$$w = \frac{pa^4 b^4}{2 Ee^3 (a^2 + b^2)^2}\left(1 - \frac{x^2}{a^2}\right)^2\left(1 - \frac{y^2}{b^2}\right)^2 \quad \ldots \ldots \quad (12),$$

skąd wyprowadza się wartość na strzałkę wygięcia w środku płyty:

$$f = \frac{pa^4 b^4}{2Ee^3 (a^2 + b^2)^2} \quad \ldots \ldots \quad (13);$$

wartość ta na f jest piątą częścią wartości, jaką daje wzór przybliżony (9), a szóstą wartości według wzoru dokładnego (3).

W płytach okrągłych, umocowanie brzegów zmniejsza tylko strzałkę w stosunku 21 do 5. Zdaje się więc, że wzór (13) powinien być pomnożony, podobnie jak odpowiedni wzór (9), przez pewien spółczynnik poprawczy, większy od jedności. A przyjmując spółczynnik ten, równy spółczynnikowi $\frac{6}{5}$, wprowadzonemu do wzoru (9), będzie:

$$f = \frac{3}{5}\frac{pa^4 b^4}{Ee^3(a^2 + b^2)^2} \quad \ldots \ldots \quad (14).$$

Z poprzedzającego równania (12), wyprowadza się wzór:

$$\max. R = \frac{2pa^2 b^4}{e^2(a^2 + b^2)^2};$$

a nakoniec wzór:

$$e > 1{,}58 \frac{ab^2}{a^2 + b^2}\sqrt{\frac{p}{R_0}},$$

gdzie 1,58 jest spółczynnikiem poprawczym, który autor wywodzi w sposób analogiczny z poprzedniem rozumowaniem przy spółczynniku we wzorze (14).

J. G.

GÓRNICTWO. — HUTNICTWO.

Gazowy piec żarowy z rekuperatorem do ogrzewania i glijowania blachy.

(Tab. XIII).

Ogrzewanie sztorców (Stüze, bidons) i pakietów przy fabrykacyi cienkiej blachy żelaznej, ma pierwszorzędne znaczenie i racyonalne urządzenie pieców żarowych (Blechglühöfen, fours dormants), jest kwestyą, na którą kierownik walcowni blachy cienkiej baczną powinien zwracać uwagę. Od jakości płomienia, w którym grzeją się sztorce albo pakiety przed rozwalcowaniem ich na blachę cienką, zależy w wysokim stopniu jakość produktu—dosyć zaznaczyć, że zapomocą odpowiedniego regulowania płomienia można otrzymać blachę o zupełnie różnym wyglądzie zewnętrznym, np. blachę matową albo błyszczącą. Główna jednak zasada dla ogrzewania sztorców i pakietów polega na tem, że płomień powinien być jaknajmniej utleniającym, a nawet redukującym.

Nie mam zamiaru obecnie zastanawiać się bliżej nad tą kwestyą, chcę tylko zwrócić uwagę na warunki, jakim powinny odpowiadać piece żarowe, uży-

Gas glow furnace with recuperator for heating and annealing sheet metal (1897)

Technical Review [Przeglad Techniczny], 1897, Vol. 35, No. 32, pp. 518-522

(Table XIII).

Heating of shafts (Stiize, bidons) and packages during the production of thin iron sheet metal is of primary importance, and the rational design of annealing furnaces (Blechgluhofen, dormants furnaces) is a matter to which the manager of the thin sheet metal rolling mill should pay close attention. The quality of the flame in which the shafts or packages are heated before they are rolled into thin sheet metal determines the quality of the product to a high degree - it is enough to note that by properly adjusting the flame, it is possible to obtain sheet metal with completely different external appearances, such as matte or shiny. However, the main principle for heating shafts and packages is that the flame should be as little oxidizing as possible, and even reducing.

I do not intend to delve into this issue further at the moment, I just want to draw attention to the conditions that annealing furnaces used in the production of thin sheet metal should meet. Fuel represents a very significant position in the costs of this production, so in addition to the ease of obtaining a reducing flame and ease of regulating it, fuel economy must also be taken into account. Neglecting these three conditions in the construction of annealing furnaces not only makes it impossible to obtain a good product, but also significantly increases the own costs, more than in the production of other types of rolled iron.

The majority of furnaces currently used in thin sheet metal rolling mills have ordinary grate firing. The reasons why attempts to use Siemens' regenerative firing for annealing furnaces are only found in a few places are:

1) significant costs of equipment
2) significant dimensions that are difficult to reconcile with the usually small dimensions of annealing furnaces and their low production,
3) difficult to reconcile the relatively low temperature required by these furnaces with the high temperature obtained with Siemens' gas firing.

Bicheroux firing, due to its simplicity, although suitable for annealing furnaces, cannot be applied everywhere because it requires high-quality fuel.

As for the use of recuperators, until recently, attempts in this direction did not yield desirable results. One of the most important criticisms of gas-fired furnaces with recuperators is that the heat of the exiting gases is not sufficiently utilized (because this heat is only used to heat air, not air and gases, as in regenerators), which is not suitable for thin sheet metal annealing furnaces. Heating of shafts and packages requires relatively low temperatures, and the heat of the exiting gases can be adequately utilized if used only to heat the air required for burning the gases entering the furnace. The remaining amount of heat will be so small that it can only be used to create a natural draft.

In principle, the use of gas firing with recuperators for annealing furnaces is entirely appropriate and can bring real benefits, and if the attempts, as mentioned above, did not yield positive results, it is because the recuperators used so far have proven to be costly and impractical.

Due to the uneven expansion of the entire furnace from heat, even the most carefully constructed recuperators soon break down, and the partitions separating the air from the gases crack or come apart, causing the air to mix with the burned gases. Repairs are very difficult and costly, and in any case, they only provide a temporary solution. The gas channels quickly become contaminated, and cleaning them is very difficult, sometimes even impossible without completely disassembling the entire recuperator.

However, as we can see, these difficulties arise only from the faulty design of the recuperator, and I believe that they are not insurmountable. Building a recuperator without these drawbacks would allow for the use of gas firing for annealing furnaces, which would be of great importance for thin sheet metal production.

Furnaces with ordinary grate firing, despite being widely used today, leave much to be desired. The temperature obtained in these furnaces is often insufficient to heat heavier shafts - it is necessary to resort to forced air blowing. With such forced heating, the flame is mostly oxidizing, causing the sheet metal to come out impure and significantly increasing the number of defects. Fuel consumption in furnaces with ordinary grate firing is generally significant; regulating the flame is very difficult and requires great skill on the part of the worker, especially when dealing with lower-quality fuel.

In one of the Hungarian thin sheet metal rolling mills, a gas furnace with a recuperator was finally built in 1894, according to the idea of the engineer of that mill, Mr. I. Tereny. The furnace's over two-year operation seems to fully confirm the hopes placed in the recuperative system for gas furnaces. The recuperator, characterized by great simplicity, is the most important part of Mr. Tereny's idea; eliminating the aforementioned drawbacks was given top priority here. From the furnace operation results published in the "Berg-und huttenmannische Zeitung" (No. 14, 1897), it can be seen that these efforts were successfully resolved.

The furnace itself has nothing special and belongs to the type commonly used. The smaller opening, located near the threshold, is used for inserting shafts, and the larger one at the front of the furnace is used for packages.

The generator has a significant width, and there was even a fear that it would be too big because of it; however, it was necessary to comply with the length of the wood used as fuel. To reduce the volume of the generator and prevent the un-reduced gases from seeping around the walls, the latter were built slightly inclined; the wood fits much better to the inclined walls.

Air enters the generator not through grates but through square openings *aa*. The upper row of these openings can be plugged with bricks if necessary. The bottom openings also serve to extract ash and slag.

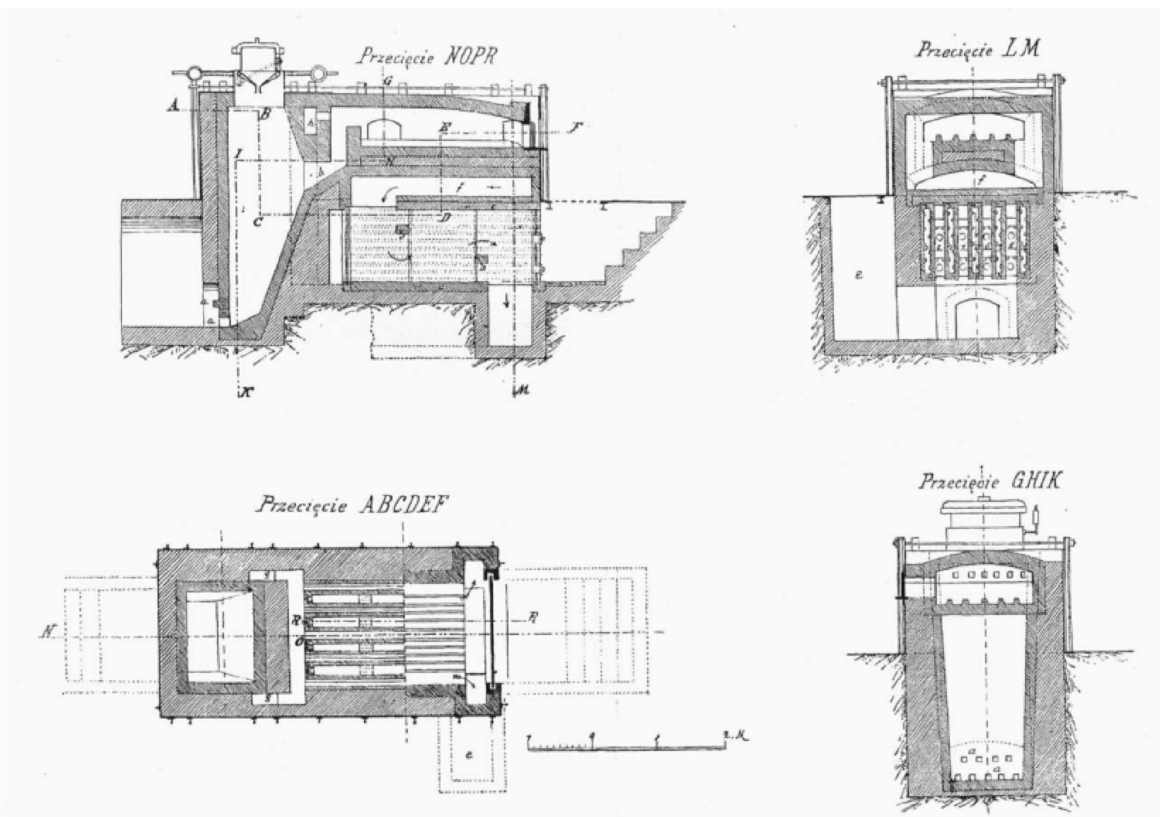
The gas outlet *b* is located halfway up the generator to ensure that the space above the opening is used only for drying the wood - there was a fear that too much steam would be present in the entering gases since the wood put into the generator was not dried.

The recuperator consists of two systems of channels: 1, 3, 5, 7, 9 for air and 2, 4, 6, 8 for gas. The walls are made of fired clay plates, 70 mm thick, and have proven to be completely impermeable. Longitudinal protrusions on the plates facing the air channels serve to increase the heating surface. The gas channels are closed at the opposite ends by narrow plates placed between two protrusions of the longitudinal walls. The walls of the recuperator are tightly secured at the bottom and top to the plates *c c*.

The partitions *dd* serve to distribute the gases evenly throughout the recuperator. The front walls of the gas channels are equipped with several rows of circular holes for cleaning the channels, which are plugged with clay stoppers during operation.

The door *e* is used to remove dust after cleaning the recuperator.

The burnt gases flow as indicated by arrows in the figure. The flue passes along the bottom of the recuperator. This device is useful for the uniform heating of the entire recuperator, which serves to prevent it from cracking.



The attached drawing was also obtained from the same source.

Space *f* can also be used for heating packages or for the final annealing of the sheet metal, if necessary.

Air enters through openings in the plate in front of the furnace; after passing through the recuperator in vertical side channels *gg*, it enters the furnace through square openings above the gas inlet through channel *h*. As can be seen, the air flows through the recuperator in the opposite direction to the gases.

Slides (dampers) placed in the chimney and in the side channels *gg* (not shown in the diagram) are used to regulate the flow of gas and air. By adjusting the latter, an oxidizing or reducing flame can be obtained.

The inventor, citing the results of the furnace's operation, points to the following advantages of his design:

- Ease of cleaning the channels, which can even be done during operation of the furnace, as the channels can be cleaned independently of each other. The channels only need to be cleaned three or four times a year at most.
- Very small furnace operation - only one stoker is required.
- Because the recuperator heats up very evenly, it lasts a long time, the walls do not crack or deform. In case of wall breakage, replacement is very simple and inexpensive, and it is not necessary to dismantle the entire recuperator.

The two-year operation of the furnace seems to fully confirm the above advantages. During this time, the recuperator did not require any repairs, and the dust that accumulated in the places where the gas direction changed only needed to be removed once.

With the help of regulating the flow of air and gas, it was possible to achieve a very high temperature in the furnace, which, in addition to the threshold, reached almost white heat.

As for fuel savings, it should be noted that the rolling mill in which this furnace was built was powered by water. Fluctuations in its flow caused frequent interruptions in rolling, which did not allow for intensive use of the furnace operation. To get an idea of the efficiency, the furnace's results were given during a four-month period (from March to August) when the water flow was the most constant.

During this period, the average daily production of the furnace (12 hours) was 7 tons of billets, and the monthly production was 197.5 tons. On average, 173 cubic meters of wood were burned per month, which equals 0.088 cubic meters per 100 kg of billets. In August, production increased to 8.5 tons of billets per day, while 0.78 cubic meters of wood were burned per 100 kg of billets. The maximum wood consumption did not exceed 0.1 cubic meters.

Conventional furnaces in this mill used between 0.14 and 0.20 cubic meters of wood per 100 kg of billets, averaging 0.17 cubic meters.

Therefore, the fuel savings amounted to 40%.

Daily reduction increased by 7%, and the consumption of iron per 100 kg of finished sheet metal decreased from 129.2 kg to 123.2 kg, i.e., by 5.3%. The combustion usually amounts to 1.3 to 1.4 kg.

Mr. Tereny assumes that the application of his recuperator to gas-fired coke furnaces will also yield good results.

I believe that the figures given above should not be taken literally. The tests conducted by the inventor himself are usually under the most favorable conditions, even if, taking into account the usual conditions and the worker's habit of using ordinary and simpler furnaces, these figures should probably be reduced somewhat. In any case, it must be acknowledged that Mr. Tereny's recuperator is well-conceived and will bring significant benefits, especially since its simplicity paves the way for the use of gas-fired furnaces. Gas-fired furnaces have so many good sides when used for coke furnaces that a rational step in this direction represents a significant progress in the production of thin sheets.

K. Adamiecki