seal at the entrance would be smashed open with hammers, and the products slowly retrieved.

Chapter 294 Dome Kiln

In Adhania, the bricks would be fired in small batches of ten to hundred pieces in tiny furnaces.

This was because the rulers of his country never bothered to industrialize brick production.

One, because it was a somewhat capital-intensive process, and two, more importantly, because they were rich enough to afford stone.

Hence bricks were relegated to the sidelines, only produced by poor individuals who usually produced them for their personal kilns using small homemade furnaces.

Alexander let these micro kilns operate for the first few weeks to get the workers used to the brick-making process and also because he needed the initial building material.

But he had little idea the production rate would be so abysmal, and hence decided not to wait any longer and chose the commencement of the dome kiln.

His current design of the kiln was capable of producing 20,000 pieces of bricks a day, and according to his calculations, these bricks would be far cheaper than stone.

He came to this conclusion by first estimating that the kiln would have a fuel consumption rate of 500kg of firewood per ton of brick.

Alexander could get this theoretical value because he had a rough idea of the energy used to make a ton of bricks and the energy density of dry firewood.

Hence, given such consumption, and knowing 10kg of firewood went for 1 ropal, that came to 50 ropals per ton in fuel cost.

And then after taking into account all other costs, ranging from the raw materials to manpower to the kiln construction cost, Alexander got the cost of one ton of brick at around a nice whole 80 ropals.

Which was quite cheap, about one-fifth the cost of stone, which sold for 350 - 400 ropals a ton.

The reason for such a high price of stone was because a miner had to be paid a minimum of 6 ropals a day and could only extract 20-25 kgs of stone a day.

And if one used slave labor, excluding the cost of buying the slave, his master would also have to at least spend 3 ropals a day feeding the man to enable him to do such physically tiring work.

Thus the dome kiln was a huge step forward in the branch of civil engineering.

Though it could be argued Alexander's choice for this particular brick kiln was not the most optimum one.

A far better alternative kiln existed called the Hoffman's ring kiln, which was in many ways better- being faster, more fuel efficient, and one which did not need its entrance to be smashed open every time.

But Alexander had skipped on that for the time being due to the complexity of its design, and its much greater requirement for time and construction materials, both of which Alexander was short of.

And though the dome kiln was inferior to the ring kiln, it was still not a bad kiln and certainly adequate for his current needs.

In fact, given the simple operating procedure of the dome kiln, the reverse argument that it was in fact the superior choice could be made.

And the operation of the kiln was indeed very simple.

The way the kiln worked was at first, the brick would be placed in stacks inside the kiln.

This stack would not be just bricks placed parallelly atop each other, but in a perpendicular way, with some gap between adjacent bricks.

Such a method was needed to allow the hot gases inside the kiln to properly come into contact with all the sides of the bricks and cook them evenly.

In fact, the reason why bricks would have holes in them was exactly for such, to permit the passage of air through them and enable them to be cooked more quickly and evenly.

Once the bricks were properly stacked, the entrance would be sealed, and the stoves fired, slowly bringing up the kiln to firing temperature in this preliminary stage called the preheating phase.

This phase, even with all six stoves running, would take approximately ten to fifteen hours (10-15 hrs) as the area inside the furnace was huge, thus slowly bringing up the temperature up to the appropriate range.

And this time would not be wasted as within this time period, the green bricks would dry and relieve themselves of a large portion of the moisture.

pαnda Йovê|,còM After this, much more firewood, sawdust, or even coal would be added to alleviate and keep the temperature at a much higher level, and the bricks would be burned for thirty to forty hours (30-40 hrs) at around 700 to 900 degrees Celsius at this stage.

This would complete the firing, and the stoves would be turned off, after which the bricks would be allowed in the kiln slowly for an additional one to two days.

Throughout this entire process, the sealed dome would be provided with fresh oxygen through a network of pipes connected to a chimney on the outer walls of the dome, the pipes themselves connected to the six stoves which would draw in air by a natural draught.

And this natural draught would be created because there would be a tunnel right below the dome that connected to another large chimney some distance away through which all the hot, pent-up flue gases would escape to the outside, thus creating a low pressure inside the dome which would suck in fresh, cold air from the outside.

This additional chimney performed another critical job, as without it letting all the gases escape, the dome would become one giant sealed pressure cooker, thus turning it into a giant time bomb.

And one last keynote here would be that unlike in the cement kilns, there would be no need to use blowers here as such application would raise the kiln temperature too much and overcook the outer surface while keeping the insides raw, destroying the bricks.

This would be because blowers could raise the temperatures to almost 1600 hundred degrees Celsius, whereas the optimum temperature for brick burning, i.e- the temperature along which vitrification or the reactions that turn clay into bricks takes place in the range of 700 to 900 degrees Celsius.

Receiving Alexander's direction, Krishok got down to knowing about the details.

"My lord, how many men will I have? And how fast do you want me to finish it?" Krishok asked.

"I have ordered the five thousand miners in the quarries to switch to other jobs. You can employ a part of them," Alexander spoke, adding, "By my estimate, the dome will need 100 tons of materials and can be constructed by a hundred men in a few days."

His voice then turned casual and breezily, a clear indication he was about to say something absurd, "So, you will choose a thousand men for now and simultaneously build ten of these within the next week."

"...." Krishok went silent for a while as Alexander certainly delivered on his promise of being absurd.

'There he goes again with these ludicrous deadlines,' Krishok lampooned at his demanding master.

This new master of his was perfect in every way- generous, pleasant, courteous, and supremely competent.

Well almost perfect as his one flaw was that he drove those under him like slaves, setting absurd goals and expecting all others to comply.

Krishok thus tried to squirm some more time for himself, "Your Grace, I also have the cement kilns and experimental armors to make. So..."

But he did not get to finish his request as Alexander curtly interjected, "If you are too busy like Jazum, just say so. I will find someone else."

Alexander's brusque tone and damn care attitude made Krishok feel that Alexander could easily choose another over him if he failed to deliver on time and so he immediately changed his tone, making a complete u-turn as Krishok hastily replied, "No, no, milord. It's alright, it's alright, I will get started on the kilns as soon as possible."

"Mmmn, good," Alexander approved with a nod and a light smile, advising, "Diaogosis will not need the stones anytime soon. So, use those to make the kilns."

Alexander planned to build the initial kilns using stone and then switch to bricks once they became more readily available.

"As you command." Krishok this time obediently replied, and then cleverly asked, "Is there anything else?"

"Yes, in fact there is." Alexander gave a light smirk that made Krishok involuntarily shiver.

"One is the number of brick kilns," He began,

"As I said before I want to have the capability to make one million brick pieces a day. You must build enough kilns to get me that capacity. I estimate it would be around 50 kilns."

The confirmation of Alexander's desire turned Krishok a little pale, as it would mean the processing of 2,000 tons of clay and 1,000 tons of firewood.

Never an easy task.

And Alexander certainly noticed this, and so decided to soothe the man with some easy maths,

"One million bricks might sound like a lot, but even a decent brick maker can mold 6 bricks a minute. Experts can even do 9-10. And that means a minimum of 3,500 bricks can be made by each worker per day,"

"So, you will need only 300 brickmakers to make a million bricks."

"And then comes the diggers. Given that they can dig close to 2 tons of dirt a day, let's say another 1,700 will be needed to do everything else, from the digging to cleaning the clay to running the kilns."

"So, don't get scared by the large numbers. It will be very easy." Alexander helped alleviate Krihsok's fear by patting the man's shoulders repeatedly, to which the man agreed with a weak, anemic nod.

Chapter 295 Mine Inspection (Part-1)

Alexander spent some more time with Krishok ironing out the details.

"My lord, will I be provided fuel or should I get it myself?" The tanner raised another issue.

"Hmmm, how should I do this," Alexander hummed thoughtfully for while, asking himself what fuel he would use in the kiln- firewood, charcoal, or coal and how should the logistics of these materials be.

And after a while, taking various things into account, and feeling that brick production was a critical component to the prosperity of the city, decided to give it independent fuel logistics capabilities.

"For making a million pieces of bricks a day, I will give you one hundred and fifty lumberjacks (150)." Alexander promised, reasoning, "One lumberjack, working in a team can cut one ton of firewood in an hour. So these men will be more than enough to cut and transport the 1,000 tons of firewood you will daily need."

In this way, Alexander would be able to make 2,000 tons of bricks with only 2,200 men, which was less than half the 5,000 men used in the quarries that only produced a hundred tons (100 tons) of stone a day.

"Thank you, my lord," Krishok bowed heavily as if weighed by the mammothness of the task, and asked to confirm, "My lord, I intend to use the clay diggers to construct the kilns initially, is that okay?"

"Yes, you can use your judgment on that." Alexander left that up to Krishok's discretion and then after a few more pleasantries, excused the tanner.

Or he almost did.

As he added at the last moment, "Oh just one more thing. The brick fields are being run by a boy named Jafor. Coordinate with him to build the kilns. Because although you will build the kilns, he will operate them."

Alexander wanted to give that silk pants one chance to prove himself so that Jazum could not accuse Alexander of never giving his son a chance.

This directive surprised Krishok because he was under the impression from now on he would run the brick fields, as Jazum did.

But Alexander did not appear to give him such powers, which made Krishok a bit less enthusiastic about the work, but he kept such thoughts to himself, and only obediently bowed, "Yes, my lord."

With this, Krishok soon trotted off to carry out his responsibilities and Alexander was left with only one last great major site inspection.

The mines.

Alexander then spent the next month and a half getting his iron production up to speed and then on one fine morning in late December, he decided to visit all the facilities.

"Greetings my lord, greetings. Please watch your step along the way," Harun enthusiastically greeted Alexander at the foot of the mines and then gestured for him to climb the mineral-rich hills.

Alexander graciously accepted this invitations, lightly chuckling, "Haha, how are you?" as he was flanked on both sides by his bodyguards.

The two men casually chatted with each other about the various mining operations and took in the surrounding sights as Alexander climbed the large hill, taking in the scenery around him.

The many mines on these hills were one of the largest and most productive metal production in all of Zanzan and even in the whole of Adhania, and why Adhania guarded it so fiercely from Tibias ruled and worked by Pasha Muazz and his ancestors for generations and the surrounding landscape around Alexander attested to that fact.

The very first thing one would notice when one looked around was the total absence of any vegetation.

The huge hills and all the surrounding hills for that matter were stripped of any and all green, removed either to dig mines, used up as firewood for the workers and slaves or to simply clear the forest of any dangerous animals and reptiles.

This bald, barren look of the hills did not impress Alexander, who commented, 'Hmmm, without anything to hold the topsoil, chances of a mudslide are inevitable,' he rose up the slopes.

And so he instructed, "Harun, you are to plant trees like pine and white oar on these hills. This will prevent disasters like mudslides during heavy rainfall as the plant roots will bind the soil together."

Alexander's directive surprised and impressed the miner very much.

He knew from the workers such a thing usually occurred once or twice a decade and he had intended to raise this issue with Alexander later, but listening to Alexander give the answer by himself, made Harun once again marvel at Alexander's abilities.

Harun, being an expert miner himself, had certainly seen his fair share of mudslides back in Adhan.

In fact, he was even once caught in one but had always believed it was divine punishment from Ramuh for being too greedy and digging too deep.

'So that's the reason mudslides only happened in hills where there were humans,' Harun felt his eyes open as Alexander stated the real reason behind this disaster.

"At once my lord," Harun then quickly and humbly answered, skipping the endless hackneyed praises others always used to dole out to Alexander.

As Alexander kept up going up the slope, the next impressive structure that caught his eye laid beneath his foot- the road.please visit

This sloping road they were climbing was huge, with it being wide enough to accommodate two fully loaded double horse carts side by side without any problem, and was made of very good, high-quality stone, making it very smooth.

Clearly the despot Pasha knew where the money laid and understood that it would need good roads to smoothly flow down to his greedy, awaiting palms.

And then there were the actual mines themselves, their entrances being huge holes cut into the faces of the hill.

These led to huge, twisting caverns inside the hills, which were supported by large wooden scaffoldings and were where all the precious ore veins lay.

And at last, outside the mines, over flat pieces of land, were scattered hundreds of huge shared logs houses, acting as lodging for the workers and miners, each capable of housing a hundred men.

Space was sparse in these and hygiene non-existent, as the fifty meters long, and eight meters width houses packed the men in double-decker accommodation in two rows, each row facing the other.

There were no sanitation facilities and the workers could not even take a bath at the end of a day of working in the scalding, hot mines.

"Harun, you are to slowly replace these wooden logs with large concrete buildings," Alexander thus decided to improve the appalling conditions of the workers, and then gave Harun the dimensions of the buildings, "Build them 12m high with three stories and a three-meter foundation. And keep the length the same but increase the width three times to 24m meters."

He further added, "These buildings should have four entrances, one each at the back and front and two in the middle, and all must have stairs that go upstairs."

"*Nod*," Harun kept attentively listening, as Alexander spoke,

"And last of all, I see there are no public latrines. So you are to build forty individual latrines outside these buildings. They should also double was shower facilities, with the water supply coming from the small nearby springs via aqueducts."

"Yes, my lord," Unlike the others, Harun did not moan and groan about Alexander's directive like the other, because after working under this lord for close to two months, he got a general understanding of his boss's nature.

When the Pasha wanted you to do something, he would give you all the material and manpower as requested, but you would be then expected to deliver.

Because failing to do so will mean getting sidelined by someone else at the snap of a finger.

This young lord had no patience for incompetency and generally disliked pufferies, so buttering him up usually had the opposite effect.

Harun's docile attitude also had to do with the fact that Alexander had not set some strict deadline for Harun but told him to slowly replace the lodgings one at a time, thus giving him some breathing room.

"My lord, how many men will I get to make these houses? And what about the stone and mortal?" Harun asked about the tools he would need to accomplish his task.

"These buildings will be relatively simple. You will just need to build the outer perimeter walls and then install the door and windows. The inside will be entirely hollow," Alexander announced.

The workers would not have any real privacy, as Alexander planned to follow the same layout currently, which was just placing double-decker bunk beds side by side with a little bit of free space between them so that the workers could place something like a trunk containing personal belongings there.

Alexander then said the maths for the building out aloud, "So including the foundation, a million pieces of bricks and 250 tons of cement will be enough, So I will give you a hundred men to do these constructions."

"And, notwithstanding shortages of raw materials, each of these buildings, including the latrines, should not take more than two weeks." He issued his expected speed of work.

'Haaaaa,' Harun struggled hard to keep his emotion in check, feeling the way about Alexander as Krishok did.

In fact, it was a running gag to refer to Alexander as the 'Slavemaster' between the artisans when they got together to drink.

All of them were quite satisfied with Alexander in most cases, their only sticking point with him being that Alexander liked to assign them huge amounts of work, stretching their capabilities to the utmost max.

Harun then asked his last question, "And master how many will people will each of these buildings accommodate?"

Chapter 296 Mine Inspection (Part-2)

Harun's question about the number of occupants in a building was a roundabout way of asking Alexander how many buildings would he have to build.

And this tactfulness was certainly noticed by Alexander, who internally evaluated Harun as a better statesman than his peers who were much more direct and blunt with their questions.

Then he did some simple internal maths.

'The current lodgings give each worker a space of just 4 square meters (4m2). So, dividing this by the building's new dimensions of fifty by twenty-four (50m x 24m) gets me a number close to 300.' Alexander concluded.

"Two hundred and fifty (250) men per floor, comes to a total of seven fifty (750)," Alexander answered, letting the workers have almost an extra square meter.

How generous he was!

'*Nod*' Harun nodded at this number as he then quietly started to calculate the required number of buildings.

'With the ten thousand (10,000) men under men, that comes to a bit more than thirteen. So instead of fourteen, should I cram a bit more and settle for thirteen?' Harun wondered if he should skip out on building the last one.

But soon back backtracked, "No, it won't work. Judging from the pasha's attitude and the possible future projects, his demand for ores and minerals will only increase. So, more and more workers are bound to join.'

"I will get to choosing the suitable places and start building them as soon as possible," Harun promised.

"Mmmm, I will rely on you," Alexander placidly nodded, and continued the climb.

And as Alexander was approaching the top, where the blast furnace was supposedly operating, he suddenly said to the mining leader, "I want to go inside one of those caves and see the conditions for myself."

"..." Harun's eyes darted a bit in slight fear at this request as he silently signaled Hemicus to discourage this dangerous act.

And this stoic gentleman seemed to understand what the miner was worried about, which he related to Alexander, "My lord, as you well know, mines are not safes. The temperatures inside are extreme and falling debris and even cave-ins are not uncommon. So, may you should reconsider."

"That's right, that's right," Harun chirped up loudly, saying, "It's really dangerous lord Pasha. Every day a few workers will be injured or even die in these cursed places."

This vehement opposition made Alexander feel slightly displeased.

He felt it was necessary for him to inspect the mines and check if Harun was following the safety procedures diligently, and not just putting on a show.

Hemicus knew Alexander long enough to know when he would do things his own way regardless, but nevertheless, this usually silent guardian felt he had to step in and discourage Alexander from venturing into such perilous places, "My lord, please heed mister Harun's advice. If something were to happen to you, a thousand deaths would not be enough to save me. Or Zanzan."

".....*Sigh*, fine, I will not too deep. Just fifty meters," Seeing the pleading eyes of his two retainers and feeling that risking his life for some dumb mine inspections was not worth it, Alexander relented.

And this drew if not a full sigh of relief, but at least a half one from his entourage.

Alexander was soon led into an iron min, at the entrance of which Hemicus pointed to two men at the back and said, "You two stay out here and guard the entrance. And if anything untoward happens, immediately go call for help,"

"Yes, sir." The disciplined soldiers shouted in chorus.

As Alexander went deeper into the mines, the wide external mouth of the mine soon tapered off into multiple narrow tunnels all clinking with the distinctive sound of pickaxes hitting the hard ore veins, joined by the ever-present rhythmic dripping sound of underground water.

Clink! Clink! Clink!

Drip! Drip! Drip!

Alexander's ears played this strange mix tape as he witnessed the men in linen tunics, all wearing helmets and a large wicker basket on their backs, tolling away in these dark, damp caves as they constantly hit the solid rock face with their bronze pickaxes.

These workers worked very hard, going deep inside these tunnels and working for twelve to sixteen hours a day, slowly chipping away at the rock-hard walls in the darkness, illuminated only by the low, soft glow of lit torches.

And for all that back-breaking work all day long, what would they have to show for it all?

A measly fifteen to twenty (15-20kg) kilograms of good iron ore.

Because manually, using just a pickaxe and a bucket, that was the extent a man would carve out of the rock-hard ore veins.

Alexander stayed inside the mines for only a little while, casually inspecting the mines and finding its architecture adequate with the tunnels being securely supported using thick logs and being appropriately lit using large torches every few ten meters.

"Harun, these bronze pickaxes are too weak. Since iron production has started, slowly change all bronze tools into iron," He ordered.please visit

"As you order my lord. I will ask the blacksmiths to slowly start replacing them," Harun promised.

Alexander did not stay in the mines for long as he said, "Well, you people seem very concerned about a possible cave-in. So let's end it here."

Alexander used the excuse of safety to quickly exit the mine, though the real reason was because he was already feeling very hot and beginning to sweat and could not wait to get out.

And along the way, he dreaded to think what would one hour feel like in here, much less ten hours.

And to do that every day for the rest of his life.

'I was lucky to be sold to Nestoras,' Alexander thanked his lucky stars, as the dangers and perils of a battlefield were far more pleasant to him than toiling away in the mines and dying slowly over years if not decades.

The workers here worked in scalding hot temperatures caused by the underground heat from the rocks, or in cold, damp, miserable conditions caused by leaking underground water, and if fate had made Alexander a slave miner, Alexander felt he would have contemplated suicide.

But these 'what if' scenarios only haunted Alexander for a little while, as once he made his way out of the mines, Alexander pushed such thoughts out and instead focused on work, asking

"How many workers have we got here in total?"

And Harun replied, "My lord, you gave me ten thousand (10,000) men who were farming till November."

And then he gave the breakdown,

"Among them, three thousand (3,000) are in there mining iron, my lord."

"Another one thousand (1,000) is digging the open pit coal mine we fortunately discovered last week."

Alexander had been extremely relieved to know that Lady Luck had at least smiled a little bit at him, by letting him get a huge coal deposit right in his backyard.

This was because, although he could have refined iron with charcoal, coal would make his job a few times easier.

Harun was still speaking and at last, finished, "And the rest of the six thousand (6,000) are in the Faika hill mining limestone."

The Faika hills were a small part of the huge Cisrian hills and housed one of the largest deposits of limestone in not only Zanzan but the whole of Adhania.

The numbers of workers and their subsequent delegations were already known to Alexander as it was he who had set them up based on his needs

In fact, he later even revised his numbers as initially one thousand (1,000) men were supposed to work the iron mines while nine thousand (9,000) would extract limestone.

So this was only a way for Alexander to confirm that Harun was following his directives.

And then he asked the succeeding question, "And how much are the daily outputs of these mines?"

Harun quickly in a memorized manner readily replied, "We get around fifty-five to sixty tons (55-60 tons) of iron ore per day, sire."

"As for coal, we get a lot more. That's because we mine in an open pit and all the coal is extracted just by digging up the ground. So we get close to 2,000 tons a day of the stuff."

"And lastly limestone. That is much softer than iron and the Faika hills are literally made of it. That's why we get around 600 tons of it daily."

"Hmmm,..." Alexander hummed as he did some maths regarding the forecast of future demand for these minerals and found the current production to be adequate.

"Good, you did well," Harun waited with baited breaths as Alexander finally gave a praise of approval, making the mining leader let out a large grin and say, "All by the grace of the lord. I will strive even harden in the future."

"Mmmm, work hard. I will put another five thousand workers into the mines soon," Alexander revealed his further ambitions.

And this number though initially surprised Harun, he quickly got an inkling where they might be allocated.

"Does my lord intend them to work the silver and gold mines?" He cleverly asked.

"Yes," Alexander said with a nod, reasoning, "Zanzan must soon print its own currency, And leaving such lucrative sources of money empty and without production is stupid."

Zanzan being the home city of a Pasha for generations certainly had its own huge silver and gold mine which had fueled the extravagant expenses of their and their family's ancestors for generations, and though the veins had been reduced significantly, there was still enough for Alexander to chew on for a while.

Chapter 297 Traditional Smelting

The two men made all sorts of small talks and minor decisions along the way, with Harun additionally promising to start making appropriate arrangements for the silver mines.

In this way, Alexander finally got to a very large, flat piece of the hillside, around the middle section of the hill, where the apple of his eye stood- The blast furnace!

It was close to fifteen meters high with a belly diameter of two meters, and a hearth size of one meter, and was in full swing, with hundreds if not thousands of workers around the massive industrial complex.

Its size, and capacity though nothing when compared to the standards of Alexander's twenty-first century, was enormous for the time being, and knowing what did structure represented, made Alexander's eyes glow with desire and longing as he laid his eyes on this magnificent hot, roaring beast, finding the stretched part of the furnace's belly almost as beautiful as the curves on his women.

In his mind, this was the greatest invention that he would use to change his and his city's fate and that's why he had spent more than twelve hours a day every day for last the last month and a half overseeing its construction.

And it was not just the blast furnace that need constructing, but many other periphery equipment and furnaces, an effort that need the muscle power of close to ten thousand men, and was only completed last week.

"Even though it's been almost a week since it started, the amount this thing can produce still blows my mind," This unreserved praise was awarded by Harun, who looked at the beautiful white structure with sparkling eyes.

And there was justification behind this praise as the current civilization had barely learned to smelt iron, much less mass produce it at such a scale.

"...." Alexander only lightly smiled at the man as his mind drifted to the extremely primitive way iron was currently extracted.

In this time period, to smelt an iron product, first, a miner had to collect the iron ores.

And the primary source of this was from surface pits or from deposits just a few meters underground, which could be extracted by simple shovels, or even just by human hands.

This type of iron ore would be called bog iron ore and the iron smelted from it bog iron.

Large, deep mines that would become the norm in later times existed only in major deposits and were owned by men who counted among the richest men in the world.

This was because constructing mines like the ones in Zanzan, one that went deep into the mountains, with multiple stories below and above the surface was very expensive to not only set up but also to run.

And if one did not have an enormous army of workers ready to smelt the extracted iron which was a snail-paced process using the traditional method, even recouping the running cost would be difficult.

And this problem was compounded by the fact that it was not the supply of the iron ore that was the bottleneck for iron production, but the smelting technique.

Once this bog iron was collected, the processing would move into the next step- Roasting the iron ore for ten hours.

This process was really simple and just involved digging a large hole in the ground, putting the pieces of iron ore into it along with the necessary kindling, firewood, and sawdust, and then lighting it on fire, while adding fuel from time to time as necessary.

This had two basic effects.

One was drying the iron as all the water content of the iron ore would be released, and its structure would become looser, making it easier to smelt.

Two was a bit of desulphurization, i.e- removing some of the sulfur bonded to iron as iron sulfide (FeS) by reacting with oxygen to form sulfur dioxide (SO_2).

Though this would not remove all the sulfur, it would help, as sulfur was toxic to steel, making it weaker and more brittle.

Next came the smelting process.

But before getting the now roasted and crushed ore into the fuel, the fuel that would be used to run the furnace- the charcoal, that had to be manufactured.

This step involved, chopping wood into small pieces, placing it into a pit with a chimney in the middle, and then coving the surrounding area with a layer of leaves and soil to make the pit, not impermeable, but restricted to oxygen.

The charcoal pile would then be ignited through the chimney, and through pyrolysis (the process whereby wood becomes charcoal by losing its water content) charcoal would be slowly created over one to a few days.

This charcoal would be then transferred to a furnace, built using clay mixed with sand, and with tuyeres, or the nuzzle used to connect the bellows and the furnace, built into them and be used as fuel.

One side note to note here would be the tuyeres would also be made of clay and required a lot of skill and experience to build, thus making furnaces generally very expensive equipment.

And with all these done, finally, the actual smelting could start.please visit

At first, the furnace would be pre-heated by filling it up with burning charcoal over which a layer of roasted bog iron ore would be placed and then another layer of charcoal alternately.

After this, the furnace entrance would be closed using mud and clay and for the next several hours the mixture would be constantly heated using the blowers and by adding fresh charcoal through the chimney.

This would cook the ore and produce a thin layer of slag, primarily non-iron substances from the iron ore and some iron that could not be reduced from the ore and would be tapped from the furnace through a slag-tapping hole built near the entrance of the furnace.

It is important to note here that, unlike modern steel-making, the iron stays in a solid state throughout the smelting process, only changing from the solid rock-like state to a kind of sponge-like structure called the iron bloom which formed in the hearth of the furnace.

This sponge iron would be full of slag impurities and be removed once the smelter felt it had become large enough by breaking open the sealed entrance.

This would then move the iron smelting to the last step, the forging.

Blacksmiths would use heavy, repeated strikes to shape the iron bloom into a piece of iron by wielding large hammers and it would take hours of slow, tedious, and back-breaking work to produce a single piece of iron.

And ironically, for all that work and effort, the blacksmith would not have a very good piece of iron to show for it, as due to all the slag inclusions, it would not only be much more difficult to forge a piece of iron than modern steel but also because these iron contained harmful impurities that would make the iron very weak and brittle.

This huge presence of so many impurities was the reason blacksmiths were not able to make large pieces of iron, as making the structure long would many times cause the iron to split and open up during the forging process, resulting in cracks in the material.

In this way, about 20 kg of bog iron using 30 kg charcoal would be obtained from the smelting process in about 10-12 hours, which was almost equal to a rounding error when compared to the tens of tons of steel Alexander was capable of producing per day.

And hence, Harun's admiration for the white, blazing beast was very understandable.

As the two men silently observed the workers working like tiny ants all over the huge plant, an assistant of Harun suddenly appeared, bowed to Alexander, and then whispered something into his master's ears

The information did not seem to be something untoward, as Harun's face lit up not with concern but surprise, as he quickly ordered, "Okay, you go escort the lords. And tell them I'm here with the pasha."

Then he turned to Alexander with a gentle smile and relayed, "My lord, it seems the military and civilian lords that you invited are waiting at the foot of the hill."

"Mmmmn, then let us wait here for them before starting the tour," Alexander suggested.

He had asked his retainers to come and bear witness to Zanzan city's capabilities and to discuss future policies by taking into account such changes.

As the two men chatted, Harun raised, "My lord, it is quite rude that you should arrive before them. This is a great breach of etiquette,"

It was an Adhanian tradition for the lower classes to wait upon the upper classes and such duties were even applied to the nobility, with the lower ranks serving those above them.

"Haha, no worries," But Alexander simply waved these concerns while fanning his large palms, and excusing the others by saying, "It was I who arrived early because I was too eager. They are actually on time."

Alexander was never a slicker for such stuffy rules and regulations and unless the other side blatantly disrespected him, he would usually turn the other cheek.

The two then further continued the small talks, until finally, the large group of all the council members had managed to catch up with them.

And the real tour could finally begin.

Chapter 298 Coke Bed

"We are terribly sorry that we are late, Your Grace," Menicus lightly bowed as he greeted Alexander, followed by all the others.

"Haha, no worries, no worries. I just arrived too," Alexander lightly replied and then decided o to skip the tedious greeting ceremony as he hastily instructed, "Harun, the day is not getting younger. So let us start the tour."

"Yes, yes, my lord." Harun quickly answered and then gestured, "Then let us go this way please, my lords."

Harun's direction of gesture surprised the newly arrived men as it pointed not to the blast furnace but somewhere adjacent to it.

Sensing this confusion, Harun elucidated. "We will start from the very beginning of the iron production process, and it starts from there.."

'There' pointed to a huge shed, with a waterwheel attached to it, as Harun introduced not the building, but first the waterwheel.

"My lords, as I'm sure you all know, this is the waterwheel invented by the pasha and it is what enables us to do anything at all here." Harun flattered Alexander.

This got a unanimous nod from the whole group, who, when first introduced to it had been astounded by the simplicity and ingeniously of the wooden structure.

"Of course, I know. It was me who the pasha first showed it to. And I have also built two that both make this look like a toy!"

The loud, boastful remark was made by Diaogosis who puffed up his chest in front of all the others, pride dripping out of him as he reminded the others of the two 20m diameter waterwheels he had built and that operated 24/7, processing 200 tons of Portland cement per day.

"Yes, I also know you are scheduled to build five more similar ones to process not just the cement, but also to grind the bricks into small pieces to be used in concrete," Harun had a condescending tone to his voice, and then he sarcastically asked, "So what are you doing here? Shouldn't you be working?"

This bad blood between the two had started when Alexander had transferred a large part of Diaogosis's ten thousand men to Harun to work in the foundry, which did not involve just the blast furnace, but three other major devices as well.

There was also the fact that in addition, Diaogosis was also jealous of what the blacksmith had accomplished and felt acrid in his heart at the man's success.

Now Diaogosis did not have the guts to blame Alexander, and so took his anger out on Harun, who, not being a man to take a beating laying down, also launched his own counter-attack, resulting in such frequent clashes of words.

"Haha, both of you are doing an excellent job in helping Zanzan, and all its people. So there's no need for animosity," Alexander chuckled as he played the benevolent mediator, pretending to put a stop to this bickering.

He knew that in addition to Diaogosis not liking Harun, this boastful remark was a way to draw Alexander's attention towards himself and remind the pasha of his achievements, which was ultimately a roundabout way of asking Alexander to grant him a peerage, something the pasha had yet to promise him.

'Hehe, I don't like impatient men,' Alexander darkly mused about this little covert play, his displeasure about Diaogosis's character growing even more, as he decided, 'Stay a civilian for a while and cause some more trouble.'

This internal thought was the exact opposite of how he appeared outside and he did not truly oppose such barbed exchanges too much and even indirectly supported some of them.

And the reason for this, reason why Alexander somewhat approved and even encouraged such behavior was because if the nobles and high-ranking officials under him were too busy with petty squabbles among themselves, they would not have the time to plot against him, thus making this life on the seat much safer.

Of course, Alexander would step in if these small arguments flared up into full-scale hostilities, but a 'healthy' bit of animosity among his retainers was something desirable for him.

Alexander's intervention instantly made the two men shut and Harun's smirking, taunting face flipped to that of a wide, flattering grin in the blink of an eye who quickly addressed the crowd, "Haha my lords, then please enter the shed and let us observe it's operations."

With this invitation, the large number of people entered the enormous and enormously busy shed, eager to see its function.

A function that Harun, like the diligent guide he was, gave quickly, "My lords, this shed is used for two things, both hugely important."

"First," Harun pointed to one of the two huge flat, open concrete beds that combined covered 80% of the huge shed and introduced, "This first bed is the coke production bed."

This explanation was self-evident as right in front of them was a truly enormous field of coal, laid out horizontally across the entire structure, and being heated up via a blazing inferno that burned underneath.

To help facilitate this, there were numerous large firing holes underneath the bed to allow the entry of firewood and coal as fuel, while the simultaneous removal of soot ash.

There were small porous holes, around a centimeter (1cm) in diameter punched into the bed which allowed the hot gases to escape through the bed and into the air, while in the process also heating up the coal that is on it.

Harun gave the others a very succinct version of the explanation Alexander had given him, "Here coal is heated for twelve to fifteen hours to drive away all the water present in it and thus turning it a substance called coke." Harun claimed, and then gave its use,

"We need to do this because this coke burns much faster and hotter than coal and is ideal to be used to produce the heat needed to melt iron in the blast furnace."

This explanation produced an understanding nod from all the visitors.

The news about molten iron did not cause any commotion within them as they all came here knowing that a process for producing liquid iron had been discovered by the pasha and that the lord wanted all of them to see exactly how it was done.

While for one man named Alexander, it reminded him of many things currently wrong with this method of coke production.

First was the open bed design.

Normally the coke would be made in an enclosed furnace like the brick kilns where the temperature would be raised to 900 degrees Celsius by trapping most of the air.

This created the oxygen-lacking atmosphere needed to turn the coal into coke through pyrolysis.

But Alexander had chosen this open-air design for the time being because of a couple of reasons.

The first and biggest one was because it was adequate for the time being.

It was cheaper, easier to operate, and because the coal extracted here was of exceptionally high quality, hence the current design was enough to get the job done.

One major problem that Alexander had faced while designing a closed furnace was the loading and unloading of the charge.

Though the loading would be done by making the entrance large enough for horse carts to directly enter and dump their load inside, unloading the furnace was a lot more difficult.

The hot furnace had to be allowed to be sufficiently cooled, and then the tons and tons of materials had to be manually placed into carts using shovels.

This was not only very slow and time-consuming but also very inefficient fuel-wise, as the furnace had to be stopped, cooled, and then reheated from scratch again in the next cycle.

Hence, due to the periodic nature of these types of kilns, they were called periodic kilns and were generally quite inefficient.

It was not such a problem in Alexander's previous life, as then, the load could be mechanically loaded and unloaded using mechanical hydraulic levels, so even if the furnace was turned off, it did not have to be cooled down to room temperature.

The next problem with this method was Alexander using big lumps of coal in the coking produce and not crushed or even partially crushed ones.

This was highly inefficient as the ground-up coal would have had much more surface area and hence needed much less time to turn to coal, making the process much more time and fuel efficient.

And even more, was the fact that Alexander would have to grind this coke anyway before placing it into the furnace.

But Alexander did not do it because he was afraid that these crushed coals could fall into the small pores that let the flue gases out or do so as the coals shrunk in volume when transformed into coke.

And the last flaw with this open bed design was that producing coke not only drove away the water vapor but also volatile natural gases like methane and ethane, which currently he was just letting escape into the air.

And this was because Alexander did not have any way of collecting and storing gases.

For that, he would have to invent rubber which could then be used to make gaskets and produce an air-tight seal, an endeavor he was already working on.

'If I can get rubber from that, I won't need to look for any rubber trees. And I can then invent gaslighting,' Alexander ambitiously thought.

In this way, as Harun continued with the tour, showing the marvels of Alexander's creation, the chief guest of the tour was already busy making other plans.

Much, much grander plans.

Chapter 299 Ball Milling Machine

Alexander knew the significance gas lighting could have on a civilization as it was capable of transforming the dark, economically useless night into a productive time almost equal to the day, and almost doubling it's industrial output.

He also knew that none of the challenges of collecting the gas by heating coal through pyrolysis was nowhere substantial enough to be unassailable.

But the main reason why he was using such a crude method was due to the time constraints Alexander faced when building this facility and also because there was no competition forcing him to lower his prices.

The setup was simple and it worked for the time being.

But the key point was 'for the time being' and as Alexander was not the type to sit on his laurels, he said to himself, 'I should design a new coke oven as soon as possible, with all the improvements.'

And soon a blueprint began to take shape inside his mind, the schematics of which contained facilities to trap the precious flue gases.

But the true shape of that invention would, even by Alexander's optimistic estimate would have to wait a few months, and so, deciding to shelf the project for a little while, Alexander returned his attention to the tour being provided by Harun.

And he caught Harun almost at the end of his explanation of the coke bed, who was saying, "Once the coke is made, it is then collected off the hot bed into large buckets using long rakes by workers, while the bed is refilled by pouring buckets full of coal from above."

"This hot coke is then cooled by pouring water from a spring using aqueducts over there," Harun at last pointed to a huge pit of coke on one side of the shed over which a torrential stream of water was gushing over, and then being discharged through dug drainage pipes.

Harun then moved on to a second similar bed just beside the coke bed, and introduced, "This step should be known to us all, it's the roasting bed where the iron ore is heated."

And then since this step was done in the original process, Harun simply skipped to the next step, saying, "Now, let's move to the last function of the shed."

With this said Harun gestured to the elephant in the room, something that everybody noticed the moment they entered the workshop.

"My lord, I'm sure you are eager to know what this is," Harun very grandly pointed to a giant drum that was slowly rotating at the far end of the shed and the crowd responded with an eager look.

"This is called the ball milling machine, as I'm sure many of you might know. and it's used to grind rocks into powder." He introduced.

The lords had heard of this new gadget too and knew this device could turn stone to powder in a matter of minutes.

But they were also not too clear on the details of how it worked, and looked expectantly at Harun for an explanation

But here they were disappointed as under Alexander's directive, Harun could only ruefully shake his head, signaling further information was restricted.

Alexander had instructed Harun before on what to reveal and what to conceal, even from his own council members.

So Harun only gave them its function, but only how it worked, "We use it to grind our three main ingredients, iron ore, coke, and limestone into small chucks."

"We do this because according to the pasha this smaller size aids in faster iron production."

Alexander's reason for the secrecy was obvious, to protect his core technology.

In fact, he had even strongly debated on whether to give his retainers this tour and finally relented because of several reasons.

The first and foremost was because Alexander understood that to try and hide all the secret technologies and innovations being applied here, a place where close to ten thousand men worked in and around was utterly futile.

But though some leaks were inevitable, that did not mean Alexander would give detailed descriptions of the machines here to help his rivals and enemies.

And so, with that thought, Alexander decided to change strategy and only try and protect the core of these new inventions, while leaving the less technical aspects out for everyone to study.

And it was this less technical aspect that Alexander was showcasing his retainers, with the additional intention of making them understand Zanzan's potential and increase their loyalty to the city, the province, and to him.

And an example of such a technique being applied could be seen right now, as was the case with the ball milling machine.

These ball milling machines might look very simple, like simple rotating drums, but their inside did hide a few secrets.

For one, there were small internal protrusions that helped carry the balls up and dropped them from a height, thus providing the smashing action that made the mill actually grind the minerals placed inside it.

Without such a benign-looking, but actually vital piece of architecture, the entire thing would be useless, and the large bronze, concrete, or steel balls that were used to crush the minerals would just harmlessly tumble around with the rocks inside.

Then there was the number of balls to be placed in proportion to the ores.

Too little and the grinding would take too long or be incomplete.

Too much and the balls would smash against each other and not the rocks, thus decreasing efficiency.

Seeing Harun being tight-lipped about this device's inner mechanisms, the lords very well understood under whose orders he was behaving as such and thus, instead of pressuring the still civilian, they focused their attention on watching the operation of this marvelous device of both mechanical and civil engineering.

"Is the drum rotated using the waterwheel?" Menes inquired.

"Yes, my lord. I'm sure you have noticed all the aqueducts outside. We used them to divert the water supply from nearby springs. It took a lot of effort," Harun explained.

"I see," The black general nodded in understanding and then focused on the large drum.

It had a capacity of five tons, was made of concrete, and had the rear end penetrated half a meter by the wooden transmission system of the waterwheel.

To securely connected the machine to the wooden log, long thick steel spokes that went all the way out of the walls of the machine were used and the whole connection gave a sense of strength and robustness.

This huge drum was placed on two elevated pillars about one story above the ground, placed in a slightly slanted alinement, with the rear end a bit higher than the front, designed as such so that the ground-up material would automatically empty out of the machine when the door was opened.

These supporting pillars were very strong, made using the same techniques used to make reinforced concrete, with the only exception being the steel rods substituted with strong pieces of cut oak instead.

A very notable feature of the two pillars was the surfaces on which the drum sat were baby bottom smooth, designed as such so that the drum would slide over them with ease, an action which was additionally facilitated by a constant stream of a mixture of olive oil and water applied by workers.

"How is this huge thing stopped?" Came the curious inquiry of Melodias, who additionally asked, "I presume it needs to be stopped to empty and refill the thing?"

"Lord Melodias has discerning eyes," Harun produced a large smile, and then answered the general's question, "The drum is tuned on and off by turning the waterwheel on and off. And that is done by operating the sluice gate installed outside."

Harun further explained, "When the sluice gate is opened, water is allowed to flow over the waterwheel and turn it, thus turning the ball milling machine with it."

"But once the gate is closed, the water can no longer flow over the waterwheel and is instead redirected to an adjacent channel through which the water harmlessly bypasses the waterwheel and falls into the ground, thus turning off the waterwheel and with it the machine.

"I see. That's quite the ingenious approach. As expected of the great pasha." Melodias loudly cheered.

"Ohh, look, it's stopping!" Suddenly the excited exclamation of Grahtos rang out as he drew everyone's attention to the machine that was slowing down.

"Oh, it seems the lords will be able to fully see how the machine works," Harun sounded pleased with this coincidence and thus waited with everyone else to observe the unloading and then loading of the structure.

So for a while, the men stood and watched as the workers worked like busy bees, their first task opening the large thick door of the machine.

This concrete door was closed tightly shut by using two thick wooden bars that went in front of it and into the two large handles situated at the opposite ends of the door, very similar to how ancient gates were closed using massive wooden planks.

These wooden planks appeared to be very heavy, as evidenced by the need for multiple men on the scaffolding to remove each of them, after which the door would swing open by itself, pushed open by the weight of the huge amount of powder that is a slanted angle.

"This batch was the coke," Harun commented, as the now dried up during the grinding coke fell below into a huge, custom-made eight-wheeled wooden cart reinforced with iron and was then pulled away by six, strong horses.

Chapter 300 Blast Furnace

The product of the grinding would not right away be taken to its destination, for this product still contained one last impurity.

And to remove this, the cart would be taken to a separate station a bit further from the machine and about fifty workers would scamper into the cart, carrying buckets on their backs, and then start quickly shifting through the crushed ore.

They did this to retrieve the make iron balls that were used to grind the ore and though some balls were inevitably lost, close to 95% retrieval was possible for these expert men.

'Hmmm, I should invent the magnet. I will need it to make the compass anyway,' Alexander made a mental note as he watched the diligent workers shifting through the black coke and turning their faces and hands pitch black in the process.

While this was going on, the empty machine was being filled up in a novel way others had never seen before.

It was being done by placing one end of a hollowed-out log into the center of the machine, while the other end rested atop the scaffolding built much taller.

Using this hollowed-out log like a slide, the iron ores, limestone, or cokes would be easily deposited into the machine, with workers using large wheelbarrows to rapidly transport these commodities.

'So, that's why the machine is slanted and placed so high,' The mystery was made clear to all as the council members continued to observe the complete operations of the ball milling machine.

Once the machine was filled, the necessary amount of iron balls was added, the door pushed closed, the wooden planks reinstated, and the whole cooperation would start again.

"Hahaha, to think one day we would be able to produce so much of anything," Heliptos would sleep in his sleep thinking of all the money that could be made using

"How much can we grind in a day?" The aged Menicus was more interested in their capacity and so pointedly ask.

"....." Harun shot a glance at Alexander and after seeing the nonchalant look on his boss's face, he got the message.

"I'm sorry, my lord. But that is classified." Harun had wondered if Alexander would make an exception for the most senior and powerful council member but it seemed the pasha was adamant about keeping his secrets.

"Enough for the foreseeable future," Alexander decided to at least give this amount of respect to the senior statesman, and it got an understanding nod from Menicus.

The daily capacity of the machine was twenty to twenty-five tons a .day, and there were three such similar machines in workshops similar to this.

And the reason why it was so low compared to those at the cement production which could process a hundred tons (100 tons) a day was because the currents and amount of water in the springs near there were extremely high, allowing for the spinning of much greater loads.

"Now let us go to the actual furnace where iron is made," Harun finally decided to lead the group to the place all these people had come to witness.

The crowd hence moved quickly, ignoring the scores of workers moving about the place like ants with no time to waste, and instead focusing on the huge tower that stood against the skyline, like a proud peacock, Alexander's pride and joy.

The white blast furnace had been made using stone and concrete, with a thick layer of clay lining to resist heating, and was of the same design as the cement kiln, the only difference being that the dimensions were a bit larger.

No, scratch that, a lot larger, particularly the height, reaching close to sixteen meters, as opposed to the cement kiln's measly four.

But it was a lot leaner too, designed as such because many of the reactions needed such a tall design to allow different temperature gradients to appear.

There was also the difference in how the double-action blowers were operated.

Instead of being manually driven by human hands like it was with their sister furnaces, the two enormous blowers were operated using pistons driven by two waterwheels on both sides, these giant wheels themselves spun by water transferred via aqueducts from nearby springs.

"As you can see my lord, this is where the magic happens," Harun did not really need to point out the obvious as everyone had already disregarded the miner's existence and instead focused on the huge, roaring structure whose belly was full of fire and who was connected to a myriad of scaffolding, aqueducts, pipes, and waterwheels.

They could see huge cranes situated next to the blast furnace which were being used to fill the enormous, hungry beast, as the load would be raised using ropes pulled by animals and then the special buckets would be tipped over by the few strong men on the scaffolding around the mouth of the blast furnace.

"We always keep the furnace full, and run the furnace 24/7," Harun added some commentary, but did not reveal in what arrangement the charge inside the blast furnace was kept.

This was to be kept secret under Alexander's order, as the way the charge was introduced into the furnace affected the final production.

The correct way to do it was not to mix the three ingredients, iron ore, coke, and limestone together and then dump it all in, but to do it in layers.

First, a layer of iron ore would be deposited, followed by a layer of coke, and then a layer of limestone, after which the pattern would repeat itself.

And these layers could not just be of equal amount, with the proper proportions being 1.6 tons to 500kg of coke to 150kg of crushed limestone, or any amount maintaining this ratio.

These particular numbers were used because to produce one ton of pig iron, this amount of raw materials formed the perfect balance.

Any less, and some of the numerous reactions that take place in the blast furnace would remain incomplete.

While any more, and the excess would interfere with the reactions taking place during the next phase.

This chain of reactions were vital to steel production, and it all started at the very top.

This was facilitated by the design of the blast furnace which was a counter-current gas/solids reactor in which the descending column of burden materials [iron ore, coke, and limestone reacted with the ascending hot gases and produced the desired products.

These numerous reactions were a continuous process and were kept constantly running by adding new raw materials to the top of the furnace and molten iron and slag being tapped from the bottom of the furnace at regular intervals.

At the very top part of the furnace, any free moisture would be driven off from the burden materials and limestone (CaCO3) would decompose into calcium oxide (CaO).

A bit below, some of the iron oxides would be reduced by carbon monoxide produced due to incomplete combustion of the coke, and this typically occurs at 700-1,000°C.

In the middle part of the furnace, called the bosh, was the place iron starts to soften and melt and where the real smelting took place.

And it was also here that heated, hot air, at around a 1,000 to 1,300 degrees Celsius was blown into the furnace by blowers, combusting the coke and raising the temperature to around 2,000 degrees, making it the hottest place in the furnace.

This heat would cause the iron to finally melt and being denser, it sinks down, causing the less dense pool of impurity formed by various reactions with the limestone, called the slag to float to the top.

The two liquids would have different tap holes and these would be periodically opened and the products extracted to the outside.

That was the basics of a blast furnace, but Alexander did face one large issue while designing this, and that was the tap holes.

This was because whereas in modern times, such access points would be electronically operated by opening and closing the doors, currently he was required to design a kind of manual switch that would be opened and closed repeatedly without having to go too close to the burning inferno.

And after thinking for a while, the solution he came up with a both simple and ingenious.

What he did was design a horizontal L-shaped concrete plug, with the lower part of the letter driven into the plug hole, while the other part of the structure was attached to pillars that connected to large wheels placed on concrete rails.

In this way, draft animals could be used to move the L-shaped plug, thereby opening and closing the tapping holes.

These concrete plugs were not too heavy, as the holes they plugged were really not that large, only about 15cm in diameter or half the shoulder width of an average man and these would be opened for about 30 seconds every two hours, letting out 4 tons of pig iron, along with around 800kg of slag

The slag would be taken away to be used as fertilizers in Alexander's personal estate as the amount of the stuff was nowhere near enough to be useful in large-scale productions, while the molten pig iron would be taken through a concrete channel right below the tapping below into a Bessemer converter situated at an elevation 6m below the blast furnace some distance away to be converted into steel.