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# 伝 熱 研 究

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Heat Transfer Society of Japan

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## 論 説

§ 1. 機械学会関西支部二相流研究会の  
流動グループの経過と現状

神戸大学 赤川 浩 爾

二相流体の流動と伝熱に関する研究会の設立が昭和35年5月13日の準備会で要望されたが、その直後5月16日の日本機械学会関西支部幹事会および評議員会において、関西支部の事業として発足することが決定された。それによつて昭和35年6月10日に第1回二相流研究会が開催されて以来、昭和39年8月25日の現在まで毎月1回の会合をもち51回の研究会が行なわれてきた。その間、昭和39年4月に従来 of 研究会が改組されて、日本機械学会関西支部二相流研究分科会となつて現在まで運営されている。会員数は会を数えるにしたがい漸次増加し、現在では15大学、14会社、合計167名の参加をえており、各会の出席者は平均30名程度である。

研究分科会は設立時より多少の変化があつたが、現在では伝熱グループ、流動グループおよび固体を含む二相流グループの3部門より構成されている。会員はいずれのグループにも重複して参加できるが、会合はすべて一体として開かれており、これらのサブグループの作業、討論は本会合終了後に行なわれている。分科会の運営方針は各年度当初に討議されて決定されており、年度により多少異なつているが全体を通じての基本方針は、(1)研究者相互の連絡、(2)文献および資料の調査と整理、(3)共同研究の企画、である。その具体的作業としては、(1)主要文献の表題の一覧表作成、(2)それにもとづいて選定された文献抄録の作成(分科会で定めた様式による)、(3)後記の研究テーマ毎の整理、(4)特別講義と討

論，であつて，これらの詳細については機械学会関西支部総会において配布された「事業報告」（昭和35～38年度のはそれぞれ12，20，33および42ページ）において紹介されている。なお昭和38年度までは研究会は文献紹介と整理作業を主として運営されてきたが，昭和39年度は毎回2題目に対する特別講義をもとにしたシンポジウムを主とし，そのほかに従来文献紹介，各テーマ毎の整理の共同作業などが行なわれている。

流動グループによつてなされた本会整理方式による文献抄録数は圧力損失：42篇，ポイド率：21篇，流動様式：8篇，流動の安定性：3篇，汽水分離：4篇，その他整理方式によらずに紹介されたもの30篇，計108篇であつて，各会合において抄録担当者より説明があり討議が行なわれている。

流動グループが第1回研究会以来引き続いて取り上げた研究テーマは，(1)ポイド率，(2)圧力損失，(3)流動様式，(4)分岐合流損失の各整理方法，および(5)フラッシュ流の流動計算法であつて，研究会に提出された流動，伝熱関係の資料，および未提出の資料によつて各テーマに対する担当大学および会社の共同作業で整理結果が報告されている。前記テーマの(1)(2)については昭和36年度事業報告に一部記載され，また(1)(2)(3)に対する最終的整理結果が第45回（昭和39年2月），第46回（昭和39年3月）分科会に提出されている。その内容は次のとおりである。

1. 流動様式の分類
2. 流動様式の状態図
3. 各流動様式の諸性質
  - 3.1 静止液中の発生气泡の大きさと形状
  - 3.2 伝熱面に発生する蒸気泡の大きさと形状
  - 3.3 ピストン流
  - 3.4 環状流および噴霧流
4. ポイド率
  - 4.1 平均ポイド率

- 4.2 ポイド率の流路断面分布
- 4.3 気体時間率
- 5. 相対速度
  - 5.1 相対速度の定義
  - 5.2 単独気ほうの上昇速度
  - 5.3 気ほう群の上昇速度
  - 5.4 気ほう流中の気ほう相対速度
  - 5.5 一般の二相流の相対速度
- 6. 圧力損失
  - 6.1 全圧力損失
  - 6.2 摩擦損失
  - 6.3 加速損失

前記テーマ(4)についての整理結果は第44回研究会(昭和39年1月)に提出されている。その内容は次のとおりである。

- 1. まえがき
- 2. 単相流実験値の整理
- 3. 二相流実験値の整理
  - 3.1 分岐損失係数
  - 3.2 合流損失係数
  - 3.3 支管端を本管流中に突出させた場合
  - 3.4 流量分布
- 4. 結論

テーマ(5)については、その計算法と大気圧から臨界圧までの圧力範囲の計算図表が昭和38年度事業報告に発表されている。

なお現在研究が進行中のテーマとして、(1)ブロー管系の設計法、(2)二相流の流動の安定問題、および、(3)汽水分離の問題がある。(1)は第35回研究会(昭和38年4月)に研究テーマとして取り上げられたもので、まずボイラブロー管系の実例に対するアンケートがなされた。その結果、次の12項目の問題点があることが明らかにされて、今後の研究の基礎

資料がえられた。

1) ドラム弁の有無, 2) Double Shut, 3) Double Shut以上に弁の有無, 4) Double Shutの弁間距離, 5) 隣接ボイラのブロー管と共通母管の有無, 6) ブロー弁直径と管の直径, 7) 流量と口径, 8) ブロー管の流量の算定, 9) 弁の形式, 10) 逆上弁の入れ方, 11) 連続ブローの流量調整方式, 12) アングルニードル弁のバイパス方式

テーマ(2)は昭和37年度より取り上げられて, 第39回研究会(昭和38年8月)の特別講義およびサブグループ会議で研究, 討議されつつある状況である。なおテーマ(3)は資料集積の段階である。

## § 2. 機械学会関西支部二相流研究会の 伝熱グループの経過と現状

京都大学 佐藤 俊

二相流研究会が発足した昭和35年6月以来, 研究会に伝熱グループがおかれ, 二相流の伝熱に興味を持たれる方々が集まって討議を行ない現在に至つていて, 年度毎に報告書が出されているが, 支部総会において配布されているため, 機械学会の会員にも一部にしか届いていないと考えられるので, 簡単に従来経過と検討結果をのべ, 更に現在採り上げている問題や将来の行き方などにつき所見を述べさせて頂きたいと考える。

最初まずこの方面の研究の概要を知るため, 入手して調査しうる諸種の文献より関係論文を整理リスト・アップしたが, 特に沸騰関係の論文数が毎年相当数発表されており, かつグループ員一同の興味も最も沸騰伝熱に多く向けられていたので, これら論文の主なものを抄録して, 個

々に紹介し討議することを始め、上記リスト中より重要と考えられる論文を一定の様式に纏め検討が行なわれた。現在までに抄録紹介された論文数はバーンアウト（沸騰伝熱限界熱負荷）関係が約40篇，沸騰伝熱関係約35篇である。<sup>(1)</sup>

次いで、上記論文に示された諸関係式，整理式の比較検討を行ない，設計その他の実用に供しうる一般性のある関係式の採択をめざし，昭和37年度より諸種の条件下におけるバーンアウト熱負荷を与える諸式の検討を始めた。すなわち，バーンアウト熱負荷を与える理論或は実験式を上記論文から関係事項の要約を含めて表示したが，<sup>(2)</sup> 表示された関係式は57式であつた。これらの中には直接原文を抄録していないものも加えられているが，それらは主として原文の入手が容易ではないが他の文献からその内容が明確なものである。

これら表示された式中には特定の装置による特定の試験範囲，試験条件に対して作成されたと考えられる純実験式がかなりある。これらはそれぞれの実験結果と相当よく合致しているが，二三の主要因子のみと関係つけた比較的簡単な式が多い。それで，試験条件と合致する場合には実際の適用が容易である利点はあるが，数多くの因子に微妙に影響をうけるバーンアウト熱負荷を一般的に算出あるいは推定するには適しないだけでなく，これら諸式を比較検討した結果では諸式の与える値には定量的には勿論，主要因子に関してすら定性的にもかなりの差異が認められた。そこで上記の表中より，一般性を持つと考えられる実験あるいは理論式について，実験データを適用して詳細な検討を行なつて次のような結果を得た。

(1) プール沸騰バーンアウト　自然対流沸騰におけるバーンアウト熱負荷を与える関係式として，一般性もあり，理論的根拠を持つ式として，Rohsenow-Griffith, Chang-Snyder, Zuber-Tribus, Kutateladzeらの諸式がある。これら諸式の誘導の根拠となつている考え方は，それぞれ相当異なつているが，結果はいずれも大差がなく，飽和沸騰域に対して実験結果ともよく一致していて，特にChangら以

下の諸式は一般性があると考えられる。なお表面沸騰域に対しては、Zuber-Tribus, Kutateladze の両式が一般的であると考えられるが、実験データが不十分で、充分の検討が行なわれなかつた。

(四) 強制対流沸騰バーンアウト 強制対流を伴なう表面沸騰域におけるバーンアウト熱負荷を与える関係式から、一般性を持つと考えられる約10種の式を選び、多くの因子についてなるべく広い範囲にわたつて任意に抽出した多くの種々の実験データを用いて比較検討した結果、Zenkevich, Bernath および佐藤・岐美・竹内の3式が一般性を持っていることを知つた。Zenkevich 式中低圧域に対する式は若干の疑問があるが、後者2式は適用範囲に若干の制限を附せばほぼ±15%の範囲内において、種々の実験結果を満足し、相当直径の小さい範囲に対しては佐藤らの式が、その大きい範囲に対しては Bernath 式が良好に適用されると見られる。

昭和38年度において強制対流飽和沸騰バーンアウト熱負荷を与える諸式の検討を行なつた。この領域ではボイド増加のために対流伝熱と沸騰伝熱との相互干渉が大きく、流動様式にも大きく関係するようで、伝熱機構はより複雑となり、影響諸因子の相互関係も複雑な関連を持つことが想像される。これら要因間の定量的関係を普遍的に扱つた研究は少なく、かつ関係式の検討を行なうに必要な実験条件を明示した実験値に乏しいので、検討は必ずしも充分に行なえてはいないがこの領域に対して一般性を持つと考えられる6つの式につき検討した結果では遺憾ながらいずれも満足なまとまりを示さなかつた。強いて比較すれば、エンタルピーを用いて関係づけた式が精度を別にすれば一般性があるように観察された。

そこで、現在、核沸騰、遷移沸騰、膜沸騰の文献調査を進めつつ、特に強制対流飽和核沸騰の関係式<sup>(5)</sup>の比較検討を行ない、これらを纏めた上で、その結果も勘案してあらためてその領域に対するバーンアウト熱負荷の関係式を再検討することとしている。ところで強制対流飽和沸騰熱伝達の一般的整理式として数種のものが発表されているが、大別すれ

ば、Lockhalt-Martinelli パラメータを使用し、二相流の流動損失との関連において整理を試みているもの（例えば Dengler-Addoms の式）と、单相強制対流熱伝達に関する無次元整理式との相関において整理しているもの（例えば Миропольский の式）とが代表的と見られるので、現在これら両者の相互比較検討を進めていて、近くその結果がまとめられることになっている。またこれら強制対流飽和沸騰関係式をバーンアウト熱負荷にまで拡張することについても検討が進められていてかなりの好結果が期待される可能性が確かめられているので、目下この方向に従って鋭意努力がなされている。

なお本研究分科会として今期から従来の個々の文献紹介形式と若干趣を異にして、比較的纏まつたテーマに関するシンポジウム形式の討論を行なうこととし、伝熱グループとしてもその趣旨に則り、すでに次の3題目の討議を行なった。

- (1) 二相流の圧縮性がバーンアウト熱負荷におよぼす影響（担当者：京大 林田氏）
- (2) 遷移沸騰熱伝達について（神大 井上氏）
- (3) Gilli, Collier による二相流における沸騰現象の概説（阪大 高城氏）

以上簡単に当グループの現在までの活動状況を紹介したが、当分科会は興味を持たれる方々が自由に参加して頂けることになっているので、多数の方々が参加され或は御意見を寄せて頂ければ幸と考える。

#### 参 考

- (1) 抄録論文名等は各年度二相流研究会事業報告に一覧されている。  
（昭和36年度，37年度，38年度）
- (2) 昭和37年度同上事業報告書（昭和38年3月）
- (3) 強制対流沸騰バーンアウト熱負荷関係式および熱伝達関係式（主として飽和域）は38種の式が昭和38年度事業報告に表示されている。

ニ ユ ー ス

1. 地方グループ活動

関西研究グループ

日時：昭和39年6月26日〔金〕，午後2時より

会場：新三菱重工業株式会社神戸造船所和田クラブ  
2号会議室

〔市電笠松駅下車，海岸側へ入り左側〕

講演題目および講演者〔敬称略〕

イ) 極超音速風洞用ペブル加熱器の熱伝達特性について

山口富夫〔新三菱重工神戸造船所〕

ロ) 鋼管製給水加熱器の熱伝達実験

白木武徳〔新三菱重工神戸造船所〕

(講演内容は次号に掲載の予定)

2. 国際伝熱会議は1966年8月，米国シカゴ市にて開催の予定である。

詳細は決定しだいお知らせします。

3. 燃焼伝達関連現象についての特別講演会

日本学術会議燃焼研究連絡委員会主催

日本燃焼研究会・日本伝熱研究会共催

1) 日時：昭和39年11月20日(金)，午後1時～4時

2) 場所：上野公園地，日本学術会議講堂

3) 特別講演題目および講演者

α) 液体の噴霧と薄膜の蒸発と燃焼

東北大学工学部教授 棚沢 泰

b) 流れと燃焼

東京大学宇宙航空研究所教授 辻 広

c) 焰からの輻射伝熱について

京都大学工学部教授 佐藤 俊

d) 討 論

以 上

会 告
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1. 委員会関係

a. 第3期第2回幹事会

昭和39年6月27日，午前10時～12時

出席者：内田秀雄，甲藤好郎，原朝茂，平田賢（代），水科篤郎

議事：(a) 第1回伝熱シンポジウム終末報告

伝熱研究，No. 10 参照

(b) 第2回伝熱シンポジウムの計画の概要は次のとおりである。

イ. 時：1965年5月21日，22日の二日間

所：神田学士会館（予定）

ロ. 日本学術会議燃焼研究連絡委員会伝熱

部会と，日本伝熱研究会と各学術団体が共同で開催。

その幹事会として日本伝熱研究会が一切をまかなう。この方針を希望条件として，研究連絡委員会ならびは各学術団体によびかける。

ハ. 準備委員会（◎員は委員長，○印は実行委員）

◎○甲藤好郎，○森康夫，○内田秀雄，国井大蔵，

齊藤平蔵，水科篤郎，佐藤俊

ニ. シンポジウム別刷原稿は英文で書いてもよい。

b. 第3期第2回編集委員会

昭和39年9月7日，午後4時～5時

出席者：水科委員長，小笠原，佐藤，平田，岐美各委員

議事：(a) 第11号の編集について

(b) 第12号の編集方針について

1. INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER

( 佐藤 俊編 )

Volume 7, No. 1      January 1964

Special Issue—Centenary Tribute to Richard Mollier

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