OPTICAL PYROMETRY IN NON-FERROUS METALLURGY.

Professor F. G. Donnan, M.A., Ph.D., F.R.S., spoke on "Optical Pyrometry in Non-ferrous Metallurgy."

When using optical pyrometers in cases where the conditions for full (so-called "black-body") radiation are not satisfied, as, for example, when observing open baths or streams of molten metal, it is necessary to apply corrections depending on the optical properties of the material examined. For any given spectral region employed, the correction depends on the ratio of the luminous energy radiated by the material in question to the luminous energy emitted by a full radiator in the same spectral region at the same temperature. In many cases the failure to make the necessary correction will result in serious errors, so that it is necessary to draw the attention of practical metallurgists to this matter. Mr. Cosmo Johns is going, I understand, to speak about the corrections necessary in the case of steel, whilst in the present note it is my intention to refer to the cases of gold and copper, two metals whose optical properties at high temperatures depart very widely from those of the ideal full radiator. A bath of molten copper shines with a beautiful greenish-blue light, a bath of molten gold with a bluish-green light. A short consideration suffices to show that this must be the case. Consider the case of copper, for example. Cold copper selectively reflects red light. Imagine a mass of molten copper, at a temperature, say, of $1,200^{\circ}$, inside an enclosed furnace at the same temperature. The total light coming from the copper will then correspond to full radiation at $1,200^{\circ}$. But as the copper selectively reflects in the red part of the spectrum, it must obviously be selectively emitting in the blue and green. Thus a mass of molten copper, deprived of this reflected radiation, will shine with a greenish-blue light. This conclusion depends on the assumption that the selective reflection in the red does not disappear with rise of temperature, an assumption which is justified by the experimental observations.

The emission-spectra of copper, gold, and silver at temperatures in the neighbourhood of their melting-points have been compared with the emission-spectrum of the full radiator at corresponding temperatures by Drs. Stubbs and Prideaux, working under my direction at Liverpool University.*

* "A Spectro-photometric Comparison of the Emissivity of Solid and Liquid Gold at High Temperatures with that of a Full Radiator," C. M. Stubbs and E. B. R. Prideaux (*Proc. Roy. Soc., A*, 87, p. 451, 1912): "A Spectro-photometric Comparison of the Emissivity of Solid and Liquid Copper and of Liquid Silver

The following results are quoted from these measurements, which were made by means of a spectro-photometer of the König-Wanner type, as modified by Nernst and manufactured by Schmidt and Haensch. For details of the method and results reference must be made to the original papers.

Fig. 1 shows the relative emissivities of solid and liquid gold (i.e. relative to the full radiator at the same temperature) as dependent on the wave-length of the radiated light.

FIG. 1.

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In the next figure (Fig. 2) are shown the corresponding curves for copper and silver.* Thus, whilst the relative emissivity of molten copper is about 0.45 at wave-length 450μ , it falls to about 0.12 at wave-length 700μ .

at High Temperatures with that of a Full Radiator," C. M. Stubbs (*Proc. Roy. Soc.*, A, 88 p. 195, 1913).

* Curve I. Absorptivity, solid copper; II. Relative emissivity, solid copper; III. Relative emissivity, liquid copper; IV. Relative emissivity, liquid silver.

The following table gives the black-body temperatures in degrees Centigrade of copper and silver at their melting-points, i.e. the temperatures of a full radiator giving the same emission of radiation.

Wave-length in $\mu\mu$.	Copper, M.Pt. 1,083.4°.		Silver, M.Pt., 960.7°.
	Solid.	Liquid.	Liquid.
700	896	917	792
675	912	928	799
650	924	942	804
625	943	956	808
600	966	973	816
575	988	989	823
550	1,007	1,003	831
525	1,018	1,015	838
500	1,028	1,026	845
475	—	1,033	—

FIG. 2.

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Thus, an observer employing an optical pyrometer adjusted to give correct values for conditions of full radiation (as is always the case), and making use of a portion of the spectrum whose optical "centre of gravity" was, say, $600\ \mu\mu$, would estimate the temperature of molten copper in an open bath at its melting-point 110°C . too low. It may be remarked that this table of corrections can be used also at temperatures considerably different from the melting-point, since, so long as there is no change of state of aggregation, the optical properties do not appear to vary much with the temperature.

The following table gives the black-body temperatures for gold at its melting-point, $1,063\cdot2^{\circ}\text{C}$.

Wave-length in $\mu\mu$.	Solid Gold.	Liquid Gold.
701'4	891'5	931
671'2	905	943
640'9	925'5	956'5
614'9	942	969
589'5	964	982
564'9	984'5	993
541'8	1,000	1,003
518'6	1,019'5	1,012
496'1	1,025'5	1,019
475'0	—	1,024'5

Thus, using an optical pyrometer giving black-body temperatures and employing a spectral region of mean wave-length $614\cdot9\ \mu\mu$, an observer sighting on an open bath of molten gold at its melting-point would estimate the temperature about 94°C . too low.

It may be remarked in conclusion that optical pyrometers depending on polarizing devices for measurement purposes must be set at right angles to the surfaces of baths of molten metal, in order to avoid errors due to the polarization of obliquely radiated light.

CHEMICAL LABORATORY,
UNIVERSITY COLLEGE, GOWER STREET, LONDON.